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OPERATIONAL RISK MANAGEMENT FOR MOTORCYCLE PARTS FACTORY

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A Thesis Submitted in Partial Fulfilment of the Requirements

for the Degree of Master of Engineering Program in Engineering Management

The Regional Centre for Manufacturing Systems Engineering

Faculty of Engineering

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ปริยา พรพัฒนเลิศกุล : การบริหารความเสี่ยงด้านการปฏิบัติการสำหรับโรงงานผลิตชิ้นส่วนจักรยานยนต์.(OPERATIONAL RISK MANAGEMENT FOR MOTORCYCLE PARTS FACTORY) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.ดำรงค์ ทวีแสงสกุลไทย, 173 หน้า.

วิทยานิพนธ์นี้ได้การศึกษาการบริหารความเสี่ยงด้านการปฏิบัติการสำหรับโรงงานผลิตชิ้นส่วนจักรยานยนต์ การวิจัยนี้ได้พัฒนาจากหาความเสี่ยงต่างๆจากกระบวนการผลิต ซึ่งได้แบ่งผลิตภัณฑ์ต่างๆออกเป็น 3 กลุ่ม คือ เฟืองโซ่(Sprocket Gear) วงแหวน (Collar) และ เฟืองวัดความเร็ว (Meter gear) ซึ่งจะเริ่มตั้งแต่ การกระบวนการเตรียมวัตถุดิบ(Material Preparation) การขึ้นรูปชิ้นงาน (Machining) การกัดเฟือง (Gearing) และการเจียรไน (Grinding) จากนั้นจะนำความเสี่ยงต่างๆมาวิเคราะห์และประเมิน เพื่อจัดระดับความเสี่ยงโดยแบ่งออกเป็น 4 ระดับ ซึ่งในการวิจัยครั้งนี้จะนำความเสี่ยงที่ถูกจัดในระดับสูง(High risk)และระดับฉุกเฉิน(Emergency risk) หรือสามารถเรียกได้อีกชื่อหนึ่งว่า เหตุการณ์ที่มีความเสี่ยงขั้นรุนแรง (major risk event) เพื่อนำมาบริหารจัดการเพื่อลดความเสี่ยง

การวิจัยนี้ได้นำเทคนิคการวิเคราะห์ที่ใช้ผลต่อเนื่องที่อาจเกิดขึ้นของเหตุการณ์ (Fault Tree Analysis) สำหรับวิเคราะห์หาสาเหตุต้นตอของความเสี่ยง จากการศึกษาพบว่าบริษัทมีกลุ่มปัญหาหลักๆ 4 กลุ่ม ที่มีผลกระทบต่อคุณภาพของสินค้าได้แก่ 1) ปัญหาการวัดที่ผิดพลาด ซึ่งเกิดจากความผิดพลาดที่เกิดจากคน 2) ปัญหาขนาดและรูปร่างของชิ้นงาน ซึ่งเกิดจากความผิดพลาดของเครื่องจักร 3) ปัญหาคุณสมบัติของวัตถุดิบ จากวัตถุดิบที่เปลี่ยนแปลง4) ปัญหาของผิวงานซึ่งเกิดจากวิธีการทำงานที่ไม่เหมาะสม ผลจากปัญหาเหล่านี้ได้นำไปสู่ สาเหตุของความเสี่ยงขั้นรุนแรงทั้ง 12 ความเสี่ยง ผลที่ตามมาคือ ความเสี่ยงทั้ง 12 ความเสี่ยงนั้นมีผลทำให้เกิดชิ้นงานเสียที่มากกว่าเป้าหมายของบริษัท

การจัดการด้านความเสี่ยงจึงถูกกำหนดขึ้นเพื่อที่ลดระดับความเสี่ยงเหล่านั้น ซึ่งแผนต่างๆนั้นประกอบไปด้วย การฝึกอบรม การซ่อมบำรุงเชิงป้องกัน การจัดทำมาตรฐานการทำงาน การตรวจสอบของเสียระหว่างการผลิต และเอกสารตรวจสอบระหว่างการทำงาน ซึ่งจากการตรวจประเมินผลการดำเนินงานพบว่า ปัญหางานเสียได้ลดลงจาก 25,077 ชิ้น เหลือ 22,943 ชิ้น คิดเป็น 8.51 เปอร์เซ็นต์ และในแง่มุมของตัวเลขวัดระดับความเสี่ยงจากทั้ง 4 กระบวนการพบว่าระดับความเสี่ยง ลดลง 54 เปอร์เซ็นต์ เมื่อเทียบก่อนและหลังการกระยุกต์ใช้การบริหารจัดการด้านความเสี่ยง

ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต ลายมือชื่อนิสิต.....

สาขาวิชา การจัดการทางวิศวกรรม ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก.....

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KEYWORDS : RISK MANAGEMENT / MOTORCYCLE PARTS FACTORY

PARIYA PORNPATTANAOESKUL: OPERATIONAL RISK MANAGEMENT FOR MOTORCYCLE PARTS FACTORY. ADVISOR: ASSOC. PROF. DAMRONG THAWESAENGSKULTHAI, 173 pp.

The application of operational risk management is conducted in this research to control operational risks for motorcycle parts factory. This research has developed from the risk identification within manufacturing process of 3 groups of product, Sprocket Gear, Collar and Meter Gear from process of Raw Material Preparation, Machining, Gearing, until Grinding. Then, the risk analysis and evaluation has been applied to classify those risks into 4 levels. This research has determined the treatment for managing the high and emergency risks which named as major risk events.

The study mainly used the Fault Tree Analysis (FTA) as the technique for analyzing the root cause of risks. Base on the study, it was found that there were 4 groups of failure that impact to product quality. They include 1) Misleading if measurement from human error 2) Diameter and Shape failure from machine error 3) Material changing from material specification 4) Roughness error from inappropriate method. Those failures led to root of causes of those 12 major risk events. Consequently, those 12 major risks had an effect to the number of defects that over company's targets.

The risk treatment plan had been established for mitigation those major risks. Those plans include training, preventive maintenance, skill evaluation, In-process of quality control, working standard, and check sheet. From the monitoring and evaluation after implementation, the result is that the improvement of defects has been reduced from 25,077 pieces to 22,943 pieces, or to 8.51 percent. In aspect of Risk number, the percentage of Risk Number from 4 processes comparing between before and after implementation has been decreased to 54 percent.

The Regional Centre for Manufacturing System Engineering Student's Signature .....

Field of Study : Engineering Management Advisor's Signature .....

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Chapter I

Introduction

1.1 Background of the Research

Since the competitive between motorcycle parts suppliers become intensive, only the company who achieves customer satisfaction by keeping on time delivery and stable products specification as what customers' expectation is able to survive in this market.

By implementation of the operational standard in manufacturing, this gives the company the direction of reliable and consistency of quality achievement. Together with the operational standard, it is important to apply risk management to detect the possible risk's impacts from wrong adoption of working standard, employees' resistance from the implementation of the operational standard and other factors which may block the company to meet the quality target. Regarding to the cultural awareness, risk management enables company to win market order by arrangement of risk control to the team members of each department. These can be the initial development of a project hierarchy, an elementary plan as well as objectives of the project.

In the integration of risk management, this assessment will define those risks base on likelihood' and consequences' from the process of material preparation to shipping to customers. The application of risk identification into the project has implemented the techniques that use within a project are prepared questionnaires given to a group or team. Risks and potential problems should be brainstormed in the generic risk two areas: internal risk and external risk. The internal risk is the risks that occur because the factors within company. On the other hand, the external risk means the risk that may occur outside the company which come from outside factors.

As well as, the Fault Tree Analysis (FTA) technique of the root causes of the risks and potential problems or failure that can disturb to the operational process has been taken place. These can ensure that the root cause of the risks and potential problems are identified. After that, all risks have been identified, next step are the risk evaluation,

treatment, and monitoring &control which will be applied to ensure that those impacts will not the play significant effects.

1.2 Statement of the Problem

This research is conducted by using the motorcycle parts company as a case study, referring as ABC Company. ABC has been established since 2003 as the family business, located at Pathumthani, Thailand. In the first year, the company supplied metal lathe, metal grinding, machining parts and supplied motorcycle parts and gears, of following in consecutive years.

The company is trading with the well-known motorcycle manufacturing companies. ABC has achieved ISO 9001:2008 in order to ensure the customers that having high quality products in 2009. The company's quality management is running as following the objective to pass the certification and the market force. The table 1.1 the performance indicators compare to the organization objectives can be showed the quality objective and the performance of each aspect as below;

Table 1.1: Report of Performance from Jun to Dec 2009

No.	Indicator	Goal	Month							Avg.
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1.	No. of defects in process (%)	<=5%	11.25	7.90	6.63	6.02	6.35	8.75	8.85	7.96
2.	On time delivery to customers (%)	100 %	100	100	99	100	100	100	100	99.86
3.	On time delivery of suppliers (%)	>=95%	100	100	100	100	100	100	100	100
4.	Total time of maintenance per total time of machine utilisation (%)	<=2.3%	1.39	4.61	3.25	.1.16	4.89	2.26	1.59	2.74
5.	Customer satisfaction (%)	>=96%	95	100	100	100	100	100	100	99.29
6.	No. of customers' complaining (times)	<=4 times	1	0	0	0	1	0	0	N/A
7.	No. of reject from customer (ppm)	<=100ppm	3.7	0	0	0	2.75	0	0	0.92
8.	Training hours per person (Hr./Pers.)	>=8Hr/Per	8	8	8	8	8	8	8	8

According to Table 1.1, although the quality system has been run, some aspects still couldn't reach to the target. For example, the number of defects still over than 5% of the percent of target, deviation is 2.967%. This means there are some existing risks have not controlled in the operations process.

Without understanding the real purpose of Quality Management system, the effort to achieve standard registration involves with pressure from the customers and competitors, leading to the weak link between ISO 9001: 2008 and the real quality improvement. The quality policy became a paper which people have to follow those standards just for auditing, not from their awareness. Result in the company may not obtain full benefits of quality improvement. Again, the risk management should be included, in order to reduce impact of the risk of unable of standard achievement and gain more effective of process.

Therefore, the risk survey was interviewed. After that, all risks are indentified, and then overall of risks identification and evaluation can be showed in table 4.6- table 4.9

According to Table 5.1-5.2, the risks evaluation are applied by the interviewees who weigh their score on 'Likelihood' and 'Consequences' to determine which risks have Extreme level(E) and High level (H) or it can be called 'Major Risk Even

1.3 Objective

To apply Operational Risk Management for reducing major risk events in the operation of motorcycle parts factory

1.4 Expected Benefit

The expectation from this research as following:

1. Through their identification, assessment, analysis and continued management, those risks and uncertainty events enable to be made visible. Therefore, those reduced and mitigated plans to the risks and defects' problems are identified in time.

2. The decisions to reduce the major risks are able to build up the quality awareness. And, the effectively management leads to the number of expected problems will not occur, hence this help in improving the process to avoid non-confirmative products that will pass to customers.

3. Full implementation of risk assessment can increase in open communication because the people in organization are able to discuss and document the issues and potential problems in a structured manner.

1.5 Scope of the Research

The scope of this studying is the applicability of risk management within operation of motorcycle parts factory as below:

1. The major (priority) operational risks will undertake for the assessment.

2. Those selected of plans will be implemented to reduce likelihood and consequence of 2 major risk events in order to minimise the impact and prevent the likelihood of those 2 risks

1.6 Research Procedure

1. To research on literatures and textbooks which involving this thesis;
2. To collect the quality management system data;
3. To assess risk events base on the operational manufacturing;
4. To evaluate the risk score for find out ‘major risk’;
5. To determine the risk treatment;
6. To develop risk monitoring and review;
7. To compare before and after of implementation;
8. To prepare the draft of thesis;
9. Thesis examination;

1.7 Research Schedule

The research schedule is showed as Table 1.2:

Table 1.2: Research schedule from January to September 2010

Descriptions	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1. Research literatures and textbooks									
2. Collect the data									
3. Risk Assessment on the current process									
4. Evaluate the risk score									
5. Determine the risk treatment									
6. Develop risk monitor and control plan									
7. Evaluate the result comparing to problems									
8. Prepare the draft of thesis									
9. Thesis examination									

Chapter II

Theoretical Consideration and Literature Survey

In this chapter, Risk Management System and Fault Tree Analysis (FTA) that applied for risk control in motorcycle parts production have been discussed.

2.1 Risk Management System

2.1.1 Definition of Risk Management

Risk is effect of uncertainty on objective (ISO 31000: 2009). An effect is the difference from the expectation and it can base on different objectives' aspects such as operational, financial, and environmental goal.

Risk Management is to manage and control activities including all processes by reducing cause of damaging. Therefore, the organization can limit and evaluate the level of risks to be control as the acceptable level. Risk management can be called as Enterprise risk management.

"Enterprise risk management is a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objective." (The Committee of Sponsoring Organizations of the Treadway Commission, 2004)

2.1.2 Risk Classification

Base on the factor of source of risk, risk can be classified into two main categories as following detail:

1. External risk is uncontrollable risk that caused by external factor but those external risks are able to affect on the company, for example, the tax raising of

government can increase a risk of company budget. Those external risks can be divided as below:

- Competitive Risk is the risk the competition among business' environment for example, new entry of new competitor into the market, new product introduction, new innovative product from rival, etc.
- Supplier/Customer Risk is the risk from supplier such as the delay of raw material delivery or the risk of unstable of financial issue from customer.
- Compliance Risk is the risk that caused by the changing of some systems, i.e. law, company obligation, etc.
- Economic/ Political Risk is an effect from economical and political issue.

2. Internal Risk is the risk from internal processes of company, for example, a critical employee getting illness. The internal risk can be presented as following lists:

- Strategic Risk related to the risk of the current and prospective of business plan and implementation of decisions to achieve that goal.
- Operational Risk occurs from execution of business functions. It may arise from the people, machine, material, method and environment through the operation.
- Financial Risk is the risk of finance allocation with may affect on the company proceeding, for example, suspending of payment order from customers.
- Hazard Risk is unpredictable event such as natural disasters; impairment of physical assets; terrorism.

2.1.3 Systematic Risk Management: The 5-M Model

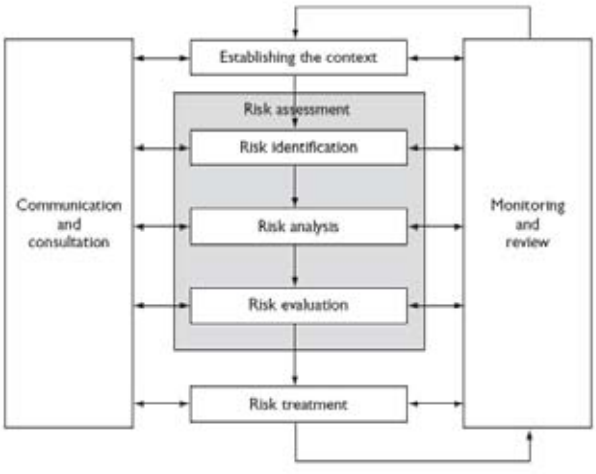
Risk management is the systematic application of management and engineering principles, criteria and tools to optimize all aspects of safety within the constraints of operational effectiveness, time, and cost throughout all operational phases. To apply the systematic risk management process, the composite of hardware, procedures, and

people that accomplish the objective, must be viewed as a system. The basic cause factors for accidents fall into the same categories as the contributors to successful operations--Human, Media, Machine, Mission, and Management. (FAA Handbook, 2000)

The 5-Ms' in ORM are modified from military ORM in FAA Handbook. This includes Man, Machine, Material, Method, and Media. In this model, 'Man' is indicated as the human participation in the activity. 'Machines' include hardware and software used as intended, limitations interface with man, and 'Materials' are any resources that input into the process. 'Methods' provide the procedures and system of performing the task. In term of 'Media', it is defined as external, and largely environmental and operational conditions. When an operation is unsuccessful, the system must be analyzed; the inputs and interaction among the 5-Ms must be thoroughly reassessed.

2.1.4 Risk management process

Many countries have developed their own risk management standards. Typically, these are frameworks. However, there is the international risk management approaches as ISO 31000, the International Standards Organization (ISO) published ISO 31000 entitled 'Risk management 2009'. As in following Figure 2.1, show the diagram to illustrate the risk management process in ISO 31000.



Source: Standard ISO/FDIS 31000:2009 Risk Management: "Principles and Guidelines": International Organization for Standardization, Page 14

Figure 2.1: Contains elements of the risk management framework

The key stages of the risk management process can be described into 6 stages

1. Establishing the context is the scope of risk management that have established as a first stage, that is the goals and objectives, timeline, location, project scope, resource required, and the risk management activities.
2. Risk Identification, both of under and over controllable risk which are the cause of uncertain effect should be listed. To ensure that the possible causes and scenarios will be considered, the engineering techniques such as flow charts, data flow diagram, brainstorming, system analysis should be applied.
3. Risk Analysis is the stage that analysis the likelihood and consequences.
   The likelihood illustrate the possibility or frequency of the risk, this can rank into five levels as following Table 2.1 below:

Table 2.1: Likelihood Ranking

Probability	Criteria	Score
Rare	Rare number of risk likely and occur in exceptional case. ABC Company has determined any risk event that occurs only one time in 3-5 years in group of rare case.	1
Unlikely	Very few of risk likely: the ORM team agree that risk which occurs once in 2 years is classified as unlikely case.	2
Possible	Moderate of likelihood: this ranking is to take into account some uncertainty events that ORM team has anticipated that it may happen 2 times per year.	3
Likely	Frequent number of risk likely: the team has predicted from history of occurrence at Company that some event will probably occur in most circumstances or occurring at less once in a month.	4
Almost Certain	The ORM team decided that repetitive occurrence occur are the common or approaches to almost certain in everyday.	5

Source: established by ORM team within ABC Company

The consequences mean that result of loss, injury, disadvantage, loss of opportunity and profit, etc. Those consequences can be divided into 5 levels as following Table 2.2 below:

Table 2.2: Consequences Ranking

Probability	Criteria	Score
Insignificant	Very Slightly effect on product quality or none of defects occur.	1
Minor	Minor effect on product quality, a few defects come out but less than 1 % of whole batch since minor defect will possibly not notice to customers	2
Moderate	Moderate effect on product quality. Some defects occur in process more than 1%, but less than the maximum limit of company. (Amount of defect that more than 1% of batch will make the safety stock of good products become lower than the level that was set by customers. And, this situation must be reported to customer by rule).	3
Major	Extreme effect of quality of product which the product cannot achieve the specification, defects occur more than the limit (5% of whole batch). Leading to insufficient product and unable to deliver to customer, this level will cause dissatisfaction from customer.	4
Catastrophic	Potential hazardous effect and able to stop production line; safety-related; highly defects; delivery failure. Disruption to subsequent process operations or non compliance with government regulation,	5

Source: established by ORM team within ABC Company

In order to level those risk priority, the score should be weighted by likelihood multiple by consequence, then arrange from highest score to lowest score as following Table 2.3 below:

Table 2.3 Risk Analysis Matrix

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
Almost Certain	M	H	H	E	E
5	5	10	15	20	25
Likely	M	M	H	E	E
4	4	8	12	16	20
Moderate	L	M	M	H	H
3	3	6	9	12	15
Unlikely	L	M	M	M	H
2	2	4	6	8	10
Rare	L	L	L	M	M
1	1	2	3	4	5

Source: established by ORM team within ABC Company

Notes: L stands for Low Risk Level;

M stands for Medium Risk Level;

H stands for High Risk Level;

E stands for Emergency Risk Level;

4. Risk Evaluation, to analyse all risks, they have to compare to the benchmarks that was set up. In some case the acceptable level should be above L level, the all risks which over than L level must be considered as major risk. So, the organization is necessary to figure out the way to manage those risks.
5. Risk Treatment, this is the method or solution to reduce likelihoods or consequences of any risks' occurring to be the controllable levels. There are five differences method as following list:
    - Avoid the risk is to terminate any activities which contain unacceptable risks or proceed other activities which can ensure that none of risks will be occurred.
    - Reduce the likelihood of occurrence is to control the likelihood as low as possible, such as to put more safety procedure, inspection, and good maintenance.
    - Reduce the consequence is the method to reduce the result after risk have occurred. For example, moving the dangerous plant to non crowded city.
    - Transfer the risk is to move the risks to others which can handle those risks. For instant, the company may outsource some part of risked jobs from the supplier or insure company by using insurance company.
    - Retain the risk is to do nothing if there is too high cost of risk responding. However, the organization should keep monitor the risk to know any changes closely.
6. Monitoring and Review is a process to monitor and review the result of risk management for ensuring that the way to control risks are appropriate. The stage of monitoring should to be assessed as a normal process of management activities. In aspect of scope and frequency of separate evaluations, the primarily of risks and effectiveness of ongoing monitoring procedures should be considered to arrange the scope and frequency.

7. Communication and consultation, in order to let everyone in organisation to understand the ongoing of risk management. The effective communication is enable people to carry out their responsibilities, moreover some risks that may not be able to control by themselves. So, they may ask the consultants or risk specialist to advise them.

2.1.5 Benefit of Risk Management

There are many advantage of the application of Risk Management as following:

2.21 Risk management makes outcomes less negative. Also, this technique will reduce the expected losses and can ensure that the overall cost is under control.

2.22 The effective management makes outcomes more positive. Meanwhile, there are opportunities to approach to increasing the revenue from the product or service.

2.23 This enhance the people in organization become have more risk awareness culture. Therefore, it will develop human skill, such as systematic, analysis, evaluation.

2.24 The customer will get on time delivery and better value for money.

2.25 The resource will be assessed as more efficiency because all resource will be planned to spend on important sectors.

2.26 Organisation will know that any problems in advance, so they may prepare the method to prevent from trouble or solution.

2.1.6 Implementing risk management

The key have led to successful risk management, all activities and functions undertaken by managers should be considered the principles of risk management and undertaken as an initiative. The implementing of risk management should have main stages as below details:

1. Planning

In this stage, the benefits of risk management should be identified. And then, the risk management strategy, roles and responsibilities will be presented to gain board support.

2. Implementing

   Next, the organization should divide risk classification and adopt suitable risk assessment procedures.

3. Measuring

   The benchmarks of Risk management should establish first, then determine risk tolerance and evaluate the existing control. Moreover, they have to ensure cost-effectiveness of existing controls, along to control environment and resource allocation.

4. Learning

   The Report risk performance should be presented to the broad the review risk performance. This will embed risk-aware culture to people in organization.

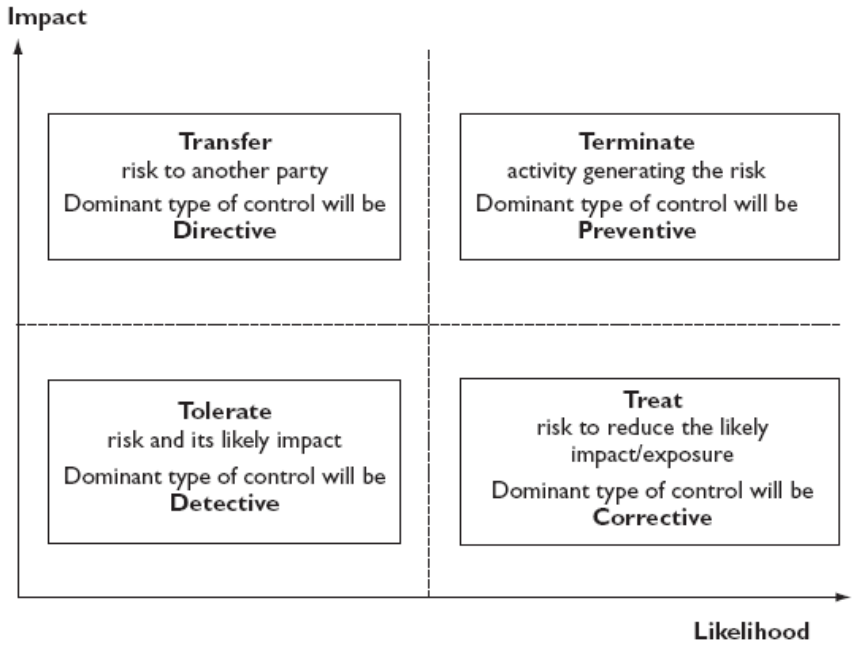
2.1.7 Risk tolerance

The definition of risk tolerance in British Standard BS 31100 is “the organization’s readiness to bear the risk after risk treatments in order to achieve its objectives”. On occasions, some events may occur over level of comfort zone and risk appetite and the company are necessarily have to tolerate current level of risks that are beyond its actual risk capacity. Those events may not frequently occurs, however the company will be vulnerable during that period.

The category of those risks which have low-likelihood risks with low impact have been adopted by company as one of risk tolerance. In some case, the hazard risk is considered to be within the risk appetite which is accepted or tolerated by company, even though any risk control measures have not been applied. Also, the company decide to tolerate or accept with current hazard risks that levels are high because those

risks are relate to high cost-effective of control measures, and they are associated a fundamental process or the nature of the business.

In case of inherent level of the risk is been unacceptable, the control measures will be applied in order to move the risk to the low-likelihood/low-impact quadrant of the risk matrix, as illustrated in Figure 2.2



Source: Pual Hopkin," Fundamentals of Risk Management: understanding, evaluating, and implementing", 2010

Figure 2.2 Types of controls for hazard risks

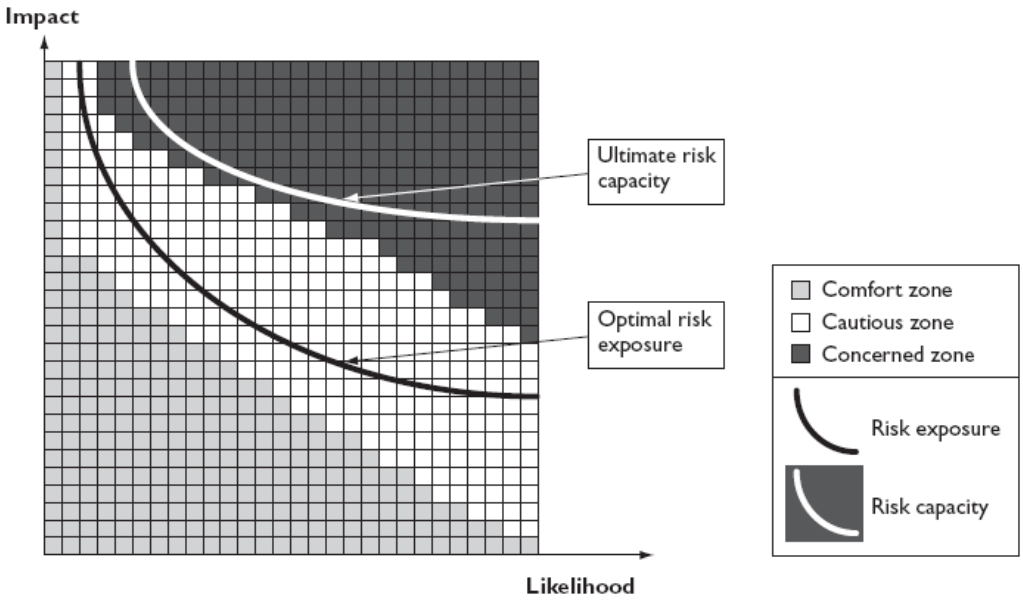
2.1.8 Risk appetite

In some case, the company have to accept a number of risks as part of its normal operations. The definition of risk appetite in British Standard BS 31100 is the "amount and type of risk that an organization is prepared to seek, accept or tolerate".

Related to the risks, those cost of incidents will be occur in terms of the cost of loss-prevention, damage-limitation, and insurance costs. Therefore, those risks and costs associated with those risks should be quantified how much the company will tolerate and this is part of the total risk appetite. Therefore, the cost within the projects that the company is currently undertaking is necessary to be control as the part of the overall budget for a project.

"The cost of the controls within the project budget represents the control acceptance of the organization. The portion of risk appetite that is associated with opportunities can be considered to be the opportunity investment that the organization is willing to embrace. Organizations will be willing to invest resources in opportunities that the organization believes will produce a positive gain. However, the organization should recognize that value put at risk in this way may not produce a positive gain. Implementation of strategic decisions may result in losses". (Hopkin, 2010)

However, the actual exposure to hazard risks may be greater than the anticipated because of incorrect strategic decisions as in Figure 2.3 shows the difference of range of outcomes and risk exposures.



Source: Pual Hopkin," Fundamentals of Risk Management: understanding, evaluating, and implementing", 2010

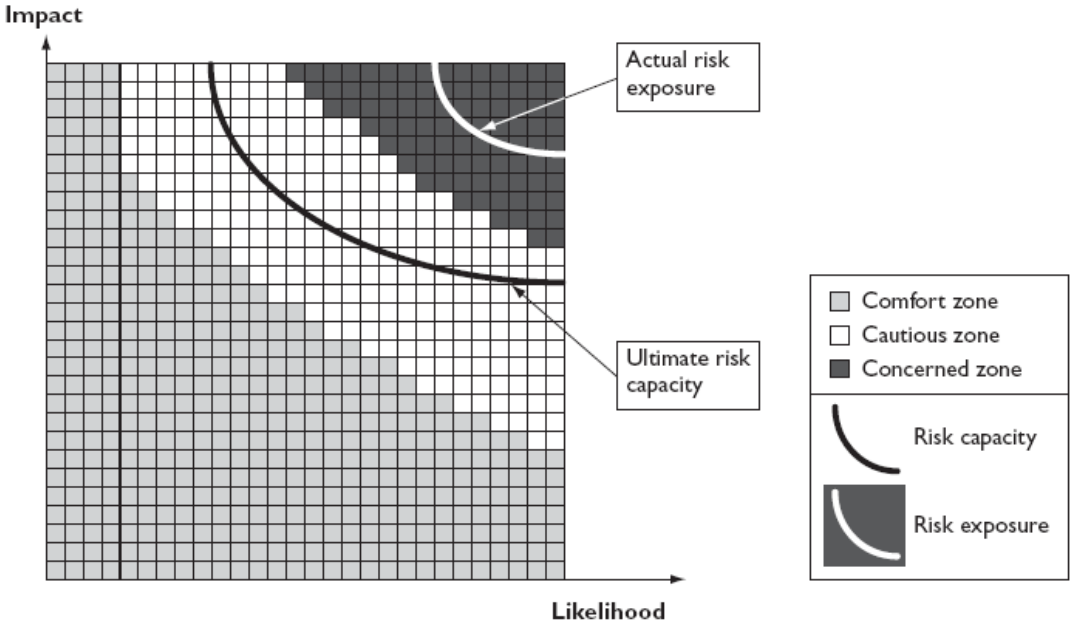
Figure 2.3 Risk appetite, exposure and capacity (optimal)

Figure 2.3 represents the overall risk exposure which is the optimal position. The overall of optimal risk is in the lighter section while the line the risk capacity of the organization cut through the darker area. This is the optimal state that overall risk is within the appetite and not exceeding the ultimate risk capacity curve. As in figure 2.2, most of risks are in comfort zone for accepting risk. The lighter-shaded represents

cautious zone which is smaller. And, the darker square which represents concerned zone that it is only in this area that the company will consider that the risks are significant has the smallest part of the overall figure.

In relation to opportunity investment, the company may invest sum of money for having risk appetite, but it needs to ensure that value at risk is not beyond the capacity of the company. Therefore, having carefully calculating on the actual risk exposure compared to the opportunity is required.

The case of situation that the company have to take risks that are beyond the ultimate risk capacity of the company, as figure 2.4:



Source: Pual Hopkin," Fundamentals of Risk Management: understanding, evaluating, and implementing", 2010

Figure 2.4 Risk appetite, exposure and capacity (vulnerable)

In Figure 2.4 represents the situation of vulnerable circumstances which the actual risk exposure is embedded within the darker area. The ultimate risk capacity curve is below the actual risk curve and within the medium-shaded zone. In other word, the actual risk exposure is shown to be well beyond its ultimate risk-bearing capacity.

“The identification of the risk appetite for the organization requires judgement, and this judgement can be exercised at different levels within the organization. Consideration of risk appetite will be a strategic driver at board level. Risk appetite is likely to be an operational constraint at line-manager level because line managers will be expected to operate within the risk appetite policy that has been established by the board. At the individual level, it is likely that consideration of risk appetite will be a behaviour regulator. This is because individual members of staff should only operate within the risk appetite framework that has been developed at board level and is implemented by line managers.” (Hopkin, 2010)

2.2 Fault Tree Analysis (FTA)

“FTA is a technique for identifying and analysing factors that can contribute to a specified undesirable event (called the “top event”). Causal factors are deductively identified, organized in logical manner and represented pictorially in a tree diagram which depicts causal factors and their logical relationship to the top event.” (ISO 31010/IEC 2009)

2.2.1 Process of Fault Tree Analysis

In order to analysis FTA, the occurring events should be identified as a model. Then, the estimation of probability of the head event should be calculated base on individual pathways. For the detail of process to outline FTA model are as below:

1. The organization should identify the top event. This top event may be any failure of the result of failure.
2. They should figure out the possible immediate causes that lead to the top event.
3. Then, this stage is to identify how each cause will have an effect on the top events.

4. This stage will place any undesirable system operation at the chart those are identified from top to successively lower system level until further analysis becomes productive.
5. Finally, when base evens can place to the lowest level, then the probability of top event may be calculated. “For quantification to be valid it must be able to be shown that, for each gate, all inputs are both necessary and sufficient to produce the output event. If this is not the case, the fault tree is not valid for probability analysis but may be a useful tool for displaying causal relationships.” (ISO 31010 IEC, 2009)

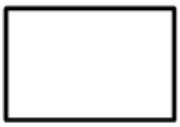
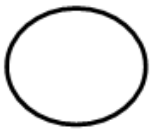
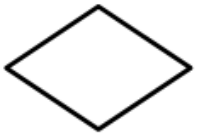
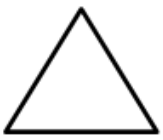
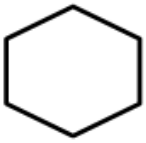
2.2.2 Benefit of FTA

1. This analysis method is highly systematic while it is also flexible to allow s vary factors, such human factor and physical phenomena to be analysed.
2. This application can show the relationship of those effect and failure from top to down, and those are related to the top event directly as well.
3. With this technique, there are many interfaces and interactions in analysing systems.
4. This is analytical method by using visual presentations, so it is easy to understand the level of behalf and the factors inside. Therefore, it can convey more complex logical relationship easily.
5. Risk management is proactive system

2.2.3 Representative of FTA chart

There are two types of symbol to represent on FTA chart. Firstly, Event symbol, these are symbols to represent any occurring events. Second, Logic gate which show the logical of any pathways. Those symbols can be shown as below Table 2.4, next:

Table 2.4: Fault Tree Analysis

Type	Name	Symbol	Description
Event Symbol	Fault Event		An event that result due to the interaction of number of other events
	Basic Event		A basic initiating fault (or failure event).
	Undeveloped Event		An event which is no further developed. It is a basic event that does not need further resolution.
	House Event/ External Event		An event that is normally expected to occur. In general, these events can be set to occur or not occur.
	Tree Transfer		Indicates a transfer continuation to a sub tree.
Logic Gate	Or Gate		The output event occurs if all input events occur
	And Gate		The output event occurs if at least one of the input events occurs.
	Inhibit Gate		The input event occurs if all input events occur and an additional conditional event occurs.

2.3 The role of ISO 9000:2008

“The International Standards Organization (ISO) published ISO 9001:2008 entitled ‘Quality management system’ as ‘this International Standard specified requirements for a quality management system where an organisation needs to demonstrate its ability it consistently provide product that meets customer and applicable statutory and regulatory requirements, and aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.” (The International Standards Organization (ISO),2008).

2.3.1 Definition of ISO 9000:2008

ISO 9000:2000 is a series of three International Standards for Quality Management Systems. They specify requirements and recommendations for the design and assessment of management systems. ISO 9000 is not a product standard. None of the standards in the family contain requirements with which a product or service can comply. There are no product acceptance criteria in ISO 9000, so those products can’t be inspected against the standard.

2.3.2 Purpose of ISO 9000:2008

The purpose of these standards is to assist organizations of all types to implement and operate effective quality management systems. These standards provide a vehicle for consolidating and communicating concepts in the field of quality management that have been approved by an international committee of representatives from national standards bodies. It is not their purpose to fuel the certification, consulting, training and publishing industries. The primary users of the standards are intended to be organizations acting as either customers or suppliers.

2.3.3 Elements of ISO 9000:2008

There are many changes in ISO 9001. Some phrases from the 1994 version have been retained although only 17 instances could be found. In a great many cases, the

wording has changed but not the intent. In the majority of cases, the wording represents a new requirement often as a new topic not only addressed in the 1994 version but also as a modification of the previous requirement extending its scope or application. Of the new requirements the following list presents those that are considered key to understanding the differences.

Audits

Audits of management system design, processes and conformity with ISO 9001 – no longer limited to procedure audits

Communication

Processes for internal communication rather than systems of documentation

Continual improvement

The effectiveness of the management system to be continually improved – not merely reviewed

Contract Review

Replaced by a wide-ranging, review of all product requirements including customer, Organizational and regulatory requirements – have no longer limited to contracts and tenders. The standard has moved away from the original intention of it being used in a contractual situation to one in which there might be no contract until after a product or service has been developed.

Customer satisfaction

Customer perceptions of the organization's performance to be monitored as one of the measures of management system performance

Design

If the organization designs its own products and services, design and development processes must be included in the management system

Documentation

Determined by the organization as necessary for effective operation of its processes – not simply as required by the standard

Linkages

Organization purpose, policy, objectives, processes and results to be linked to demonstrate effective process management

Management review

Top management to review the system for its effectiveness in enabling the organization to meet requirements of customers and other interested parties – no longer limited to a review of audit results and customer complaints

Marketing

The processes employed to determine customer needs and expectations must form part of the management system – no longer limited to contract review activities

Measurement

Required for all processes not only production, servicing and installation processes

Procedures

Only six procedures specified as requirements, others as needed for effective operation and control of the processes

Processes

All processes that serve the achievement of the organization's objectives to comprise the management system – no longer limited to production, installation and service

QMS

To be designed around the organisational processes not the elements and clauses of the standard

Quality Manual

Needs to describe the interaction between processes – is not to be a response to each clause of the standard

Quality objectives

Separate from the policy but consistent with it and established at relevant levels and functions – the driver of continual improvement in performance

Quality policy

To be appropriate to the purpose of the organization and provides a framework for quality objectives – not a motherhood statement

Records

As needed to provide evidence of effective operation – all types of records not simply those referred to as quality records

Requirements

Commitment to meeting requirements of customer and other interested parties – no longer limited to the organization's own requirements

System effectiveness

To be measured, analysed and continually improved and judged by the degree to which customers are satisfied – not judged on conformity with standard

Top management

Must be involved in establishing, developing, reviewing and improving the management system

2.4 Literature survey

Financial Institutions Supervision Group (2003) issued the integrated framework to enhance their internal control system. The Operational Risk Manual is to incorporate into policy, and regulation, and control their activities in moving toward achievement of their established objectives.

Bank of Thailand had referred to the definition of "operational risk" from the Basel Committee on Banking Supervision as "the risk of damage resulting from the lack of skillful management or good governance within an organization and the inadequacy of proper control, which might involve internal operations, personnel, the system, or external occurrences that in turn affect the income and capital funds of financial institutions". (Basel Committee on Banking Supervision)

Therefore, financial institutions have applied 3 key components in order to have an effective operational risk management system, as following:

Establishing strategy in managing operational risk

To manage operational risk in the right direction, the board of directors of the financial institution should establish policies, scopes, and strategies in managing its operational risk, as well as, producing consistency by building corporate culture by communicating, and developing consciousness, knowledge and understanding to all involved employees.

Establishing an organization to ensure the management of operational risk

The board of directors of the financial institution should determine organisational structure and establishing roles of responsibilities. The working unit has been divided into form of committee, subcommittee, or business unit. Then, those working unit should be established the roles and duties in order to monitor the business operations of the financial institutes and assure the sufficient control system.

Installing the operational risk management system

Through out all levels of business units, the instituting a risk management system according with the international standards should be established. The procedures for risk management should have the following processes:

- Risk identification
- Risk assessment
- Risk monitoring and reporting
- Risk control

Nancy R. Tague (1994) described that the definition “quality product” must broadly define .Those qualification of quality product is included on-time delivery, correct packaging, correct documents, and much more. Therefore, these services are provided through that network of processes, which must be managed in order to assure quality. They must be defined, analysed, improved where necessary, and maintained. Both ISO 9000 and TQM begin with this concept.

Customer focus is the heart of any total quality process. In many organizations, the challenge of implementing total quality is increasing the customer focus. ISO 9000 can help to meet this challenge, because the ultimate goal of all the internal process analysis, improvement, and documentation is quality assurance to the customer. There is nothing included in the ISO 9000 standard that does not directly relate to assuring the customer of quality products and services.

Fiona D. Patterson (2002) described in “Project Risk Management and its application into the automotive manufacturing industry” that the Risk Management Methodology have 5 stages of development and can be the continuous and cyclic

process. Those stages are; Risk Identification, Risk Assessment, Risk Analysis, Risk Reduction and/or Mitigation, and Risk Monitoring as the following Figure 2.5.

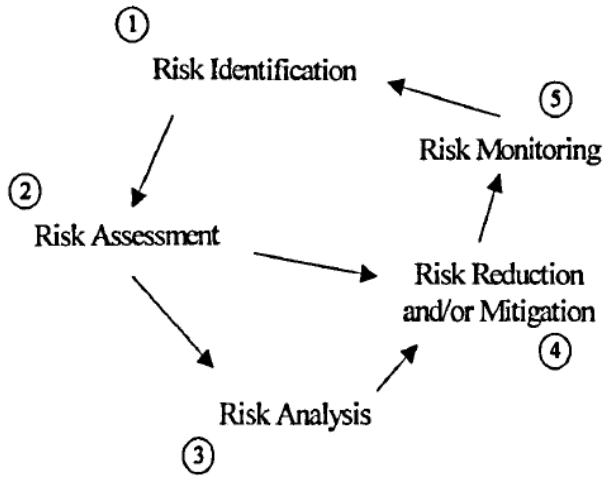


Figure 2.5: Risk management process

Source: Fiona D. Patterson (2002), Project Risk Management and its application into the automotive manufacturing industry

Jeff Henning (2008) studied Risk management in emerging markets: Insights and findings from the automotive sector". In his study, "many automotive companies have changed their primary purpose from the cost reduction which is the traditional view into the most effective approach of doing business. Also, they are more concentrated on the risk management in areas that far from the cost-effective manner. He stated that, "the best approach to risk management allows for an integrated answer on how to align effectively the relationship between risk, control and performance in a way that directly allows for an increase in competitive advantage and enterprise value." (Henning, 2008)

John P.T. Mo and Andy M.S. Chan (1997) summarized his survey that the major driving forces to ISO implementation is related to sales-elements. These include:

- Pressure from major customers' requests;
- Anticipation of request from customers soon;
- Requirement of potential customers;
- Ability to capture more market share;
- Pressure from competitors.

On the other hand, there is the list of proactive drives which ISO 9000 certification involved with the total quality management (TQM). Therefore, this ISO 9000 can be referred as the effective tool to enable the TQM process, leading to continuous improvement of the company.

Also, they considered that another tool for continuous improvement is the internal auditing process for ISO. Since this process will identify any weakness from overall system. Then, the "Corrective Action" will be analysed in order to find out the root causes of the process, bring about the developing of response action and solution to solve the problems and getting more quality system satisfaction.

Evgeny Avanesov (2009) studied the Risk Management in ISO 9000 Series Standard" He described that the company have used the process approach, which followed the standard ISO 9000. With the striving to achieve the certification, the Quality management is no longer preserve the efficiency tool for organizations and fail to meet an additional benefit of working with ISO standard which requires to improve the processes. (Evgeny, 2009)

Traditionally, risk management has no place in this Quality management system (QMS). However, nowadays, the risk approach method is an integral part of other management systems standards. This means that the "organizations should identify and assess each of the risks they've been faced. Infrequent risks with minor effects are shall be only controlled. Significant risks with severe consequences should be managed in such a way as to either completely eliminate them or reduce the frequency of their occurrence and severity of consequences." (Evgeny, 2009)

William C. Worsham (1999) explained Maintenance has changed the way we think about Preventive Maintenance (PM). "It has caused some to question whether it is even necessary to do preventive maintenance. The truth is most manufacturing facilities would benefit from a good preventive maintenance program. It would be especially beneficial for those plants that rely on breakdown or run-to-failure maintenance. But, a preventive maintenance program is potentially risky, so it must be administered and performed properly to be successful. This paper will examine both the benefits and risks

of preventive maintenance and offer some ideas on how to make it successful. We will start with a definition of preventive maintenance.

Preventive maintenance is planned maintenance of plant and equipment that is designed to improve equipment life and avoid any unplanned maintenance activity. PM includes painting, lubrication, cleaning, adjusting, and minor component replacement to extend the life of equipment and facilities. Its purpose is to minimize breakdowns and excessive depreciation. Neither equipment nor facilities should be allowed to go to the breaking point. In its simplest form, preventive maintenance can be compared to the service schedule for an automobile." (Worsham, 1999)

Edwarr Remind (2008) described Incentive Piecework Standards. "An incentive is intended to motivate a person or people to put forth increased effort. Incentive systems are plans that link employee compensation to some measure of company success. Wage incentive plans throughout the United States are varied. Some plans endeavor to link compensation to the company's performance history, others to department or unit performance, and others to individual or team success. However, the majority of wage incentive plans are linked to individual achievement. Incentive plans tie the compensation of the individual workers directly with the work that is done. Simply stated if a worker on incentive produces over the required standard they earn a bonus over their base rate. There are two basic types of incentive plans: Individual Incentive Plans and Group Incentive Plans." (Remind, 2008)

Peter P. Feng (2004) indicated that paper presents a proof of concept that standard work procedures as prescribed by lean theory can be implemented within a concrete construction company. "Standard work procedures and knowledge transfer utilizing the "J" programs as prescribed by Training within Industry and lean theory can and does reduce variability in construction processes. Variability in work processes increases the probability of breakdowns (any deviation from an expected outcome), errors and negative iteration which leads to schedule and cost overruns. Standardizing work methods reduces the probability of breakdowns, thereby improving work flow, providing a basis for learning from what breakdowns do occur, and providing a basis for experimentation with alternative work method designs." (Feng, 2004)

"Exploratory research with work standardization in a concrete construction divisionis presented, including the cultural and organizational issues that were overcome to change the current paradigm. Two findings from this research are: 1) obtained a better understanding of what standard work procedures are and how they differ from preconceived notions, and 2) development of standard work procedures to create a baseline for continuous improvement. Practitioners can use this research to understand how to analyze processes, improve them and transfer critical knowledge." (Feng, 2004)

Damrong Thawesaengskulthai (2009) classified the risk evaluated level in 'Quality Management & Technology Module Notes of and Risk Management' those levels were divided into 5 levels as follow Table 2.5

Table 2.5: The Comparison of Risk Level

Likelihood	Consequences				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Almost Certain 5	Medium 5	High 10	High 15	Emergency 20	Emergency 25
Likely 4	Medium 4	Medium 8	High 12	Emergency 16	Emergency 20
Moderate 3	Low 3	Medium 6	Medium 9	High 12	High 15
Unlikely 2	Low 2	Medium 4	Medium 6	Medium 8	High 10
Rare 1	Low 1	Low 2	Low 3	Medium 4	Medium 5

Note: E (Emergency Risk) means the risks that need to manage as soon as possible

H (High Risk) means the risks need to closely monitor

M (Moderate Risk) means the risk that need to manage

L (Low Risk) means the risk that not plays significant impact

Source: Damrong Thawesaengsakulthai (2009): "Quality Management Technique", University of Warwick a Chulalongkorn University

Chapter III

Existing Operation

In this chapter, the background of company, policy, organisation structure, roll of responsibility, and overview of manufacturing process have been described. Next, the specific processes for motorcycle parts have been summarized, as the research of operational risk management has been conducted on manufacturing process for motorcycle parts.

3.1 Background of Company

The company is located on 14,400 Square Metre at Pathumthani province. Nowadays, there are 400 employees who working in 7 department, production department, human resource department, quality control department, accounting department, purchasing department, marketing department, and maintenance department.

The main products of company can be divided into 3 groups as below:

1. Motorcycle parts, those included transmission gear, mile gear, collar, spur gear, engine gear, and chain gear.

2. Agriculture mechanical system, that is, the bevel gear for corn rolling machine.

3. Part for speed boat, there is the gear of speed boat engine and engine gear.

3.2 Policy

To build up customers' satisfaction by improving quality and service continuously

3.3 Organisation Structure

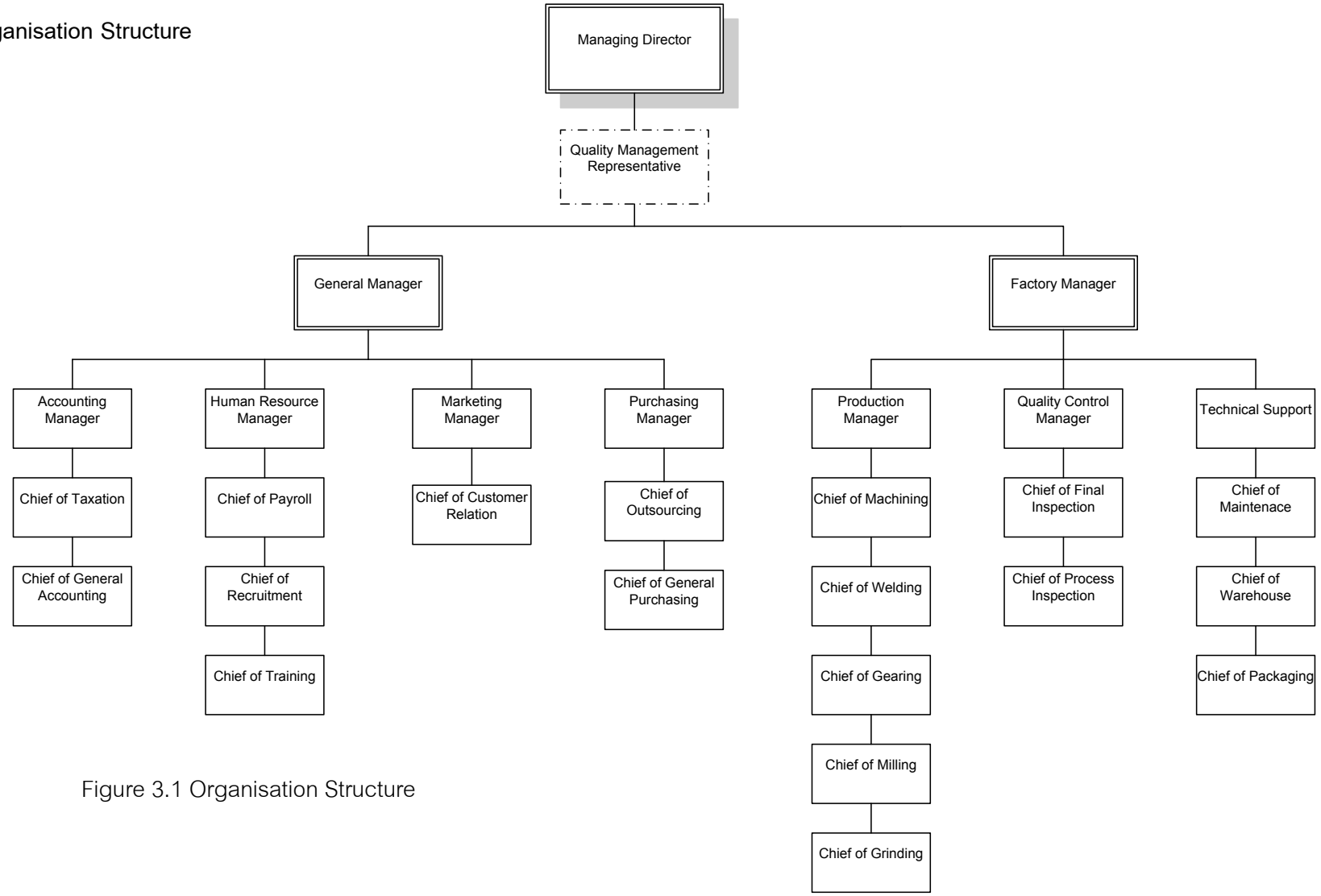


Figure 3.1 Organisation Structure

3.4 Roll of responsibility

Related to this case study, there are several sectors that this dissertation will get involve. Each roll performs on each responsibility as below:

1. Managing Director

A managing director who is the head of an entire company has to take responsibility for establishing and implementing a company policies and business plan. About enterprise risk management, he has to consider the entity's risk appetite in evaluating strategic alternatives, and manage risk to be within its risk appetite.

A managing director is the chosen person from member of senior management with the basis of experience and qualifications. Above of keeping a company on the right track, he will handling specific issues and managing people and make a decisions to promote expansion innovation within the industry, invest in new machines, keep a company solvent.

2. Quality management Representative (QMR)

Quality management representative (QMR) is the person who the board of member selects one from those managers. He has the authority of enabling the proper functioning of the quality management to meet company's target. The duties of QMR have 4 stages. First, he will establish, and implemented, the quality management system. Second, he has to maintain the system and ensure that those systems are consistency. Third, he will keep monitoring and reporting the performance of the quality management system to top management and, adjust the way of the improvement. Lastly, he is in charge of ensuring the promotion of awareness of customer requirements throughout the company.

3. General Manager

As the one of the top management of a company, a general manager has overall responsibilities for a company through subordinate manager. Following the overall

strategic planning and direction of the company, he is primarily responsible for guiding employees in achieving the goals. All processes should been ensured that those practices are working in appropriate method.

One of his important duties is to communicate with customers and attracting new projects to the company. And when the new project is execution and finalization, he needs to ensure that every individual department is able to perform their best possible outputs, and recommending. Other communication is to conduct the any specific goals, which are to be accomplished within a certain time period, to these operators who work under the chief of department, also to present the marketing, and advertising strategies, and all other necessary aspects of the company processes to the higher management.

4. Factory Manager

The factory manager is the person who manages the whole production line. Those responsibilities are production meetings, machine maintaining schedules, worker schedules, and monitoring on that the receiving and shipping schedules are followed accurately. Another main role is to ensure that quality control issues of the production are carried out as the customers' requirement and cooperate with subordinate manager to find out the cause of NG products and make sure that quality's problem will not repeat.

For supporting of the risk management, he takes responsibility to manage risks within risk tolerances by selecting risk responses – avoiding, accepting, reducing, or sharing risks. Another dimension of the factory manager job description is to set up the scheduled corporate meetings and training, conduct performance reviews of employees and to ensure that the safety rules have been followed by the workers. During the manufacturing of any product, a factory manger has to cooperate and meet with other managers of all the departments to ensure that there is no communication gap among the teams. The production manager appoints teams to analyze the quality of the products so that in the quest to reach targets, quality of the product doesn't deteriorate.

5. Accounting Manager

Relating to financial reporting, accounting manager is responsible for ensuring accurate and timely financial statements. The accounting manager obtains and maintains a thorough understanding of general ledger preparation, financial reporting, year-end audit preparation and the support of budget and forecast activities.Another direction is to monitors and advice other accountants' staff to work to develop more efficient procedures and handle of non-routine reporting transactions. Also, the Accounting Manager is associated with other segment including senior-level Attorneys and the firm's Executive Director, and Controller to ensure a clean and timely year-end audit.

6. Human Resource Manager

The responsibilities of human resource manager are hiring people, employee retention, identification the talent of each employee, utilize their talents, and position the employee best suited for a particular role. First, HR has duty to recruiting efficient employees who are able to deliver their abilities to the company. Second, hiring employees which search every individual who has, educational background, and skills can perform their unique talent to company. Third, training & developing employees: the training course has been set for both of the new employees and the old employees to improve their compatibility. Forth, HR manager has the main role to evaluate performances of the employees by collecting the record and comparing to the key performance indicators set for each employee and assess them accordingly. Then, the appropriate wages and bonuses should be rated base on the performance appraisals.

7. Marketing Manager

An account manager is the person who manages and maintains the good relationship with the customer, as well as developing the new contact for the new customer. Throughout the various stages of the purchasing process, the process of communicating with customers is important for marketing manager to deliver and

manage the expectations of customers with a positive service experience. This is accomplished by listening to each client in order to gain an understanding of their individualized needs, in order to direct them to the appropriate product or service.

8. Purchasing Manager

Those responsibilities of purchasing manager is approving the purchase process of raw material, equipment, and products that were required by company, then the purchasing department has to keep reviewing quality of raw materials, components, equipment and monitoring quantity and timing of deliveries. Also, purchasing manager has the duty to plan on inventory system to checks the available products in the inventory and deals in the procedures of product's replacement from the supplier. Moreover, a Purchasing Manager's responsibilities are including determining the reliable suppliers to provide quality goods at reasonable prices and communication with the suppliers to negotiating for the process to cost down.

9. Production Manager

The production manager has the key role to control the all the stages of production process. Related to the management, planning. The production manage have to ensure that the supply of raw materials are met in time, also, the quality of the products and productivity of the firm can meet the targets.

Production managers can decide on some issues before sending solutions to factory manager for approval. Those issues are managing the budget, human resources, material resources, machines' investment, and the purchase of the equipment, in case some equipment needs to be replaced.

10. Quality Control Manager

To ensure the quality of products, the quality control managers will manage on the inspection process. By performing tests to evaluate their quality, the research and analysis are conducted to make sure that those products that are produced by operators and machines have the highest quality. The inspection processes are taken

from material receiving, during production, until production has been completed right before the product is shipped to the customer.

During the inspection's stage, the quality control manager will monitor on the working method of those operators to ensure that their way of inspection are correct following the procedures and company safety rules. Normally, most of inspection's methods are involve a visual inspection, comparing products to customer specification. The manager is responsible to check on overall process. In case, there are high number of products that are not met standards, meeting with other managers will be set to report on the problems, so that the other management staff can redirect the efforts of workers. Then, the brainstorming and figure out the cause and plans to improve performance, production, or they turn to other management staff to aid in changing production techniques.

3.5 Overview of the manufacturing process

This sector is to describe overall of manufacturing process under responsibility of production department. Those include Material Preparation, Machining, Gearing, and Grinding's sector as details below:

3.5.1 Material receiving and preparation

This process can be categorized into 2 segments. Both segments are under control of the chief of inventory department. First, all of raw materials are delivered by suppliers to the warehouse. Another, the material preparation is to reform those materials into the designed shape, then send to next process.

1. **Material receiving**

   The warehouse's staff begins to check at amount of round steels that are sent by suppliers, comparing to purchasing documents. Next, some of steels are randomly passed to inspect material's specification and packaging.

2. **Material preparation**

   Normally, most of materials are passed from inspection segment to storage. Before storing, the initial raw materials are cut to smaller bar of steels and place them on shelves, separating by grade and size. Once the production's schedule issued to the inventory staffs, they will release the bar of steels on shelves to production line. And, they have recorded remained stocks, receiving's date, amount of new arrival, and outgoing.

3.5.2 Lathing

In the lathing process, all bar steels are fed into lathe machines under different cutting speeds and cycle times. Each machine will automatically run base on CNC programs which have been initially installed together with tool setup, following specific condition in the operation standard sheet. While, the parts that are finished from lathe process continuously drop from the other side into containers or conveyor belts. Then, the operators collect finishing parts, measure, record into check sheet, and place finished part into containers. They also keep recording the tool using per amount of works, lot s' control card, and machine status.

3.5.3 Milling

From lathing process, some kinds of work that requires uneven surface form are sent to operate in the milling process. In this process, each piece of work is manually loaded into machine by operator. Depending on the geometry and type of work, it is required different shape of cutting tool and individual fixture. Following method in the operation standard sheet, the operator will setup the part on fixture and run the machine with specific condition, also measure and record amount of works in check sheet.

3.5.4 Gearing

Gearing is the most critical process to create the shape of tooth by removing part of steel until the outside area to become gear shape. Also this process has many

controlling points that have to carefully measure. Since the finished gears relate to the product's durability, smooth usage, and noise controlling.

In this department, there are 2 types of machine that can produce the similar output. Those manual and CNC machine have different functionality and method of work. On manual machine's controlling, the operators are required high skill and well experience than CNC which require only human for feeding function. Both manual and CNC are begun with that operator set the piece work into fixture. Then, they have to carefully install cutting tool on machine arbour which require the precision of each position. Then, the operator will run the CNC machine following the programs that were initially set by the chief of department. In manual machine case, the operator will control all parameters and the movement of machine by themselves following the work instruction.

3.5.5 Welding

In this process, 2 parts are assembled by pressing machine, and then passed to welding process. The operator will place welding head on the area between 2 edges and drag it until both are attach together. Finally, the toughness test is randomly measured and record by the supervisor.

3.5.6 Grinding

This process is to control the surface's roughness that defines in the drawing. This department consists of 5 types of machine. Those are as below:

- Internal grinding is to control the roughness in internal area such as drilling and grooving area.
- External grinding is to control the roughness on external area as a circular outside.
- Centre-less grinding have functionalities to grind outside piece of work with 2 grinding wheel works together and no need to set up the work on fixture.
- Surface grinding is the type of grinding machine that able to grind on surface of work with high amount in the same time.

- CNC grinding is all functions run together within one machine by program that work set initially.

3.5.7 Final inspection

After grinding process finished, all parts will be inspected the quality as the specification. This step is to ensure the motorcycle part quality before delivering to customers.

3.6 Group of product and current control

This research focuses on the operation of motorcycle's part manufacturing which can be categorized into 4 groups of motorcycle's part as following:

3.6.1 Chain Gear

This kind of gear can be called as Sprocket Cam Chain which is a gear that has teeth's parts fitted onto a continuous chain and used especially for supporting the steel chain to drive motorcycle's wheels. To produce Sprocket Cam Chain, there are 6 processes as following:

1) Raw material receiving and preparation

After all of round steels have been shipped by supplier, the warehouse's staffs will select only specific steels' grade and size. In this gear's type, only diameter between 25-30 mm. and SCM steel are randomly passed to inspect specifications. Then, those steels are cut from initial length of 6,000 mm. into 600 mm. and released to lathing process as amount indicated on production's schedule.

2) Lathing

To creating round shape and specific diameter, the lot of steels that prepared from previous process is sent into the lathing process. Those bar steels as 600 mm. are fed into lathe machines to remove outside circular's part, drill to the hole, and cut into each unit. While the program have been initially installed with medium cutting speeds

the machine is continuously operate stable, the operators have responsible to collect finishing parts, measure, stop machine to change the cutter, and place finished part into containers. They also keep recording the tool using per amount of works, lot s' control card, machine status.

3) Gearing

This type of gear is produced by manual machine which requiring high skill and well experience operator to set the even circular part into fixture. On setting up to the fixture process, all parameters of setting point have to be carefully control less than 5-10 microns. Then, the installing cutting tool on machine's arbour are necessarily required the precision of each axis. Then, the operator will control the movement of machine following the work instruction, until the outside area is removed and the part becomes gear shape.

At the first setup after cutter changing, the first finished gear that come out from machine has to be inspected the profile of tooth shape and leading's measurement. If the test result is under controllable, the process will be run continuously. On the other hand, the process of gear cutting has to be stopped, in case of any error occurring on the tooth profile, and leading data. Next, the finish gear are sent to hardening process which under responsibility by supplier.

4) Grinding

After, the part became gear shape and was hardened from previous process. This process is to control the surface's roughness under Class C in JIS standard. By, using internal grinding machine, this process is to control the roughness of the centre hole after drilling. And, external grinding is to control the roughness on external area as a circular outside. ,

5) Milling

From previous grinding process, those gears are passed to this process for milling the groove on surface. The groove function is required for oil flowing for keeping the cool and lubricating when the gear rotating. The 3 mm. of ball Endmill will be installed during part's setup on fixture, then run the machine with specific condition on method in the operation standard sheet.

6) Final inspection

To ensure the motorcycle part quality before passing to wrap the packaging, all sprocket gears will be measured the inside and outside diameter by micrometer. Also, the operators have checked on the run out by using the Dial Gauge for external circular and Borer Gauge for internal cylinder.

3.6.2 Collar

Collar is a strip of round steel that put to join two parts together and to strengthen those parts. The process to produce the collar is common than other processes, but the controlling parameters is the most complicated detail. Those 4 processes are as following:

1) Raw material receiving and preparation

After the hollow round steels have been received from supplier, then the warehouse's staffs will select only those steels that have good conditions and no error of bending. In this case, the outside diameter of steel is between 18-25 mm', and the steel is SCM grade. Then, those steels are cut from initial length of 6,000 mm. into 1,200 mm. and released to lathing process as amount indicated on production's schedule.

2) Lathing

The parameter of machine and part's installation is the most critical in this process since the thickness of collars is only 5 mm, therefore the capturing into fixture is very delicate process and likely to deform the shape of steel. Therefore, only well trained operators are in charge on this production. To create round shape and specific

diameter, those bar steels as 1,200 mm. are fed into lathe machines to remove outside circular's part, internal grooving, internal boring and cut into each unit. While the program have been initially installed with low cutting speeds the machine is continuously operate stable, the operators have responsible to collect finishing parts, measure, stop machine to change the cutter, and place finished parts into containers. Then, all finished parts are sent to supplier for hardening.

3) Grinding

After, collar parts have the specific size, and are hardened. This process is to control the surface's roughness under the determined data in drawing. By, using internal grinding machine, this process is to control the roughness of the centre hole after drilling. And, external grinding is to control the roughness on external area as a circular outside. Also, the surface grinding machines are used to control the roughness on surface. ,

4) Final inspection

All collar will be carefully measured the inside diameter by air gauge since air gauge can display more precision results. Also, the operators have checked on the run out by using the Dial Gauge for external circular and Borer Gauge for internal cylinder and internal grooving trace, before passing to wrap the packaging,

3.6.3 Mileometer Gear

This kind of gear is one of element of mileometer which is a device to measures and shows the distance in a motorcycle. Most of Mileometer gears under production of company are the type of Pinion which has small size. To make pinion, those consists of 3 processes are as following:

1) Raw material receiving and preparation

In this part, the company has ordered the finishing lathed parts from supplier. This process needs to emphasise on the quality of lathed parts. Begin with, the

warehouse staffs check at appearance and amount of lathed parts and compare to purchasing documents. For the specification's checking, it has been passed to quality controlling staff for inspecting to outside diameter and run-out circular. The diameters of gear are between 10-15 mm and the circular run out should not over than 50 microns. After the lathed parts were checked, only good condition's parts have been sent to store on shelve. Then, the warehouse's staffs will select only the specific model that indicated on production's schedule, and released to gearing process for cutting tooth shape.

2) Gearing

Those lathed parts are passed to gearing process to cut the gear shape by manual machine which require angle of cutter setting. To make the angular of gear's tooth, the operator will carefully set the arbour of cutter against the piece of work as the specific radian indicated in drawing. Besides, a piece of work is set on the fixture one by one which have to be clean, no chip or dust inside to fixture. The piece of work inside fixture should be controlled the precision between than 50-70 microns. Then, the operator will control the movement of machine following the work instruction, until the outside area is removed and the part becomes gear shape.

3) Final inspection

All pinion gears have been sent to final inspection the tooth profile, leading data, inside and outside diameter by micrometer. Also, the operators have checked on the run out by using the Dial Gauge for external circular and Borer Gauge for internal cylinder. Next, the lot of finished gears are sent to wrap at the packaging process, then delivery to customers.

3.6.4 Transmission gear

The gear is placed in the engine of motorcycle for transmission the power to the wheels of a vehicle. To produce transmission gear, there are 5 processes as following:

1) Raw material receiving and preparation

The diameters of round steel for transmission gear are between 25-35 mm, and the grade is S50C. Those steel are randomly passed to inspect specifications. Before releasing to lathing process, the long steel bars are cut from 6,000 mm. into 400 mm. Then, the amount of smaller unit is recorded base on grade and size.

2) Lathing

.As the productions' schedule, the lot of 400 mm. of steels that are automatically fed into lathe machines to remove outside circular's part, drill to the hole, and cut into parts. Also the grooves of oil flowing are made at this process. In this case the process of drilling is necessary to optimise the parameter of cutting condition and the tool's alignment because of the limited of tolerance of drilling line. Also, to create good condition of surface tool's life of drill have to be strictly controlled. While the machine is continuously processing, the operators have responsible to collect finishing parts, measure, stop machine to change the cutter, and place finished part into containers. They also keep recording the tool using per amount of works, lot s' control card, machine status.

3) Gearing

In this process, the operators have set the row of parts into fixture. The maximum pieces in 1 row depend on the depth of work, but shouldn't over than 10 pieces Therefore, to set the alignment of row of parts, each part is placed into the shaft which have to be precision. The condition shaft has to be complete which the circular run-out is less than 5-10 microns, and no bending of any axis. Also, the installation of cutting tool on machine's arbour is required less than 15 microns of circular run-out.

This type of part is operated in CNC gearing machine, therefore the operator will control the program of the movement of machine following the work instruction, and keep checking first lot of gear sending to the inspection lab specific for the profile of tooth shape and leading's measurement. The parameter of gear lot is the main factor to

control the next lot until the cutter will be change. After that, all lot of gear will be sent to the supplier for hardening.

4) Grinding

After, all gears were sent back from hardening from previous process. Each gear has to be fixed into outer fixture. Then, the grinding wheel has been used to external grinding. This process is to control the roughness of outside surface which is the area between teeth layer. Also, the surface grinding is used to control the roughness on upper area as the Class b in JIS standard.

5) Final inspection

All finish gear from grinding process have been passed to ensure the quality, as indicating in the inspection standard, the inside and outside diameter are measure by micrometer. For, the roughness surface, it was visual inspected. In this case, the quality roughness depends on individual judgement of each person. Therefore, the quality control's staffs who have worked for this section have to be well trained and high skill. . Also, the operators have checked on run out by using the Dial Gauge for external circular and Borer Gauge for internal cylinder.

Chapter IV

Data Collection

In this chapter, all risks and impact have been described, based on interviewing to employees from 13 difference departments as previously mentioned in chapter 3.

4.1 Establish the Scope

In chapter 3, the overall of manufacturing process has been described. Those are material preparation, machining, gearing and grinding process. The current control of those 4 processes still produce high amount of defects. Consequently, numbers of total defects are over company's target. Therefore, it is imperative to identify and eliminate those risks that occur in process in order to reduce the amount of defects in production line.

The risk identification has been allocated into four types: Strategic Risk, Operational Risk, Financial Risk, and Hazard Risk. Related to amount of defects in manufacturing process, only operation risks have been focused for defining the cause of risks and eliminate major risks that impact to manufacturing process.

The next step is to analyze root cause of operational risks. Therefore, the root causes of major risk event have been introduced in ABC Company. The potential cause analytical system enables the organization to execute the Risk Reduction and assign who should be responsible for setting strategy for management of related of group of risks. Those 4 groups of risk can be classified into factor of human, machine, material, and method. This topic has been explained in next chapter 5.

4.2 Historical data collection in manufacturing process of company

The historical data of this research has been collected since May, 1st to May, 31st of 2011. This data show amount of actual defects' average compared to the target that was set by ABC Company. This research has been selected 20 types of steel products that have been ordered by customer more than 10,000 pieces per month and covers 80 percent of total amount of all products. The data show as next table 4.1:

No.	Part Number	Part Name	Average Target	Avg. Actual	Different Percentage
1.	5YP-E1549	SprocketCamChain A	Below 9.00	9.50 %	Over 0.5%
2.	5VV-E5630	SprocketCamChain B	Below 9.00	9.99%	Over0.99%
3.	12731H00	SprocketCamChain C	Below 9.00	7.20%	
4.	33S-E1549	SprocketCamChain D	Below 9.00	9.50%	Over0.50%
5.	1B9-E1549	SprocketCamChain E	Below 9.00	8.00%	
6.	52B-E1549	SprocketCamChain F	Below 9.00	6.40%	
7.	5P0-E1549	SprocketCamChain G	Below 9.00	7.82%	
8.	5TN-E1549	SprocketCamChain H	Below 9.00	9.94%	Over0.94%
9.	20811-00	Collar A	Below 10.00	10.00%	
10.	22801-00	Collar B	Below 10.00	10.00%	
11.	15818-00	Collar C	Below 10.00	10.00%	
12.	15817-00	Collar D	Below 10.00	10.50%	Over0.50%
13.	33S-7645	Collar E	Below 10.00	6.53%	
14.	54621-07	Pinion SPDOM 8T	Below 5.00	5.00%	
15.	54621-45	Pinion SPDOM 9T	Below 5.00	6.00%	Over1.00%
16.	54621-13	Pinion SPDOM 10T-13	Below 5.00	7.00%	Over2.00%
17.	54621-23	Pinion SPDOM 10T-23	Below 5.00	4.50%	
18.	54611-07	Pinion SPDOM 19T	Below 5.00	5.50%	Over0.50%
19.	54611-13	Pinion SPDOM 23T	Below 5.00	2.00%	
20.	54611-23	Pinion SPDOM 26T	Below 5.00	2.50%	

Table 4.1 Historical data comparing between the actual defects and average target

From Table 4.1, the historical data has been showed that the averages of actual defects are over than the goal that set up by ABC Company in order to keep amount of defects lower than the target. Only 12 from 20 parts could meet the goal while 8 parts had over amount of defects. That means 40 % of total parts have highly amount of

defects over the target and have directly an impact on the organization's target. This research have been conducted the Operational Risk Management to identify all risks that impact to manufacturing process, and implement method to manage on those risks in order to reduce number of defects that occur in company.

4.3 The defects from each process

Those critical four manufacturing processes which most of products have been passed thorough are involved in Risk Ranking. Based on the score of Likelihood and Consequence that based on the criteria that were given as the table 5.1: consequences ranking, and table 5.2: likelihood ranking, those risks in four processes are generated into risk score and discussed in the next session.

Related to the mentioned processes which can produce 3 groups of product, Sprocket Cam Chain, Collar, and Speedometer Gear, any risks that may cause defects in processes have been detected and figured out the way to manage those risks as in next chapter 5 and chapter 6.

Each type of defect of 8 products from 4 main processes is classified into quantitative analysis as next table 4.2 to table 4.4

4.3.1 Raw Material Preparation Process

The Raw Material preparation is one of main process. Through this process, all steel parts have been collected, cut, and distributed. It was found that there are 10 types of raw materials have similar appearance, size and shade. Moreover, the low quality of original material that had been delivered by supplier has an effected on the quality of final products. Also, the mistake of distribution's system can lead to wrong product's specification. The summary of total defect within the raw material preparation process is as next table 4.2:

Table 4.2 Total defects in Raw Material Preparation process of May 2011

Part Number	Part Name	Type of Defects	Number of defects
15817-00	Collar D	Wrong steel's grade	534
		Distorted surface	347
15818-00	Collar C	Wrong steel's grade	1,200
54621-45	Pinion SPDOM 9T	Wrong steel's grade	353
54621-13	Pinion SPDOM 10T-23	Wrong steel's grade	489
		Total defects	**2,923**

From data above, total defects in material preparation process is 2,923 pieces. As 2,576 are defects from wrong steel grade since the Collar D and Collar C have been used the steel which has similar appearance but different grade, as same as the case of Pinion SPDOM 9T and Pinion SPDOM 10T-13 which use similar size of steel bar but different steel's composite. Another, 347 defects are from distorted defects inside steel bars which were found after cutting that many dimples were inside the material.

4.3.2 Machining Process

The Machining process is the second process after Raw Material preparation. All products have been sent to this process in order to cut and transform into the shape as customer's request. The quality of diameter is relate to each machine condition and controlled parameters. Unstable function and incomplete tool installation can make to work shape become error shape. In addition, the working method to collect to finish parts is ate essential step to remain quality of product. However there are some defects occur because of over control system as a summary of total defect within the machining process is as next table 4.3:

Table 4.3 Total defects in Machining Process of May 2011

Part Number	Part Name	Type of Defects	Number of defects
5YP-E1549	SprocketCamChain A	Over diameter	837
		Scratch and distorted surface	570
		Shape error	97
		Lower diameter	45
5VV-E5630	SprocketCamChain B	Perpendicular error	70
		Scratch and distorted surface	45
		Over diameter	34
		Lower diameter	25
33S-E1549	SprocketCamChain D	Perpendicular error	519
		Over diameter	139
		Scratch and distorted surface	113
		Lower diameter	37

Table 4.3 Total defects in Machining Process of May 2011 (Cont')

Part Number	Part Name	Type of Defects	Number of defects
5TN-E1549	SprocketCamChain H	Burr and chip	397
		Scratch and distorted surface	92
		Perpendicular error	73
		Over diameter	6
		Lower diameter	4
15817-00	Collar D	Over diameter	46
		Perpendicular error	36
		Scratch and distorted surface	21
		Lower diameter	6
54621-45	Pinion SPDOM 9T	Burr and chip	1,579
		Scratch and distorted surface	300
54621-13	Pinion SPDOM 10T-13	Over diameter	3,057
		Scratch and distorted surface	100
		Burr and chip	1
54611-07	Pinion SPDOM 19T	Scratch and distorted surface	1,533
		Over diameter	578
		Lower diameter	203
		Parallelism failure	10
		Total defects	**10,573**

From table 4.3 above, total defects in machining process is 10,573 pieces. This process has produced the highest defects since all type of products have been fed into the process. Also there are high varieties of products model which need high number of operators to run process.

4.3.3 Gearing Process

After products were reformed into the circular, some products have been passed to Gearing Process for cutting to gear tooth. Most of defects from gears are associated with the quality of tooth shape. Those defects are Incorrect Size of Tooth Span, Pitch run out error, and Deviate tooth profile, because of some factors of installed procedure. Another defect is about the roughness which needs to use special tool to inspect the surface of tooth. The summary of total defect within the gearing process is as next table 4.4:

Table 4.4 Total defects in Gearing Process of May 2011

Part Number	Part Name	Type of Defects	Total of defects
5YP-E1549	SprocketCamChain A	Tooth roughness error	459
		Incorrect size of tooth span	261
5VV-E5630	SprocketCamChain B	Pitch run out error	5
		Deviate tooth profile	2
33S-E1549	SprocketCamChain D	Deviate tooth profile	163
		Pitch run out error	22
5TN-E1549	SprocketCamChain H	Deviate tooth profile	102
		Pitch run out error	18
54621-45	Pinion SPDOM 9T	Tooth roughness error	1,657
		Incorrect size of tooth span	626
54621-13	Pinion SPDOM 10T-13	Tooth roughness error	1,322
		Incorrect size of tooth span	618
		Total defects	**5,255**

From table 4.4, the total defects are 5,255 pieces which cannot send back to rework, On the other hand, those defects have to be sent to elimination since most of misshape gear cannot modify the shape.

4.3.4 Grinding Process

One of main process for smoothening the surface to be under the range of customers' requirement, There are 3 types of defect that have occurred in this grinding process. First is the internal roughness error which is about roughness problem of inside diameter. Second, there is the defect from rusty and decay on the surface. Third, it is the error of circular run out which came from inaccuracy of grinding procedure. The summary of total defect within the Grinding process is as table 4.5 below:

Table 4.5 Total defects in Grinding Process of May 2011

Part Number	Part Name	Type of Defects	Total of defects
5YP-E1549	SprocketCamChain A	Internal roughness error	75
		Rusty and decay surface	1
5VV-E5630	SprocketCamChain B	Internal roughness error	116
		Deviate circular run out	70
33S-E1549	SprocketCamChain D	Internal roughness error	116
5TN-E1549	SprocketCamChain H	Internal roughness error	25
15817-00	Collar D	Deviate circular run out	1,286
		Internal roughness error	322
54621-45	Pinion SPDOM 9T	Internal roughness error	251
		Rusty and decay surface	263
54621-13	Pinion SPDOM 10T-13	Internal roughness error	172
		Rusty and decay surface	164
54611-07	Pinion SPDOM 19T	Deviate circular run out	1,956
		Rusty and decay surface	77
		Internal roughness error	1,432
		Total defects	**6,326**

Total of defects from above table are 6,326 that can be clearly classified into 3 type of defect as above mentioning.

Therefore, the next step is to arrange those defects from high to low number, then selects group of important defects and identify the risks that are the initial uncertain events of those important detects, as next table 4.5:

4.4 Summary of defect within process

The calculated percentages of each defect are summarised as table 4.6 below:

Table 4.6 Summary of defect

Process	Type of defect	Amount of defect	Percentage
Material preparation	Wrong type of steel	2,576	10.27%
	Distorted surface	347	1.38%
Machining	Over diameter	4,697	18.73%
	Scratch& distorted surface	2,774	11.06%
	Chips and Burrs	1,977	7.88%
	Perpendicular error	698	2.78%
	Lower diameter	320	1.28%
	Shape error	97	0.39%
	Parallelism failure	10	0.04%
Gearing	Tooth Roughness error	3,438	13.72%
	Incorrect size of tooth span	1,505	6.00%
	Deviate profile of tooth line	267	1.06%
	Pitch run out error	45	0.18%
Grinding	Deviate circular run out	3,312	13.22%
	Internal roughness error	2,509	10.00%
	Rusty and decay surface	505	2.01%
	Total defects	**25,077**	**100%**

From table 4.6, there are totally 25,077 pieces from 16 types of defect from 8 products. The process of machining produces defects up to 10,573 pieces of May 2011 which is the highest number and widest variety of problem. While, the process of Material Preparation have the fewest of defects' problems since the working procedure in this department is not complicated as other departments.

Those data from table 4.6 have been rearranged into to the chart to arrange the percentage of each defect from high to low. The figure 4.1 can be shown those 16 types of defect as below:

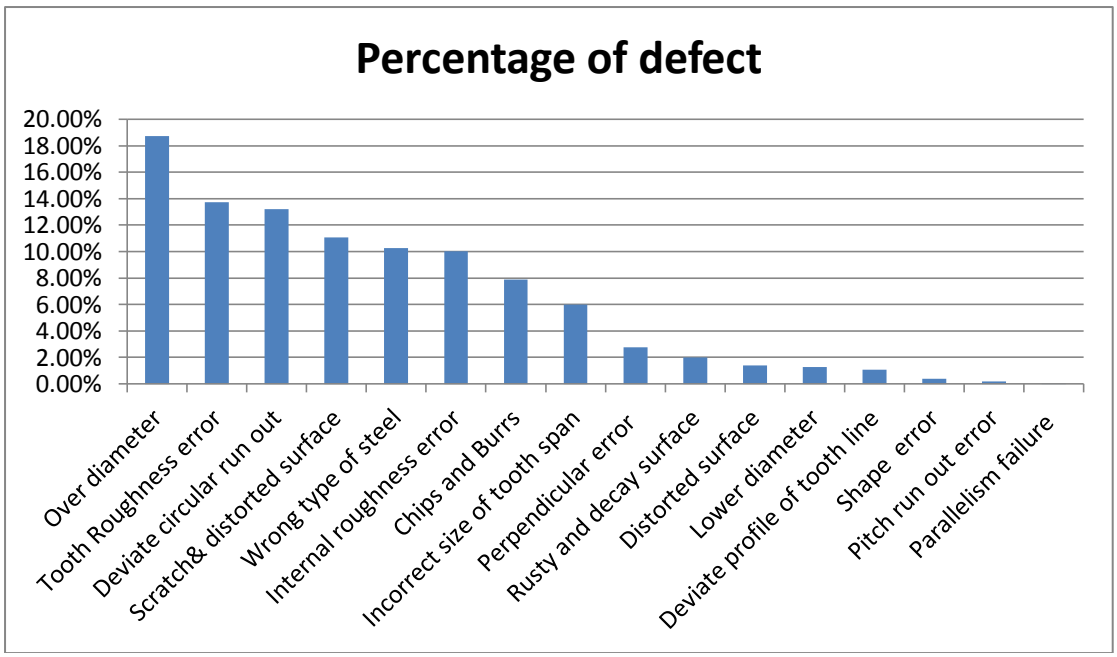


Figure 4.1 Percentage of defect

From figure 4.1, there are 5 highest defects. It can be referred that defects of over diameter have the highest number, followed by tooth roughness error, deviate circular run out, scratch & distorted surface, and wrong type of steel, respectively. In this research, those 13 from 16 defects which have percentage of defects over than 1 percent have been generated the cause and the risk which is the initial uncertain event

that may result in those 13 mentioned defects, previously. The stage of risk identification has been discussed in as next topic:

4.5 Risk Identification

After summary of actual defect has been described from high to low, this step is to identify those operational risks within manufacturing process. Then, those risks which impact to quality issue have been passed to next step that is figuring out the root cause of risks and the methods to manage those risks.

Once the scopes have been identified and the Risk Management team has been established, the questionnaires have been given to the member of Risk Management team to describe their own risks, including their problems. The Risk Identification is brainstormed by the team member who is full time staffs whom involve in each stage.

In this research, the risk management team have conducted risk management duties with the internal auditors as part of internal audit. During internal audit, the internal auditors and risk management team are responsible for determining and evaluating the risk events, establishing effective risk management, monitoring progress, and assisting other managers in reporting relevant risk and across the organisation. A detailed set of responsibilities have been ensured that the roles of risk management team and internal audit clearly defined and understood. The risk management team consists of the chief of each segment who a specific area of responsibility and chief assistant as following lists:

- Chief of Material Preparation Process: Expertise in material composition, and material preparation, training course in term of material management, internal audit, and well understanding in risk assessment.
- Assistant of Material Preparation Process: Responsibility for material preparation, training course of material preparation procedure, and well understanding in risk assessment.

- Chief of Machining Process: Expertise in machining process, training course in term of process control, internal audit, and well understanding in risk assessment.
- Assistant of Machining Process: Responsibility for machining process, training course in term of Part's cutting's parameter, and well understanding in risk assessment.
- Chief of Gearing Process: Specialist in Gearing process, training course in term of leading ship and Gear measurement, process control, internal audit, and well understanding in risk assessment
- Assistant of Gearing Process: Responsibilities including Gearing process, and well understanding in risk assessment.
- Chief of Grinding Process: Specialist in Grinding process, training course in term of Grinding inspection, process control, and well understanding in risk assessment.
- Assistant of Grinding Process: Responsibilities including Grinding process, internal audit and well understanding in risk assessment.

After the interviewing of those full time staffs, the occurring risk which against the company's objective have been generate within those 4 main processes. Based on type of defect and cause of defect, all risks have been identified are totally 29 operational risks. There are 5 risks within Material Preparation Process, 7 risks within Machining Process, 12 risks within Gearing Process, and 5 risks within Grinding Process. Risks' details are shown in table 4.7 to table 4.10:

Table 4.7: The Risk in Material Preparation Process

Process Name: Material Preparation Process			Receive by: Machining Sector		Approved date: 3/6/2011
Responsible Person: Chief of Warehouse's sector			Supplied by: Outsource		Page 1 of 7
No.	Type of Defect	Cause of Defect	Risk	Risk Impact	Risk Code
1.	Wrong material	The operator is not follow procedure of part's control.	Switching of parts during process	Switching of parts during process in case those are similar appearance	MP-01
		Unclear information on drawing	The risk of error of receiving customer's order	Unable to deliver exact product 's qualification	MP-02
		Operators' mistake	Using wrong grade of raw material	Finish goods are considered as NG products. If the parts are passed to customers, the company may lose reliability	MP-03
		Without authorisation, other type of raw material is fed by operators	The delay of raw material delivery	Other grade of raw material is used	MP-04
2.	Distorted material	Low quality of steel	Lower grade of steel grade is sent by supplier	Final products have some dimples on surface	MP-05

Table 4.8: The Risk in Machining Process

Process Name: Machining Process			Receive by: Gearing Sector		Approved date: 3/6/2011
Responsible Person: Chief of Machining sector			Supplied by: Material Preparation Process		Page 2 of 7
No.	Type of Defect	Cause of Defect	Risk	Risk Impact	Risk Code
3.	Over diameter	Unstable of feed and movement system	Machine error	Producing some errors on part	MC-01
		Wrong parameter of setting up	Working Standard is out of date in case of some detail are revised by Procedure Design Departments	The out of date standard may lead wrong work pieces' qualification	MC-02
4.	Lower diameter	The cutting edge are misshape	Malfunction of cutter condition	Worn out tool may cause rough surface of steels	MC-03
		Worn out of cutting's condition	The cost of tooling are increase	New tool were limited leading to overusing of old cutting tool	MC-04
		Tool's type is not suitable	Cutting tool are stolen	New tool were limited leading to overusing of old cutting tool	MC-05

Table 4.8: The Risk in Machining Process (Cont')

Process Name: Machining Process			Receive by: Gearing Sector		Approved date: 3/6/2011
Responsible Person: Chief of Machining sector			Supplied by: Material Preparation Process		Page 3 of 7
No.	Type of Defect	Cause of Defect	Risk	Risk Impact	Risk Code
5.	Perpendicular error	Error of the movement on Z-axis	CNC Program error	NG of inaccuracy circulation area	MC-06
6.	Scratched surface	Uncertain of injected direction	Part are scratch and collapse with machine's wall	Final products have surface problem which customer deny to receive those products	MC-07

Table 4.9: The Risk in Gearing Process

Process Name: Gearing Process			Receive by: Grinding Sector		Approved date: 3/6/2011
Responsible Person: Chief of Gearing sector			Supplied by: Machining Sector		Page 4 of 7
No.	Type of Defect	Cause of Defect	Risk	Risk Impact	Risk Code
7.	Tooth Roughness error	Cutter edges are dull	Hob Cutters are expired	Final gears have noise problem from inaccuracy of tooth roughness	GR-01
		Tooth if gear are clash each other	Gears are clashed	Shape of tooth are ruined	GR-02
		During cutting process, the inspection of tooth quality are skipped because of high amount of works	Customer increase product's precision higher than initial agreement	No competency to produce as customer's request	GR-03
8.	Burrs and chips	Too short of period to eliminate all of chips and burrs	Exhausted operators	High defects are sent to next stage	GR-04
		Brush procedure is inefficiency	The brushed wheel were worn out earlier than tool's life condition that	Unable to eliminate all burr and chips	GR-05

Table 4.9: The Risk in Gearing Process (Cont')

Process Name: Gearing Process			Receive by: Grinding Sector		Approved date: 3/6/2011
Responsible Person: Chief of Gearing sector			Supplied by: Machining Sector		Page 5 of 7
No.	Type of Defect	Cause of Defect	Risk	Risk Impact	Risk Code
		Urgent production without quality checking	Over customers' order than forecast	Products which still have chips and burr are sent to next stage.	GR-06
		There is no exact QC method. (depends on visual and individual judgement)	The company fail to develop the employee's skill to fulfil the required ability	Products which still have chips and burr are sent to next stage.	GR-07
9.	Incorrect size of tooth Span	Inaccuracy of equipments.	New equipment that's provided by supplier errors	Producing too high deviation number from standard	GR-08
		During installation, the tool is installed on wrong position.	Unable to capture new talent employees	No one has ability to complete complicated products	GR-09

Table 4.9: The Risk in Gearing Process (Cont')

Process Name: Gearing Process			Receive by: Grinding Sector		Approved date: 3/6/2011
Responsible Person: Chief of Gearing sector			Supplied by: Machining Sector		Page 6 of 7
No.	Type of Defect	Cause of Defect	Risk	Risk Impact	Risk Code
10.	Deviate profile of tooth line	Not enough precision's range of current machines	Customer want to reduce product's tolerance	No competency to produce as customer's request	GR-10
		Operator does not understand scaling procedures	The high skill operators resign	Lack of operators who run processes which requires well experience person	GR-11
		Over range of machine movement because of measurement scale is fade away	Machine's table movement are unstable	High defect of irregular profile shape	GR-12

Table 4.10: The Risk in Grinding Process

Process Name: Grinding Process		Receive by: Quality Control Sector		Approved date: 3/6/2011	
Responsible Person: Chief of Grinding sector		Supplied by: Gearing Sector		Page 7 of 7	
No.	Type of Defect	Cause of Defect	Risk	Risk Impact	Risk Code
11.	Internal roughness error	Operator works as wrong procedure	Unable to remain quality control when the operators were rotated	If the company lose the quality systems, this will directly impact of work quality	GD-01
12.	Deviate circular run out	Operators rotated themselves without permission / master plan	Those employees cannot develop their competency for implementing new technology	Misusing of new technology causes out NG products.	GD-02
		Machines were changed condition	No electricity supply	Inaccuracy of cutting reorder	GD-03
13.	Rusty and decay surface	Water drop into products	Leaking of Building	Products were directly ruined by rain and dust	GD-04
		Lid of packaging that sealed products are broken	Lubricant was polluted	Product's condition are change	GD-05

From table 4.6 to table 4.10, those 29 of operational risks have been collected. Therefore the company need to manage those risks since the risk is the original event that lead to the cause of defects and the high amount of defects have the impact to the quality target of ABC Company.

To reduce main 13 defects, all of 29 operational risks should have conducted to analyse and evaluate for figuring out the method to control those risks as next chapter 5.

Chapter V

Operation Risk Management Analysis and Evaluation

On chapter 4, all 29 operational risk events have been described. This chapter, the analysis process has been arranged to rate risks' score into 4 levels. Then, those risks which have evaluated as high and emergency risk are considered as Major Risk Events.

5.1 The Process of Conducting the Risk Analysis

After, average of actual defect has been described in term of comparing to company's target, and those operational risks within manufacturing process have been identified.

This process has considered on how often of likelihood and how severe of consequences. Those level of likelihood and consequences have modified from Quality Management and Technique and brainstormed by the full time staffs who have well background of ORM each during the internal audit at ABC Company,

Those consequences and likelihood were classified into 5 criteria and difference 5 levels. The levels of score are represented the impact and possibility of events. All risk has been filled in questionnaire form and the score of likelihood and consequence have been rated by following the evaluation criteria as next table 5.1: Consequences Ranking and table 5.2: Likelihood Ranking:

Table 5.1: Consequences Ranking

Probability	Criteria	Score
Insignificant	Very Slightly effect on product quality or none of defects occur.	1
Minor	Minor effect on product quality, a few defects come out but less than 1 % of whole batch since minor defect will possibly not notice to customers	2
Moderate	Moderate effect on product quality. Some defects occur in process more than 1%, but less than the maximum limit of company. Amount of defect that more than 1% of batch will make the safety stock of good products become lower than the level that was set by customers. And, this situation must be reported to customer by rule.	3
Major	Extreme effect of quality of product which the product cannot achieve the specification, defects occur more than the limit (5% of whole batch). Leading to insufficient product and unable to deliver to customer, this level will cause high dissatisfaction from customer.	4
Catastrophic	Potential hazardous effect and able to stop production line; safety-related; highly defects; delivery failure. Disruption to subsequent process operations or non compliance with government regulation,	5

Source: established by ORM team within ABC Company

Table 5.2: Likelihood Ranking

Probability	Criteria	Score
Rare	Rare number of risk likely and occur in exceptional case. ABC Company has determined any risk event that occurs only one time in 3-5 years in group of rare case.	1
Unlikely	Very few of risk likely: the ORM team agree that risk which occurs once in 2 years is classified as unlikely case.	2
Possible	Moderate of likelihood: this ranking is to take into account some uncertainty events that ORM team has anticipated that it may happen 2 times per year.	3
Likely	Frequent number of risk likely: the team has predicted from history of occurrence at Company that some event will probably occur in most circumstances or occurring at less once in a month.	4
Almost Certain	The ORM team decided that repetitive occurrence occurs are the common or approaches to almost certain in everyday.	5

Source: established by ORM team within ABC Company

Base on the likelihood and consequence ranking as Table 5.1 and 5.2, the ORM team whom have been well trained were given questionnaire and interviewed for listing the risk event and weighting score of consequence and likelihood within their departments. During interviewing, the team might list their problems that have faced everyday then summarise those problem that were classified as a risk event into risks' lists. Next the score have been weight base on criteria above.

After that risk analysis has been developed to calculate the Risk Number. The Risk Number is the outcome of the likelihood (L), and consequences(C) ranking. The relationship is shown as below:

Risk Number = Likelihood (L) * Consequence (C)

The combination of consequences and likelihood are expressed in term of Risk Number. The Risk number is ranged between '1' and '25' which reflect the magnitude of a risk. The result of Risk Number is summarized as from table 5.4 to table 5.7: Risk Analysis.

The Risk Number is classified in 4 ranks. The score between '1' and '3' are defined as low risk level. The score between '4' and '9' are in the medium level. The score between '10' and '15' are classified as a high risk level. The score between '16' and '25' are emergency risk.

Concept of addressing the mitigation on the risk is that selecting the highest Risk Number first, Therefore, Emergency and High risk are made explicit and move on to Risk Reduction and Mitigation stage as in Chapter 6.

All risks have been calculated and matched into Risk Matrix which is shown as next Table 5.3: Risk Matrix:

Table 5.3: Risk Matrix

Likelihood	Consequences				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Almost Certain 5	Medium 5	High 10	High 15	Emergency 20	Emergency 25
Likely 4	Medium 4	Medium 8	High 12	Emergency 16	Emergency 20
Moderate 3	Low 3	Medium 6	Medium 9	High 12	High 15
Unlikely 2	Low 2	Medium 4	Medium 6	Medium 8	High 10
Rare 1	Low 1	Low 2	Low 3	Medium 4	Medium 5

Source: established by ORM team within ABC Company

5.2 Risk Analysis

According to risk identification have been discussed in chapter 4, the Risk Analysis have developed, based on the interviewing and scale weighting by the ORM team within ABC company.

Those risks that are classified as High and Emergency risks are represented the major impact and certain possibility to the quality issue. So, those risks have been sent to next step for figuring out the root cause and the final methods to manage them.

In order to find out High and Emergency Risk, Total 29 risks have been generated into the Risk analysis within 4 process, Material Preparation, Machining, Gearing, and Grinding Process as shown in Table 5.4 to Table 5.7:

Table 5.4: Risk Analysis in Material Preparation Process

Process Name: Material Preparation Process		Receive by: Machining Sector		Approved date: 10/6/2011		
Responsible Person: Chief of Warehouse's sector		Supplied by: Outsource		Page 1 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
MP-01	Switching of parts during process	There is insignificant impact on quality target because those mistaken parts can be modified to another type of part.	2	The likelihood of this risk is that there is a time per year of parts' switching between Collar 11 and Collar 18 with since both have similar outside diameter.	2	2x2=4 (Moderate)
MP-02	The risk of error of receiving customer's order	It's very extreme impact. The wrong specification that release to the production's line will lead the operator the misunderstanding and setup incorrect parameter. Then, all products will be considered as a big lot of NG.	5	There is few chance of this kind of risk since the approval has strictly reviewed. From customer forecast until final production plan, each procedure has to compare between the drawing and actual process, then it have to get authorise and sign by managers.	1	5x1=5 (Moderate)

Table 5.4: Risk Analysis in Material Preparation Process (Cont')

Process Name: Machining Process		Receive by: Gearing Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Machining sector		Supplied by: Material Preparation Process		Page 2 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
MP-03	Using wrong grade of raw material	It is classified as the serious effect on process. All products in a whole batch (10,000 pieces) cannot achieve the customers' specification. Unable to modify to be the correct one, all have to eliminate into garbage because of wrong composite steel.	5	The likelihood of this risk may have are 4-8 times of miss using those raw materials. Since it was found that the using SCM 45: diameter 35 mm and SCM 420: diameter 38 mm had been switch during replacing new material on empty shelf on February and May, 2010. Another is the mistaking of Pinion Speedometer: 9 teeth and 10 teeth which have similar size on March and August. On 2011, those events may happen again since amount of products are still same as year 2010	4	5 x 4 =20 (Emergency)

Table 5.4: Risk Analysis in Material Preparation Process (Cont')

Process Name: Machining Process		Receive by: Gearing Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Machining sector		Supplied by: Material Preparation Process		Page 3 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
MP-04	The delay of raw material delivery	No impact on quality issue but, insufficient of raw material for manufacturing process, bring about the lead time of delivery to customers.	1	This risk may rare occur on year 2011; refer to historical of year 2010, there were 2 times of late delivery due to the political issue of Thailand which affected on international shipping port.	2	1x2=2 (Low)
MP-05	Lower grade of steel grade is sent by supplier	Low quality of steel grade is the cause of dimples inside the material leading to the customer's rejection.	4	Very few chance; It illustrates that all suppliers are able to deliver all exact products' specification as the company's ordering.	1	4x1=4 (Moderate)

Table 5.5: Risk Analysis in Machining Process

Process Name: Machining Process		Receive by: Gearing Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Machining sector		Supplied by: Material Preparation Process		Page 4 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
MC-01	Machine error	It's a huge loss since functions of machine relate to precision of products. Once this event happens, the percent of defect may be more than 5%. As in the past, there were 4,693 pieces of over diameter products (table 4.5)	4	Medium likelihood; there are twice times a year that those 2 main functions which are feeding function and tool clamping may perform unusually since both component are frequent interfere with steel bar	3	4x3=12 (High)
MC-02	Working Standard is out of date in case of some detail are revised by Procedure Design Departments	It's high impact in almost whole batch, since the parameters of machine to produce the part are based on working standard on shop floor. Out of date data will lead the operator to setup incorrect parameter and produce wrong specification.	4	The likelihood of this case is low level because the data from marketing department are normally updated twice time a year. After that, the approved data will be transferred to procedure design and production department, respectively.	2	4x2=8 (Moderate)

Table 5.5: Risk Analysis in Machining Process (Cont')

Process Name: Machining Process		Receive by: Gearing Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Machining sector		Supplied by: Material Preparation Process		Page 5 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
MC-03	Malfunction of cutter condition	Extreme effect on quality because the ineffective cutting edge made the external diameter to become too small size. The consequent of this event may made defects of lower diameter more than limit of company (5%)	4	It's high number of likely. Related to the tool record on year 2011, numbers of holder are usually clash to the products, 12 pieces per month.	5	4x5=20 (Emergency)
MC-04	The cost of tooling are increase	Only few of low quality parts have gotten an indirect impact from human behaviour that saved cost by using same old tool without new replacement.	2	Unlikely increased price: normally 1 time a year since the cutting tools industry is a competitive market	1	2x1=2 (Low)

Table 5.5: Risk Analysis in Machining Process (Cont')

Process Name: Machining Process		Receive by: Gearing Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Machining sector		Supplied by: Material Preparation Process		Page 6 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
MC-05	Cutting tool are stolen	Minor impact: some occurring of low quality products because of using old tool (some kind of new tools need long lead time before it arrives to company).	2	Medium chance; in the past there are 2 times per year of loss of cutting inserts. And it may happen again since the tool control system is carelessly.	3	2x3=6 (Moderate)
MC-06	CNC Program error	Significant: data loss & program error, leading to unreliable of all products	5	Very rare; reliable backup and revise system, strictly	1	5x1=5 (Moderate)
MC-07	Part are scratch and collapse with machine's wall	Medium: The finished parts are injected from clamper. Those parts have clashed against machine, leading to surface problem. It was showed that the parts which have distort surface reach to 2,774 pieces.	3	The likelihood of this risk may occur every time that those products come out from machine. It almost certain of attacking between products and machine.	5	3x5=15 (High)

Table 5.6: Risk Analysis in Gearing Process

Process Name: Gearing Process		Receive by: Grinding Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Gearing sector		Supplied by: Machining Sector		Page 7 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GR-01	Hob Cutter are expired	High impact; the worn out cutter have directly effect on quality of tooth surface, as an inefficiency hob cannot provide the shape and clear cutting. Once this event happens, the percent of defect may be more than 5%. As in the past, there were 3,428 pieces of over diameter products	4	Almost Certain; all piece of hob cutting have different tool life which depends on usage's condition. Therefore, this risk of hob's condition occurs every month. Lead to, the new tool's replacement of cutting tool is unpredictable.	5	4x5=20 (Emergency)
GR-02	Gears are clashed	Medium impact; the consequence depends on the skill of people who clean those pieces of works. Mostly those gears still have complete shape, only some have distorted on tooth.	3	Almost certain; after cutting, all gear are sent to soak through the oil for prevent rusty. The risk of gear clashing usually occurs every day.	5	3x5=15 (High)

Table 5.6: Risk Analysis in Gearing Process (Cont')

Process Name: Gearing Process		Receive by: Grinding Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Gearing sector		Supplied by: Machining Sector		Page 8 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GR-03	Customer increase product's precision higher than initial agreement	Major impact; Majority of products will be not able to pass new specification and will be rejected by customers because of limited of machine's precision and operator's skill	4	Very rare; in the past there is a time per 2 years that the customer required to modify the product's detail by adding extra edge of around outside diameter. However the company denied producing the mass production because the procedure is not match to the current process.	1	4x1=4 (Moderate)
GR-04	Exhausted operators	Major impact; the operators ignore to check the quality of products lead to the high amount of NG. Also, some processes have to be stopped because of lacking of staff to run the process.	4	High chance that people are exhausted one a month at least	5	4x5=20 (Emergency)

Table 5.6: Risk Analysis in Gearing Process (Cont')

Process Name: Gearing Process		Receive by: Grinding Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Gearing sector		Supplied by: Machining Sector		Page 9 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GR-05	The brushed wheel were worn out earlier than tool's life	High impact; The brush wheel is the major tool to eliminate the chips and burr on steel products. High defect of from those attached chips and burred that cannot be removed from surface have directly affected to Ng target for more than 1% of batch.	3	There are very high likelihood, since the chance of worn out condition of brush wheel happens every. Also, there is no control system of brush wheel's condition.	5	3x5=15 (High)
GR-06	Over customers' order than forecast	Low impact to quality of works however this risk plays significant effect to lead time of delivery, associated with production schedule and capacity of machine.	1	High likelihood; the historical data from production planning shows that the customers add extra orders for every month.	4	1x4=4 (Medium)

Table 5.6: Risk Analysis in Gearing Process (Cont')

Process Name: Gearing Process		Receive by: Grinding Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Gearing sector		Supplied by: Machining Sector		Page 10 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GR-07	The company fail to develop the employee's skill to fulfil the required ability	Medium impacts: The operators' knowledge has an effect to process of parts measurements and skill of parts' separating between good and NG products.	3	Medium likelihood; as checking on training history of Milling sectors, there are 2 persons didn't understand how to measure diameter of product by using Disc Micrometer. And, there are the same trend in other segmente	3	3x3=9 (Moderate)
GR-08	New equipment that's provided by supplier errors	Extreme impact in case of tools' error, since it will display incorrect result and lead to wrong product's specification for all batches.	5	Very rare; this risk rarely occur as historical equipment data show that the comparing between new lot of equipment and master tool, all equipment can display the correct result of measurement.	1	5x1=5 (Moderate)

Table 5.6: Risk Analysis in Gearing Process (Cont')

Process Name: Gearing Process		Receive by: Grinding Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Gearing sector		Supplied by: Machining Sector		Page 11 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GR-09	Unable to capture new talent employees	High impact; low skill employ are not able to control the process as operation standard, leading to unreliable product's quality for more than maximum limits (5% of whole batch).	4	There is high chance of this risk, since only few people have applied for job. Also, the main obstacle is the company's location which far away and the transportation is not convenient to them.	4	4x4=16 (Emergency)
GR-10	Customer want to reduce product's tolerance	High impact; produce many defects more than maximum limit because of no competency to fulfil the product's qualification and limitation of machine's accuracy and human ability.	4	There is no clear record of tolerance's reduction from customer. However, the marketing review that there is only few chance (one time per two years) that customer ordered to decrease the tolerance from 50 to 20 microns on transmission gear.	1	4x1=4 (Moderate)

Table 5.6: Risk Analysis in Gearing Process (Cont')

Process Name: Gearing Process		Receive by: Grinding Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Gearing sector		Supplied by: Machining Sector		Page 12 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GR-11	The high skill operators resign	High impact; lack of operators who have ability to perform the process, Also, there is no supervisor to control other staff, leading to unreliable product's quality.	4	This event is a possible case since the career path and salary are very important to the decision of people. The chance of high skill people resign is 2 times a year as same trend as year 2009-2010	3	4x3=12 (High)
GR-12	Machine's table movement are unstable	This function's error will highly affect to quality of gear tooth since the roughness of cutting depends on how stable of movement path. The fluctuated cutting path will make the tooth become rough and uneven for high amount.	4	Unlikely: There are 5 of 160 machines were reported to fix up as unstable condition as those machine's tables were shaking during gear cutting process of May 2011	2	4x2=8 (Moderate)

Table 5.7: Risk Analysis in Grinding Process

Process Name: Grinding Process		Receive by: Quality Control Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Grinding sector		Supplied by: Gearing Sector		Page 13 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GD-01	Unable to remain quality control when the operators were rotated	Extreme impact; the operators have run inappropriate condition of process. This can make the incorrect product's specification.	4	High chance; the interviewing can show that 1 of 8 people are working without quality's target and direction to achieve target.	4	4x4=16 (Emergency)
GD-02	Those employees cannot develop their competency for implementing new technology.	High impact: the people competencies have direct effect to product quality.	4	Low likelihood; As the pass action, the major technology is developed 1 time per two years, averagely.	2	4x2=8 (Moderate)
GD-03	Short of electricity supply	Minor impact; stop of production will make CNC parameter changing. Therefore, the first setup products will be considered as trial lot which is unpredictable quality	2	The possibility is uncertain since the cause of electric blackout is unpredictable. However, there are 3-4 times a year of major shortage.	4	2x4=8 (Moderate)

Table 5.7: Risk Analysis in Grinding Process (Cont')

Process Name: Grinding Process		Receive by: Quality Control Sector		Approved date: 20/6/2011		
Responsible Person: Chief of Grinding sector		Supplied by: Gearing Sector		Page 14 of 14		
Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number (CxL= Risk No.)
GD-04	Lubricant was polluted	Extreme impact since all work pieces are made from steels which need to keep in controlled condition and coating with chemical to prevent from rusty and dusts	4	With current environment, there is high chance of leaking and contamination. As internal audit on Feb and June of 2011, all chemical products had been stored at outdoor with uncontrollable condition.	4	4x4=16 (Emergency)
GD-05	Lid of packaging that seal products are torn	Medium impact: the rusty, dust, and uneven surface occur only on the products inside plastics' box which is placed on top while other layers below is not affected	2	It's likely as onsite observation, film's lid that cover on plastics' box that is placed on top of row had torn.	4	2x4=8 (Moderate)

From table 5.4 to 5.7, those risks of company that based on specific aspects can be generated into 29 risks totally. There are 5 risks that have an effect on from material preparation process, and 7 risks within Machining process. Also, there are 12 risks in gearing process, and those 5 risks exist in grinding process. After, all consequence and likelihood are defined on each type of risk and calculated into levels from low to emergency level.

From table 5.4, those 5 risks that affected on quality issue within process of material preparation can be scaled by the chief of warehouse department. From all 5 risks, there are 3 indicated as M level (Moderate Risk). There is 1 risk that is ranged as L level (Low Risk), another is E level (High Risk).

Related to above table 5.5, those risks that affected on quality of work are scaled by the operators, chief of machining department and production manage. After, all consequence and likelihood can be calculated and rank into risk levels. From total 7 risks, the majority are estimated as M level. There are 3 risks as a Moderate Risk, 2 of High Risk (H), 1 of Low Risks (L), and 1 risk of Emergency Risk (E).

The analysis of risk within process of gearing is in table 5.6, there are 12 risks that affected on quality target of company. The chief and operators of gearing sectors and production manager have involved to the evaluation process. The assessments are as the table 5.6, from total 12 risks, there are 6 of Moderate Risk (M), 3 of High Risks (H), and 3 of Emergency Risk (E).

The analysis of risk with in process of grinding as above table 5.7, there are total 5 risks which are 3 of Moderate Risk (M) and 2 of Emergency Risks (E). Those risks have an effect to on quality target. As the Production manager and chief of grinding sector have given the assessments on the table 5.7.

From total 29 risks, the majority are estimated as M level. There are 15 risks as a Moderate Risk, 5 of High Risk (H), 7 of Emergency Risk (E), and 2 of Low Risk (L). The

generated of those major risks (high and emergency level), can be show as the next table 5.8

5.3 Risk Evaluation

This stage is to evaluate for its likelihood and its consequence of each identified risk in terms of quality issue. By allocation of non-numeric value to the numeric values, this evaluation system could score each risk base on the result of likelihood multiple by consequence. Therefore, there are 4 ranks of the probability and impact values. From 1-3, they are arranged at a low risk level. From 4-9, those risk are medium class. From 10-15, those are classified as a high risk level. From16-25, they are the emergency risk.

The severity value was represented as priority. Each of risks has been assessed, using the actual likelihood and consequence number to determine the order of importance of the risk. In this case, the operational high and emergency ranked risks are made explicit and moving on to the Risk Reduction or Mitigation stage.

From total 12 major risks, there are 5 High risk and 7 of Emergency risk to be considered to risks treatment process, the major risk summary as following table 5.8

Table 5.8: Major of Emergency and High Risk Event

Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number	Level
MP-03	Using wrong grade of raw material	It is classified as the serious effect on process. All products in a whole batch (10,000 pieces) cannot achieve the customers' specification. Unable to modify to be the correct one, all have to eliminate into garbage because of wrong composite steel.	5	The likelihood of this risk may have are 4-8 times of miss using those raw materials. Since it was found that the using SCM 45: diameter 35 mm and SCM 420: diameter 38 mm had been switch during replacing new material on empty shelf on February and May, 2010. Another is the mistaking of Pinion Speedometer: 9 teeth and 10 teeth which have similar size on March and August. On 2011, those events may happen again since amount of products are still same as year 2010	4	5 x 4 =20	Emergency
MC-01	Machine error	It's a huge loss since functions of machine relate to precision of products. Once this event happens, the percent of defect may be more than 5%. As in the past, there were 4,693 pieces of over diameter products (table 4.5)	4	Medium likelihood; there are twice times a year that those 2 main functions which are feeding function and tool clamping may perform unusually since both component are frequent interfere with steel bar	3	4x3=12	High

Table 5.8: Major of Emergency and High Risk Event (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number	Level
MC-03	Malfunction of cutter condition	Extreme effect on quality because the ineffective cutting edge made the external diameter to become too small size. The consequent of this event may made defects of lower diameter more than limit of company (5%)	4	It's high number of likely. Related to the tool record on year 2011, numbers of holder are usually clash to the products, 12 pieces per month.	5	4x5=20	Emergency
MC-07	Part are scratch and collapse with machine's wall	Medium: The finished parts are injected from clamper. Those parts have clashed against machine, leading to surface problem. As table 4.5 shows that the parts which have distort surface reach to 2,774 pieces.	3	The likelihood of this risk may occur every time that those products come out from machine. It almost certain of attacking between products and machine.	5	3x5=15	High
GR-01	Hob Cutter are expired	High impact; the worn out cutter have directly effect on quality of tooth surface, as an inefficiency hob cannot provide the shape and clear cutting. Once this event happens, the percent of defect may be more than 5%. As in the past, there were 3,428 pieces of over diameter	4	Almost Certain; all piece of hob cutting have different tool life which depends on usage's condition. Therefore, this risk of hob's condition occurs every month. Lead to, the new tool's replacement of cutting tool is unpredictable.	5	4x5=20	Emergency

Table 5.8: Major of Emergency and High Risk Event (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number	Level
GR-02	Gears are clashed	Medium impact; the consequence depends on the skill of people who clean those pieces of works. Mostly those gears still have complete shape, only some have distorted on tooth.	3	Almost certain; after cutting, all gear are sent to soak through the oil for prevent rusty. The risk of gear clashing usually occurs every day.	5	3x5=15	High
GR-04	Exhausted operators	Major impact; the operators ignore to check the quality of products lead to the high amount of NG. Also, some processes have to be stopped because of lacking of staff to run the process.	4	High chance that people are exhausted one a month at least	5	4x5=20	Emergency
GR-05	The brushed wheel were worn out earlier than tool's life	High impact; The brush wheel is the major tool to eliminate the chips and burr on steel products. High defect of from those attached chips and burred that cannot be removed from surface have directly affected to Ng target for more than 1% of batch.	3	There are very high likelihood, since the chance of worn out condition of brush wheel happens every. Also, there is no control system of brush wheel's condition.	5	3x5=15	High

Table 5.8: Major of Emergency and High Risk Event (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number	Level
GR-09	Unable to capture new talent employees	High impact; low skill employ are not able to control the process as operation standard, leading to unreliable product's quality for more than maximum limits (5% of whole batch).	4	There is high chance of this risk, since only few people have applied for job. Also, the main obstacle is the company's location which far away and the transportation is not convenient to them.	4	4x4=16	Emergency
GR-11	The high skill operators resign	High impact; lack of operators who have ability to perform the process, Also, there is no supervisor to control other staff, leading to unreliable product's quality.	4	This event is a possible case since the career path and salary are very important to the decision of people. The chance of high skill people resign is 2 times a year as same trend as year 2009-2010	3	4x3=12	High
GD-01	Unable to remain quality control when the operators were rotated	Extreme impact; the operators have run inappropriate condition of process. This can make the incorrect product's specification.	4	High chance; the interviewing can show that 1 of 8 people are working without quality's target and direction to achieve target.	4	4x4=16	Emergency

Table 5.8: Major of Emergency and High Risk Event (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number	Level
GD-04	Lubricant was polluted	Extreme impact since all work pieces are made from steels which need to keep in controlled condition and coating with chemical to prevent from rusty and dusts	4	With current environment, there is high chance of leaking and contamination. As internal audit on Feb and June of 2011, all chemical products had been stored at outdoor with uncontrollable condition.	4	4x4=16	Emergency

The final list of those 12 major risks that is the high and emergency level of risk has been defined as previous table 5.8. In next chapter 6, the analysis of cause of risks to identify the factors that result in those 12 risks issue needs to be approached for risk treatment.

In order to define root causes, effective problem statements and event descriptions are required. Therefore, one must first group risks into a manageable number of categories and develops consequent of problems or events of each category in terms of attributes. The group of risk are needed to provide concise and systematic information to find from problem until the root cause as next session.

5.4 Group of risk

As the listing of 12 major risks that a company faces can be overwhelming. One step towards making them manageable is to categorize those risks into broad categories. In addition to organise those risks into groups, it is a key step towards determining the root cause of risk that may be more than one root cause.

An operational risk which is the systematic application of management occurs within the uncertain constraints. The system must be analysed; the inputs and interaction among the 4-Ms must be thoroughly reassessed. In this research, risk can be categorized based on 4-Ms as the following criteria:

5.4.1 Man

Human factor is the source of the majority of risks leading to the failure of misleading of procedure. This factor has greatest variability as below.

Performance: Risk of exhausted operator (physical, motivational, sleep deprivation, circadian rhythm), and risk of unable to remain quality control when operators were rotated (adaptive skills).

Selection: Risk of unable to capture new talent work

Personal Factors: Risk of high skill operator resigns (job satisfaction, perceived pressure)

5.4.2 Machine

Incomplete of machine performance can bring about the failure of diameter error (detail in Chapter 4). Hardware and software used as intended, limitations interface with man as following:

Design: Risk of machine function error (liability and performance problem), ergonomics.

Maintenance: Risk of malfunction of cutter condition

5.4.3 Material

The material factor controlling can cause the incorrect material's failure. The choice of a material is the result of selection procedure. Also, the optimum coating process for corrosion resistance will often vary with the chemical used. As following lists:

Selecting and evaluating the materials: Risk of wrong material's grade

Storing condition: Risk of lubricant was polluted.

5.4.4 Method

Mostly, this factor is the main cause of the failure of surface roughness error, since the defining standards that provides procedures and rules to govern interactions cannot completely control the system elements. For example, some parts that have clashed during the procedure are not under management control and individual decisions affect personnel far more than the control method. Those risks as below:

Procedures: Risk of hob cutters are expired (Checklists),

Controls: Risk Gear are clashed (process's restriction)

Operation: Risk of parts are scratched and collapsed

Standards: Risk of brush wheel were worn out

Many aspects of factors can utilise those risks' classification throughout 4 groups of risk. There are same failures that occur following those risk groups which are described in next table 5.9:

Table 5.9: Conclusion of risk classification

Factor	Group of Failure	Risk	Risk Code
Man	Defect from misleading of measurement	1)Exhausted operator	GR-04
		2)Unable to capture new talent employee	GR-09
		3)High skill operator resign	GR-11
		4)Unable to remain quality control when operators were rotated	GD-01
Machine	Diameter error	5)Machine error	MC-01
		6)Malfunction of cutter condition	MC-03
Material	Material Changing	7)Wrong material's grade	MP-02
		8)Lubricant was polluted	GD-04
Method	Surface roughness error	9) Parts are scratched and collapsed	MC-07
		10) Hob cutters are expired	GR-01
		11) Gear are clashed	GR-02
		12) Brush wheel were worn out	GR-05

From table 5.9, those 4 groups of risk based of 4-M aspects have been determined the root cause by tracking on the events that occurred as consequently. The process to find out the root cause can be explained as the Fault Tree Analysis in next chapter 6:

Chapter VI

Operation Risk Management Plan and Implementation

After those 12 major risk events are described in chapter 5, the implementation of risk treatment have been explained in this chapter.

6.1 Risk Treatment

Each risk has been levelled on their severity and the effects of varying the allocated risk values, the rank of importance have been known at the previous step.

Nevertheless, the application of the actual information within the risk treatment procedure is one of the most necessary points. Therefore, in order to make a decision the treatment method, this should begin with the risk analysis techniques to figure out all root causes of those risks by applying risk analysis tool as described in next topic.

6.1.1 Risk Analysis tool

Fault Tree Analysis (FTA) is one of appropriate methods to ensure that all main causes would be discovered. Through this FTA development, the investigation process which is the part of FTA would force everybody to get involve in their own department, and also consciously brainstorm the initial of losses, defect and delay as an integral part of the decision making process. Finally, it would bring about the mitigation actions and any decisions in the future, as well as ensuring greater understanding and acceptance of the visible risks. The charts of FTA shown as Figure 6.1 to Table 6.4:

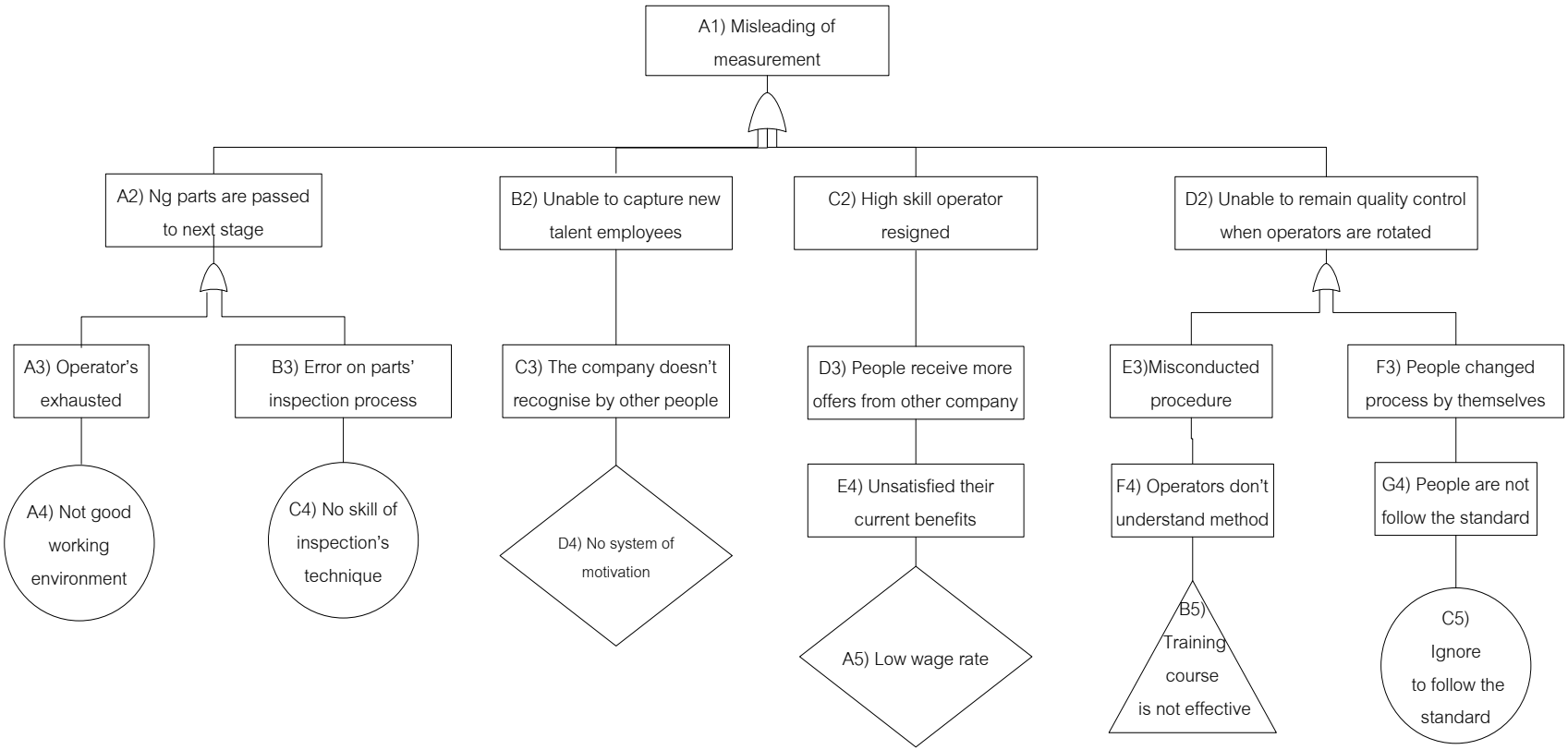


Figure 6.1: Fault Tree Analysis of Shape and diameter error

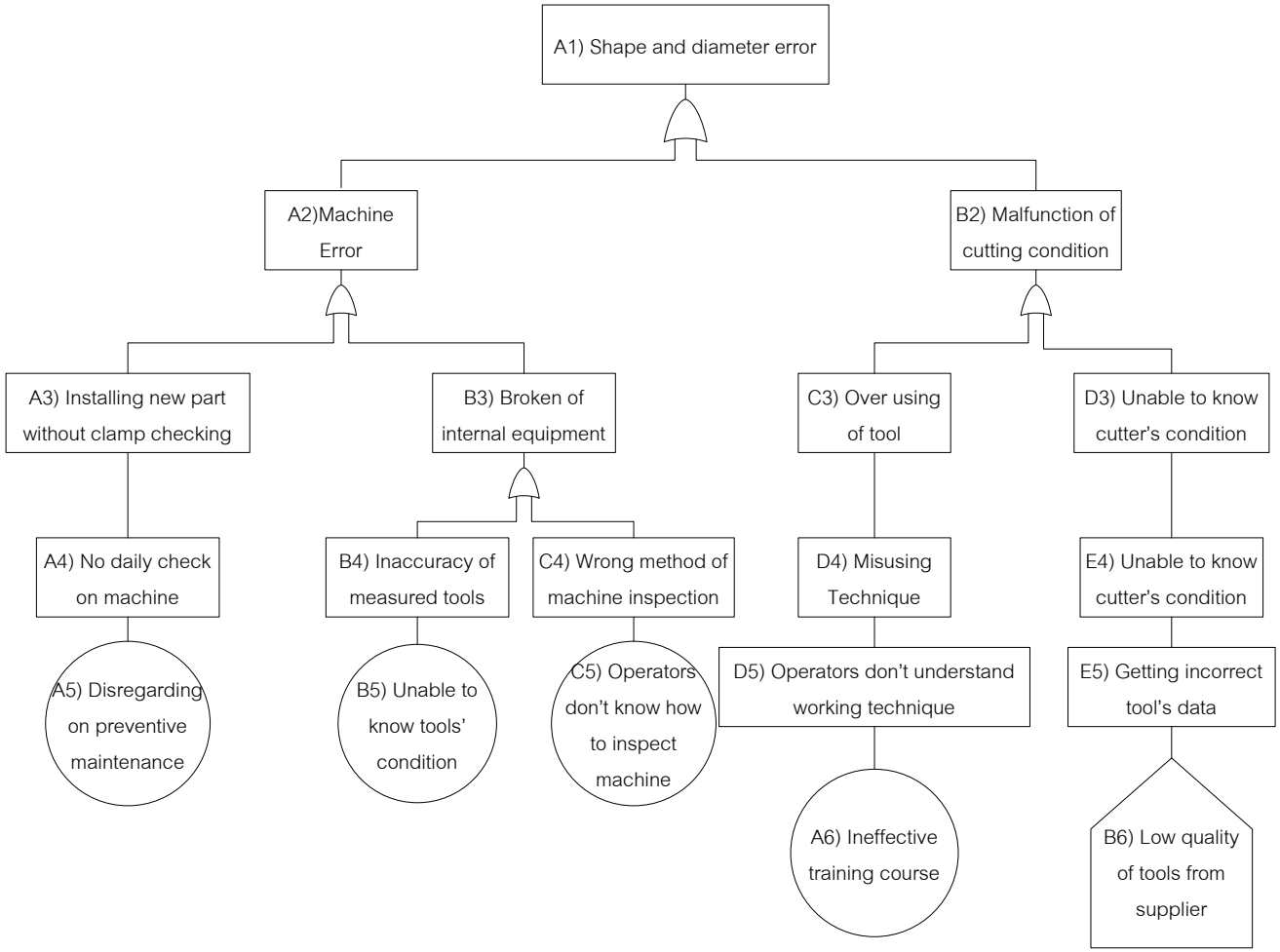


Figure 6.2: Fault Tree Analysis of Shape and diameter error

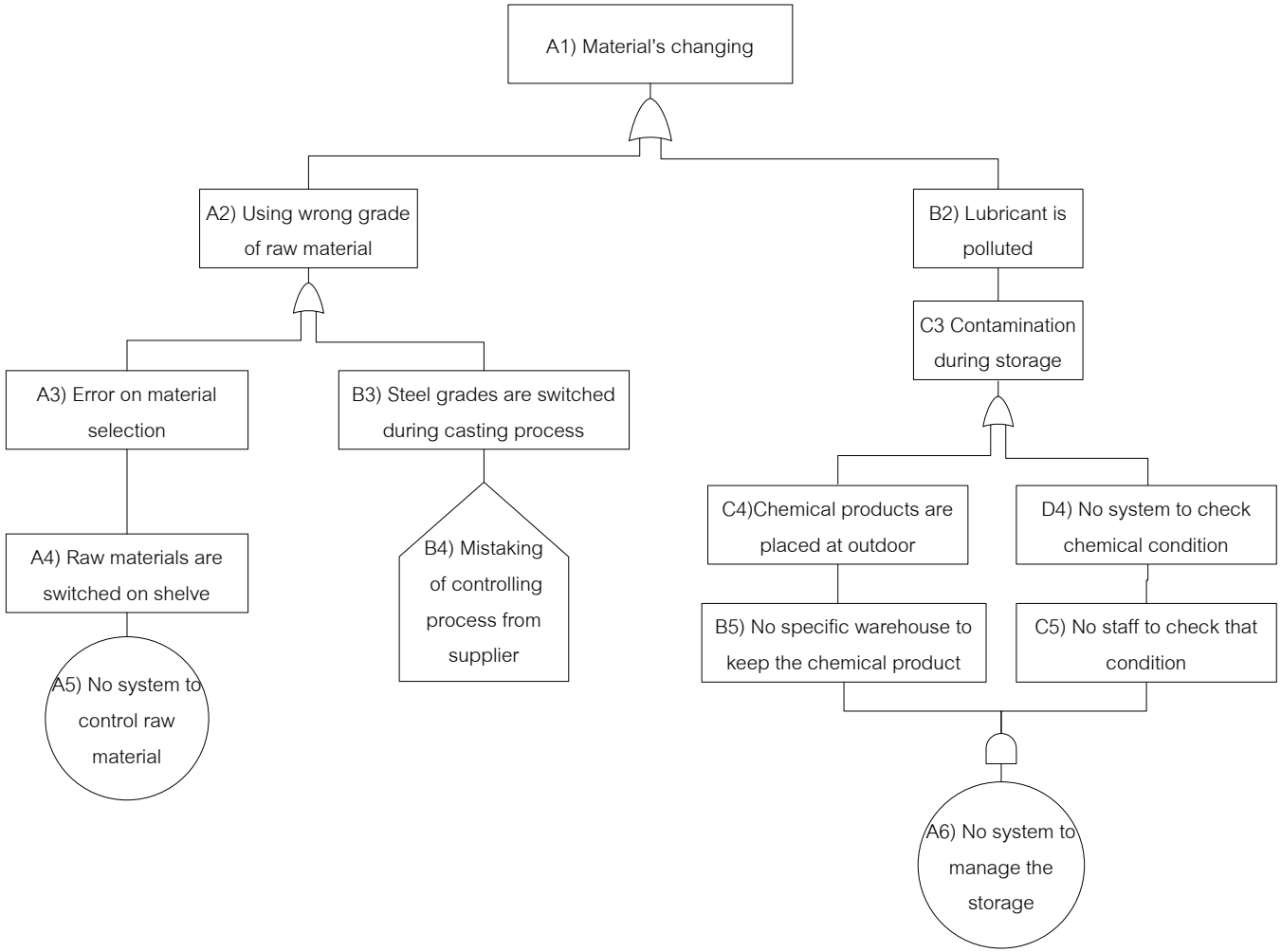


Figure 6.3: Fault Tree Analysis of Material's changing

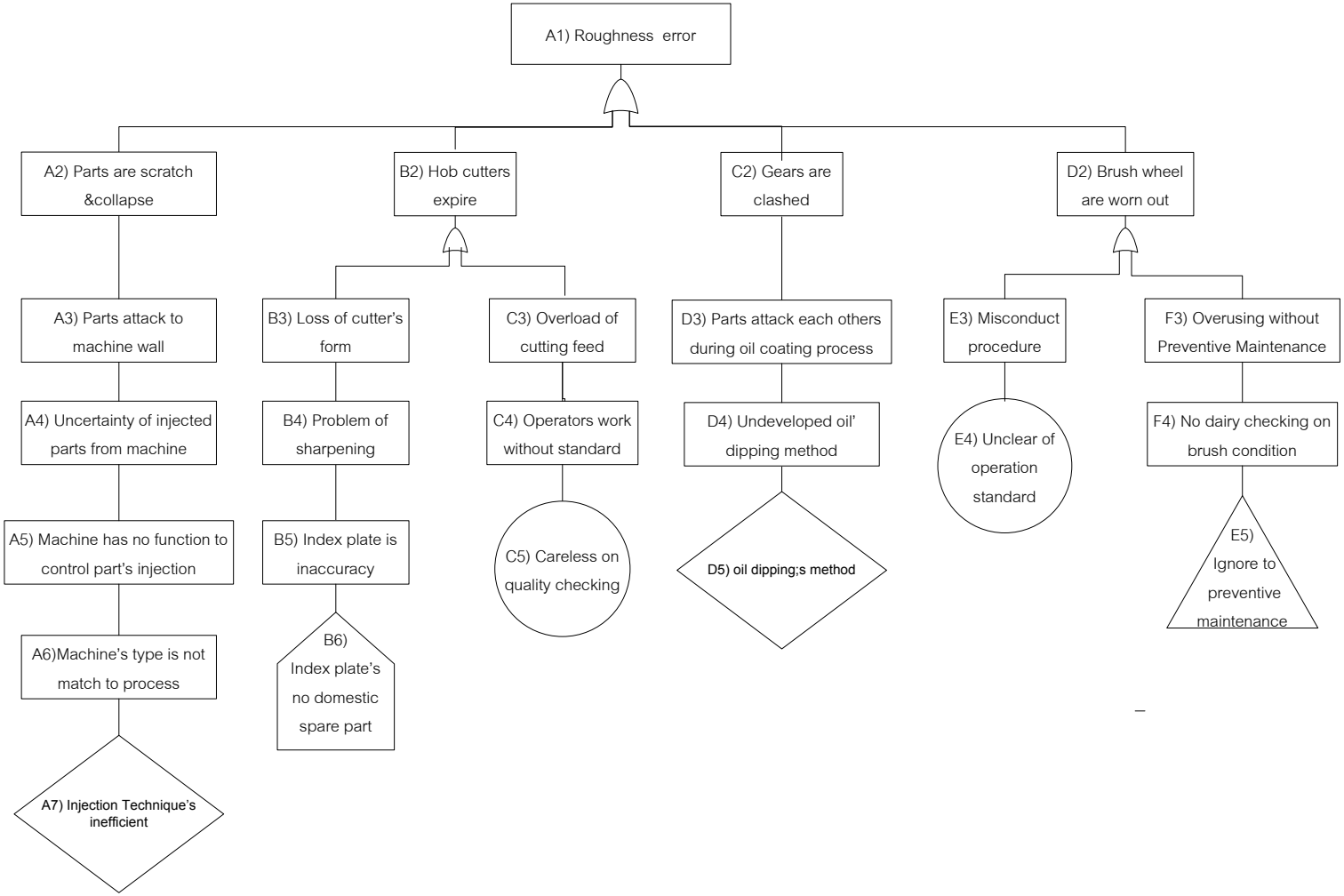


Figure 6.4: Fault Tree Analysis of Roughness error

6.1.2 Main cause of risk

According to Fault Tree Analysis as figure 6.1 to figure 6.4, there are 20 root causes that are the initial reason and lead to those 12 major risks. In this research, the 13 of basic root cause which occur from initiate fault (failure event) of internal factors of company have been generated as following detail:

1. Not good working environment

Recently, the company have received some complains about poor working environment. For example, the dirty restroom and shop floor, high temperature of work station, strong chemical smell, not enough space of cafeteria and etc. As the people stay in workplace daily 8 hours, it can be said that the environment have an effect on their jobs. If the company are difficult places to work, the operators are intensely negative feelings about work.

Recently, the board of meeting have considered as a suggestion for improvement the factory environment. However, there are many conditions that cannot change easily or have to spend high budget for investment.

2. No skill of Inspection technique

Majority of products have complicated elements, precise roughness, and limited tolerances, for example some tolerances of diameter of centre are between 10 to 15 microns (1 micron is equal 0.001 Millimetre).

Necessarily, the specific measurement method which uses special tools such as the Air Gauge for internal roughness checking, Profile Machine for geometry controlling, and Boring Gauge for circular inspection are required.

Also, those measurement tools are required specialist who has well experience in quality inspection and the interpretative skill. However, it was found that many operators that are assigned to quality inspection, still lack of data analysis skill and don't understand the trend of data.

3. Ineffective training course

Normally, the company have training course of quality management and working method, in order to keep up the quality realization and target achievement. The main problem is insufficient of good communication during training process,

Those of them would not understand the indeed lesson, some people ignore to learn the new method. Some are sleepy, boring while training. Therefore, the quality of work has been left behind leading to many error of work are passed through other sections.

4. People deny to follow quality standard

Only training course cannot fulfil the company requirement, consequently, some employees believe that the working standard is about documental issue and they would rather not to get involve with company policy. This weakness is about quality culture that has not strongly built up within organisation. Therefore the employees' attitude about the quality issue is not important and has not an effect on their working life.

5. Disregarding on Preventive Maintenance

The current controls of work instruction are not effectiveness. Those work instructions are trained to operators, but they perform with low skill. It was found that those operators believe that the working standard is about documental issue and not impact to their works. They decide not to get involve with company policy.

The weak of current training course is that the quality culture cannot be motivated to people's attitude in organization.

6. Unable to know tools' condition

As the specific range of product's precision, all measurement tools are necessary to be accuracy, especially those which using to the work that are in limited range of tolerance.

Those tools have to be in well condition which no error occurs or the maximum error should not more than the precision's range of work. However, not all of equipment that currently using in process can show the correct result since the durability of each tool is individually unstable.

7. Operators don't know how to inspect machine

Most of operators are still lack of understanding of machine checking point. Those points of oil gauge and shank level are mistaken by operators since the machine components are complicated. It was found in the checklist that most of checking points are blanked because the process of preventive maintenance all components are difficult to understand and especially, to follow method to maintain while the machine is still running. Also, some tasks need to be done by the precision equipments and special technique. As the same time, they have to focus on their main task of manufacturing process. Therefore, the high skill and experience operators are highly required as a main key to run the preventive maintenance process.

8. No system to control raw material

Regarding to the variety of products, there are many grades of raw materials which have similar size and colour. With many different composites, the selecting process has to be deeply concerned. In the past historical data, the company found out at the hardening lab that there are high amount of wrong material had been fed in production line. This mistake came from the confusing of operators who placed the wrong grade of steel into the machine.

9. No system to manage the storage

On site checking, it was found that the chemical containers are placed at outdoor with no seal and lid to prevent the leaking of water or adulterated liquid. Leading to, the NG products are rusty as a result of degraded lubricant and machine's oil.

In addition, this environment is the main cause of the loss of chemical because there is no official who takes responsibility to control incoming or outgoing of chemical. And, it has to take long time to seek for any chemical because of no tag to identify the name.

10. Careless on quality checking

In some items, the quality control of company had reached high defects, up to approximately 10 percent of total defects. Two major problems have been found that:

First, the operators have no intention to get involved in the inspection plan, even though, the Operation Standard which indicates checking point referring to customers' requirement is clearly posted on the shop floor. The cause of this problem relates to the performance evaluation program which count on working hours rather than emphasising on quality of product. Therefore, most of operators usually skip on parts' checking process.

Second, it was found that the quality checking during the process has been ignored because most of people have focused on final inspection only. Normally, most of defects that were passed from first to final stage are in the same batch with those good products since the operators didn't separate NG out. The low capacity of defect's detection leads to the high cost of production because the operators have working on those NG products.

11. Unclear operation standard

Both of new and current employees have been trained for the Work Instruction, Operation Standard, Inspection Standard, and Safety Standard through the job

orientation and On Job Training (OJT). After that, these procedures have been applied on the shop floor. Through the related documents, those operators have to fill information in complementary checklists. Those checklists are quality check sheet, tool life control sheet, and lot card. However, those of documents and check sheets have the complicated, such as inspection's points, parameter of program.

It also was found that most of machine element and inspection points that indicate in documents on shop floor are unclear. This can cause the confusing of employees and bring about the wrong working methods.

Next step is the risk treatment plans that explain the mitigation plans that can be categorised into 5 types, avoiding the risk, reducing likelihood, reducing the consequences, transferring the risk, and retaining the risk. The risk treatment is developed and acted upon those 12 major risk events which highest severity and probability as following table 6.1 to table 6.4:

Table 6.1: Risk cause of misleading failure and treatment plan

Risk Code	Risk	Cause of risk	Type of Managing	Plan Code	Treatment
GR-04	Exhausted operators	Not good working environment	Reduce likelihood	P1	To create the good working environment
		No skill of inspection technique	Reduce likelihood	P2	To emphasis on measurement technique and the skill evaluation
GR-09	Unable to capture new talent employees	No system of motivation	Transfer risk	T1	To pass the recruitment and selection process to the job agency
GR-11	The high skill operators resign	Low wage rate	Retain the risk	R1	The commitment is not established
GD-01	Unable to remain quality control when the operators were rotated	Training course is not effective	Reduce likelihood	P3	To revise the training and evaluation system
		Ignore to follow quality standard	Reduce likelihood	P4	Creating the quality awareness culture

Table 6.2: Risk cause of shape& diameter failure and treatment plan

Risk Code	Risk	Cause of risk	Type of Managing	Plan Code	Treatment
MC-01	Machine error	Disregarding to Preventive Maintenance	Reduce likelihood	P5	Training on machine inspection and tool installation method
		Unable to know tools' condition	Reduce likelihood	P6	Revise calibration system
		Operators don't understand how to inspect the machine	Reduce likelihood	P7	Review Preventive Maintenance Program and adding PM skill into one topic of the evaluation process
MC-03	Malfunction of cutter condition	Training course is not effective	Reduce likelihood	P3	To revise the training and evaluation system
		Low quality of tools from supplier	Transfer risk	T2	Using tool warranty service

Table 6.3: Risk cause of material failure and treatment plan

Risk Code	Risk	Cause of risk	Type of Managing	Plan Code	Treatment
MP-03	Using wrong grade of raw material	No system to control raw material	Reduce likelihood	P8	Coloured Visualization
		Mistaking of controlling process from supplier	Transfer risk	T3	Claiming any loss from material to supplier
GD-04	Lubricant was polluted	No system to control the storage	Reduce likelihood	P9	Set up system to control the usage of Chemical

Table 6.4: Risk cause of roughness failure and treatment plan

Risk Code	Risk	Cause of risk	Type of Managing	Plan Code	Treatment
MC-07	Part are scratch and collapse with machine's wall	Injection's technique is inefficient	Retain the risk	R2	Under discussion of purchasing the equipment to support injection' path
GR-01	Hob Cutting are expired	Index plate has no domestic spare part	Retain the risk	R3	During import the new part
		Careless on quality checking	Reduce likelihood	P10	To assign In Process QC (P-QC)
GR-02	Gears are clashed	Oil dipping method	Retain the risk	R4	Under discussion of purchasing the equipment for Oil Dipping Process
GR-05	The brushed wheel were worn out earlier than tool's life	Unclear of operation standard	Reduce likelihood	P11	To revise standard document
		Ignore to Preventive Maintenance	Reduce likelihood	P5	PM training and set up standardization

The summary of root causes, risks and plans is generated as table 6.1 to table 6.4. There are 11 plans (P1-P11) that are classified as the reducing likelihood, 3 plans (T1-T3) of transferring risk, and 4 plans (R1-R4) of retaining risk.

During this research conduction, those 4 plans of retaining risk (R1-R4) are still under considering by broad of member because of high investment. As well as, 3 plans to transfer those risks to the outsource (T1-T3) are not implemented in this research since the root causes are from external factors that should be managed by the initiators.

Therefore, the implementations of plan 1 to plan 11 (P1-P11) of risk reduction are discussed as following topic 6.1.3:

6.1.3 The plan of Implementation

In this stage, the implementations of 11 treatment plans that have been set up are explained, so that those given planes are potentially assist to solve out 12 risk events. Under the allocation of risk owners and the consensus of the management team, the implementation of treatment processes, including training and information are handed over to the QMR and each department. These 11 plans of likelihood reduction are shown as below:

1. Risk treatment plan 1 (P1): Apply 5-S activity to create the good working environment

The cause of poor working environments, the dirty toilet and shop floor, strong chemical smell, and etc, came from unorganized working routine. However, in some cases, there are many conditions that cannot change easily or have to spend high budget to build up. Those require authority from the board of meeting for improvement the factory's environment.

To improve the working environment, 5S is the methodology that uses to customize and maintain items and to enhance people makes a decision which 5 phases of standardization: sorting, straightening, systematic cleaning, standardizing, and

sustaining. Additionally, there is a clear understanding among employees of how work should be done. These 5 implementations are as below:

Step 1: Establish a 5-S and assign row of responsible

This would give the head of departments the authority of promoting and taking control 5-S implementation.

Step 2: Establish a 5-S plan

The company schedules the timeline, scope, resource, budget and implementation activities one year a time.

Step 3: Create 5-S campaign's communication

The communication should be thoroughly promoted via poster, monthly news, information's broad, to gain involvement from top to low in creating cooperation of the 5-S campaign. In some case, the training is also needed to acquaint with importance of the 5-S and ensuring the long term understanding.

Step 4: 5-S implementation

This process is to establish all activities in the site. Apart from those activities to improve working surrounding, the implementation includes 'visual 5-S methods such as red-tagging for separation the NG parts out of good parts and the signboard strategy for visualisation on orderliness.

Step 5: 5-S evaluation and follow-up

The 5-S evaluation should be check, maintain, and improve to prevent 5-S conditions from deteriorating. From steps 3 to step 4 should be repeated to help the company for the improvement.

2. Risk treatment plan 2 (P2): Emphasis on measurement technique and the skill evaluation by using Skill map, then assign the right person to the job

The skill map is the checklist which is used to record ongoing skill progressive of employees to ensure that activities and outputs are congruent with the organization's goals. It consists of assessment on key aspects by rating scale of 6 grades: 'able to train others' (outstanding), 'perform without supervisor' (very Good), 'pass and perform with supervisor' (good), 'pass training' (reasonable), 'need training' (unsatisfactory) and 'not particular training required' (not appraised).

Employees' abilities have shown whilst performing their job will be assessed base on key aspects. Those aspects are consisting of knowledge, complexity, flexibility, communication, cooperation as with these below:

1. Quality & volume of work, accuracy, skill and neatness
2. Tool and machine using technique
3. Maintenance of machines, tools, equipment
4. Ability to keep Quality Management
5. Responsibility, cooperation with others

From the calculation, the approaching overall performance would be clearly identified into different grades. Leading to the development & training that link to the risk treatment plan number 3 (P3): the training and evaluation. Therefore, the development is set up on individual lacking and should be trained in the specific course on each person. Also, the payment will match to this evaluation system that the salary will be base on the skill improvement, individually.

3. Risk treatment Plan 3 (P3): To revise the training and evaluation system for keeping quality management standard

As mention on previous sector, some of training courses had been inefficiency and had not get attention from many operators since many parts of course were intangible details and not based on current situation.

Apart from existing course, on the job training (OJT) should include quality policy into training process by using a rigorous framework, speaking a common language and clearly identify priorities topic. This would be the opportunities for employees to learn and develop themselves by applying that knowledge to their daily work. As well as, continuously monitor performance and reward to motivate people in organization are necessary to implement as a proactive way. The process of training should consist of four stages. That is, setting-up goal, reality, options and evaluation.

First stage, the goal should be prioritized on each issue, such as overall of quality policy, quantity of work, timeliness of work, cost savings, etc

Second stage, find out recently level of performance that people in organisation have. So, the coaching and training program would be developed base on existing ability of majority people in organisation.

Third stage, selecting from many training options, the company has to ensure the coaching and training method, then selecting the specific method that suit for company.

Final stage, evaluation should be done for comparing the post-training's result to the objectives expected. Also, this is the best way to compare cost/benefit analysis, since training is both time-consuming and costly.

4. Risk treatment Plan 4 (P4): Creating the quality awareness culture

The embedding of quality culture into the company has been undertaken by following three levels:

First, a quality awareness campaign to all operators, the purpose of this process is to build up all operators their awareness and responsibilities toward quality. To launch a campaign, the company has focused on the relevant quality controls of each department. The key of campaign successful is thoroughly communication which can convey through those campaigns below:

• Quality awareness training;

• Awareness poster campaigns;

• Site inspections;

• Arrangements for reporting defects;

• Leaflets and brochures;

Second, the implementation of new quality identification processes at directorate level, because the involvement of senior management is a necessary component of achieving a quality-awareness culture. Apart from availability of financial report to stakeholders, the information of product quality can be reported for management team to gain the committee against current problems and concerns, during monthly meeting. Those reports have included the customer complain records, the over level of NG products, delay delivery statistic, and any events that effect to customer satisfaction.

All information from top to low can be provided through intranet system, slide presentation, or a telephone call, as appropriate, to be used to communicate quality issue, urgent problem, and business plan as well as providing updates on measures and current level of any particular NG.

Third, the further development is to bring of the quality management towards strategic level to keep consistent of quality awareness. By launching solving manual for frequency problem to production line, those enable people identify on circumstances and other events where response is required. Those strategies included the providing of problem information, supervision and training to ensure that consistent and proper methods are followed. Besides, information of product precision would share throughout operators for remaining the products' specification awareness and ensure improvement of their performance for process control, as well as detailed practical knowledge, and learning point that were learnt and the actions that were taken to ensure in the past problem will not repeated.

5. Risk treatment Plan 5:Training on machine inspection and tool installation method

Due to many components of machine, e.g. Clamp and Arbor are required high precision which the tolerances are ranged from 5 to 15 Microns (1 Micron is equal 0.001 Millimetres). The measurement technical and proficient workers are the most essential

factor on daily Preventive Maintenance. Therefore, the efficient training on each operator to improve their best skill up to the maximum of his individual ability should be developed. During skill improvement, these have to deal with the using of resource, manpower and material up to the improvement of new Preventive Maintenance methods. There are four step of this risk treatment plan as below:

Step 1: Present the operation

With increasing of the technique complexity and the task difficulty, therefore, company must classify its process according to task variety and task analyzability in order to manage working standard. By observation and question every detail of job, the company would able to weigh and decide possible explanation or solution of new working standardization.

Step 2: Prepare the operator

This step is to define problem, parameter, and specific technique of each person from each job. To reassign on job task, is one movement to improving cost, developing employees' skills, and also assigning job to right person. By using talent management, will enhance to process effectively.

To success in rotation of job position, it is important to have clear communication and people's trust that it is not downsizing or restructuring the organization but focusing on fitting to task, and the flow of work,

Step 3: Implement new working method

This process is to trial the new standard and to develop the new methods together by taking action, also testing, collecting information.

Step 4: Follow up

After applying the new method, company have to check results and interpret those results of the test, in order to determine if hypothesis is correct. Then, the new PM Methods program should be implemented and trained to employees.

6. Risk treatment Plan 6 (P6): Revise calibration system

According to ISO 9001 registration, the Tool Calibration and Control System have to be ensured that measurement instruments are accuracy for maintaining process and product quality.

However, it is not always possible to meet requirements or able to trace particularly to all equipments for determining its acceptability. Since, the company owns large number of measuring devices that are constantly being used in vary processes. Some equipment was found that it was inaccurate, and the validity of measurement's result was suspected.

The plan to reduce the risk of unknown equipment status in production line and to build up the working standard to meet ISO requirement are as follow:

Database Collection System

Applying the Software to identify tooling status and to remind the approaching due date, in order to call back any equipments which shall be properly calibrated and/or maintained, after those equipment have been released to the production line.

First part of program is the 'Calibration and Maintenance Records' that are displayed on the main menu. This part includes:

- Tracking Number: this tracking number is the same number as the code on the equipment.
- Equipment Description, Type, Manufacturer and Model
- Location: Identify the equipment's place
- Calibration Procedure
- Calibration History
- Calibration Due

Second part, this is to report all due and past-due calibration of equipments which display as menu below:

- Date: When the next calibration is due, calendar chart shows up coming due date with all Tracking Number subject to calibration
- Authority person: Responsible person for calibrating the device.
- A maintenance program: Indicate all maintenance tasks on each device
- Past-due date equipment: Identify all of non- calibrated equipment which over the calibration due

The implementing of more precisions of equipment than product required

The selection of measuring devices should be more accurate and greater magnitude than what product needs in order to reduce the range of error when the devices are drift over the tolerance limits. So, the error of inaccuracy can be acceptable within the tolerance limit. However, the risk is still remained, in case that the measurements are taken at wildly inaccurate device due to damage or malfunction. Also, the product will be considered a nonconforming. Therefore, the discipline of recalibrating devices which have been suspected before further should be adopted.

Assign official staff for calibration

As currently, the calibration task is including in Quality Assurance Department. And, there is no direct section and staff who take responsibility for calibration equipment. The company should carefully select well trained staff whom paying particular attention to calibration controlling. Then, the procedure of measuring devices will be informed to staff in order to enable the staff to track down the products' verification and assess the magnitude of the problem. Then, the staff needs to rank problems in order of severity and resolve the minor problems at the working level and ensure that significant problems are brought to the attention of the management for resolution.

7. Risk treatment Plan 7 (P7): Review Preventive Maintenance Program and adding PM skill into one topic of the evaluation process

As mentioned in previous session, preventive maintenance does involve cause of risk. The risk of sudden breakdown machine was resulted from inefficiency performed the PM tasks. In order to minimize risk, preventive maintenance has to be carefully planned and carried out by well-trained and motivated workers. To have a successful PM, implementations that should be taken as 3 parts below:

Part 1: Scheduling

In the execution of Preventive Maintenance (PM) program, scheduling on each machine should be automatically checks up daily by operators as priority. Another, program is to monitor the schedule by maintenance staffs, as monthly, and to ensure that the daily schedule of PM is completed.

Part 2: Tangible method

The PM program should focus on remaining internal equipment of machine by applying clearly technique which includes cleaning, lubrication. For the cleaning, this is to remove dust, chip, and rust because any chips or dust are the cause of failure of cutting function. In some cases, there is no scale on gauge, therefore every lubricant's scale and oil points have to be clearly marked with the red line for correcting deficiencies found. Through testing and inspections to ensure that lubrication tasks are not missed. Also, the adjustment or replacement components should be predetermined and changed before wear-out time base on statistical tool life. If the data to support component replacement are not found, the company should collect data for statistical analysis as soon as possible.

Part 3: Motivating Operator:

Human is the key factor to drive the Preventive Maintenance plan become successful because a quality preventive maintenance program was run by highly motivated operators. There are plans to motivate operators as below:

- The explaining of reduced costs with improved up-time from good PM program should be done. And, the long term benefit that everybody will derive from increasing revenues.
- The most effective motivational tool available to the maintenance supervisor is the training. Together, the company should provide the right techniques and procedures for precision maintenance and let the employees to practice in PM on specific equipments.
- The establishment of inspection and preventive maintenance should be included as one part of working procedures.
- The follow-up to assure quality performance, the company should assign competent and responsible people to audit on preventive maintenance program one a week at lease.

8. Risk treatment Plan 8 (P8): Coloured Visualization on raw material

Although, the colour marking was appeared on steel bars that were delivered from some steel suppliers, those marking were not given for all steel products. Therefore, the company would come up with its own colour code program which evaluations to ensure proper use of colours. In case that raw material already have been marked colour from supplier, the company might remain initiated colour, related to traceability purposes back to original source of steel. The implementation of steel identification colour coding system is to prevent from replacing a raw material with another across grades. Without confusing and fast tracing, colour marking system would be used to visually remind to operators before take out any kind of raw material from shelve. Therefore, the application of a colour code was required as standardization, in order to fix working method which indicates the materials. The procedure is below detail:

1. Identification all of grade of steel bars has been developed to keep records all various kinds of steel.

2. Method of Marking for Steel Coding Systems:
    a. After, all 10 grades have been collected the data, the company would specify suitable colours matching to them. Then, indicating the list of colour coding appears on visible board.
    b. To identify title label, the indication of diameters and colours would be visibly displayed on shelf for operating positions.
    c. Marking; the designated colour should completely encircle on double-headed of bar steel or the entire bar may be painted. And, the width of a colour band may range from 10 to 40 millimetres according to the steel diameter.
    d. New replaced colour should been placed on either side of that steel after cut off any steel bars head.

3. Employee Training: The administrative steel control established by this standard shall be specifically included in the working procedure training. Also, the coding standard should been announced to all employee within department. The training is essential for all employees to recognize to associate various kinds of steel grade with coding colour, and enable the employee to avoid and eliminate confusion which results from vary colours are applied.

9. Risk treatment Plan 9 (P9): Set up system to control the usage of chemical

Apart from chemical control, this system included controlling all tools and tagging of come critical items. It can be called as a 'detective controls', related to review and monitor on chemical usage and equipment collection, and liquid storage to ensure that hazard chemical have not been removed without authorization and to provide task to control the chemical remaining procedure. As part of detective process, the department of production would arrange the meeting to brainstorm the overall plan of supply- receive and maintenance process. Next, they would establish appropriate procedures, then review and correct those procedures until acquire approval from

factory manager before implement the system. The undertaken procedures consisted of two parts as below description:

Task 1: Assign official

To assign staff who takes responsibility for collect all type of chemical and control the system;

- To classify all type of lubricants separately by functions and name;
- Tag the number on oil and make a lists;
- Check on condition and keep it cleaning weekly
- Keep updating on status of the input and output

Task 2: General Operator

- Inform to warehouse staff and sign the name into the chemical list before take any oil or lubricants out of storage room;
- Read the direction and chemical condition, carefully;
- Use chemical as the proper condition and method which indicate in work instruction and operation standard;
- Control tool usage base on liquid life recommendation

10. Risk treatment Plan 10 (P10): Assign In Process QC (P-QC)

The implementation was started at assigning in-processed quality checking into two main departments: Machining and Gearing department because insufficient checks during production problem of both departments would have an effect to majority of products.

Refer to production plan, all parts have been passed machining department which is the initial process before pass to others. For example, at first, the turning parts from CNC Machine were error in dimension, and workers did not check on it. Later, all 200 pieces in one batch were passed to others department. Until then, the first completed work piece has been reached to final checking at the end of the line. They found out error of dimension and realized there was a problem. That means 6 processes

later that were done after turning on the work pieces are waste. In Addition, all the works completely done had to be rework.

Therefore, a quality inspector should perform on site checking at actual physical of parts in Machining and Gearing stations as well, to quickly discover and block any defects that are going through other stations. And, if the quality issue of both stations are stable and controllable, the company should expand In-Process of quality control to other stations of the production process.

Another key to success of this plan is to have professional employees that are trained to properly assess every specification, dimensions, and technical detail. Based on their careful observation they are able to point out weak areas, and recommended solutions, quickly identify defects. Also, all departments should meet and share information to identify and fix the error to prevent recurring problems.

11. Risk treatment Plan 11 (P11): To revise on standard document

Apart from the training course, the company should have considered on the documental complexity since most of procedures are conveyed through those documents, for example, those are Work Instruction (WI), Operation Standard (OPS), Production Check Sheet, Lot. Control Card, Tool Life Control Sheet, and Machine Condition Check Sheet.

After that, these documents will be applied on the shop floor. Related to the required documents, the operators have to fill in many complementary sheets. However, the recent problem is the people are not understand the brush usage condition and machine parameters since the documents and check sheets have long and complicated details. Those are the machine detail, inspection point.spc, and number of lot.

Therefore, the detail of document should simplify as possible for enhancing the communication and understanding, aligning into routine operations. The relevant information would be used only, in order to reduce confusing from complicated data.

To reduce the confusing and wrong interpretation, the development of a common language and using the terminology that already have been regularly known in company is the most appropriated. However, the company may add own vocabulary if

there are many arguments about precision and technical term between those operators. Even if the vocabulary of the organization will conflict with original definitions, the communication would be more successful if the established old vocabulary that is used.

As mentioned, there are 11 plans (P1 to P11) that company has developed to reduce risk likelihood. For other 3 plans which are Plan T1, T2 and T3 which the company have transferred to outsource since the warranty policy are covered to products. Still, there are 4 risks (R1 to R4) that the company decided to remain and keep observation on those risks carefully because of the high investment.

After the meeting between chief of each sectors, the conclusion of action plan from plan code P1 to P11 has been generated and committed the schedule. The arrangement of those 11 plans have implemented within those segment of Material Preparation, Machining, Gearing, and Grinding as shown in table 6.5 to table 6.8 below:

Table 6.5: The summary action plan for material preparation sector

Detail	Due Date	Remark
1. Risk treatment Plan 8 (P8): Coloured Visualization on raw material		
1.1 Identify all steel grades	30/06/11	To ensure all types of raw materials.
1.2 Determine that Marking System	30/06/11	
1.3 Specify the coding of colour	30/06/11	
1.4 Employee training	08/07/11	
1.5 Enclose the steel's grade label on steel bar	08/07/11	
1.6 Mark the encircled of colours on double heads of steel bar	08/07/11	To prevent from people from confusing if the steels' bar are moved from the shelve

Table 6.6: The summary action plan for machining sector

Detail	Due Date	Remark
1. Risk treatment Plan 3 (P3): To revise the training and evaluation system for quality management standard		
1.1 Inform direction of cutting tool to users	25/06/11	
1.2 Set up training on tools' usage instruction	30/06/11	
1.3 Control tool usage based on tool life recommendation	08/07/11	
1.4 Evaluate on durability of each cutter	20/07/11	
1.5 Recheck on tools condition after using	30/07/11	
1.6 Evaluate the performance of tools' usage	30/07/11	
2. Risk treatment Plan 5 (P5): Training on machine inspection and tool installation method		
2.1 Data collection: Task and skill of operator	30/06/11	
2.2 Set up working standard on machine inspection of Lathe machine and create the checklist	30/06/11	
2.3 Training on machine inspection and tool installation	20/07/11	
2.4 Evaluation on operator skill	30/07/11	
3. Risk treatment Plan 6 (P6): Revise calibration system		
3.1 Responsible person for calibrating	25/06/11	
3.2 Calibration schedule, Tracking Number	20/07/11	
4.3 Tag the due date of next calibration on tools	30/07/11	
3.4 Create the database	30/11/11	This plan will achieve after this thesis complete
3.5 Revise the tolerance of tools and products	30/07/11	
4. Risk treatment Plan 7 (P7): Review Preventive Maintenance Program and adding PM skill into one topic of the evaluation process		
4.1 Set up PM Programs, daily, monthly, and annual	30/06/11	
4.2 Evaluate on skill of PM on by rechecking the oil gauge and other components	30/06/11	
4.3 Evaluate on skill to PM the condition of tools	20/07/11	

Table 6.7: The summary action plan for gearing sector

Detail	Due Date	Remark
1. Risk treatment Plan 1 (P1): Apply 5-S activity to create the good working environment		
1.1 Assign authority to chief of 5-S department	25/06/11	
1.2 Announce the 5-S campaign	25/06/11	To create good working environment
1.3 Set up schedule to clean up the area on Material Preparation, Machining, Gearing, and Grinding on every first Saturday of the month	30/06/11	To let everyone get involved in the development of working places
1.4 Set up the recreation area, smoking area, chairs and the space to expand the leg on each work station.	30/06/12	This plan is on going until year of 2012
1.5 Reward the price to departments that able to remain the best surrounding	30/12/11	This plan will achieve after this thesis complete
2. Risk treatment Plan 2 (P2): Emphasis on measurement technique and the skill evaluation by using skill map, then assign the right person to the job		
2.1 Check skill on each person by using skill map checklist	30/06/11	
2.2 Group the people who are lack of Vernier using and Micro meter technique	30/06/11	Vernier and Micro Meter are two critical tools that using in every department.
2.3 Set up training course for each group	20/07/11	
2.4 Evaluate on the skill of each person	30/07/11	To ensure the of skill improvement
2.5 Assign the chief of sector to follow up their performance	30/07/11	

Table 6.7: The summary action plan for Gearing Sector (Cont')

Detail	Due Date	Remark
3. Risk treatment Plan 5 (P5): Training on Brush inspection and installation method		
3.1 Group the people who are lack of skill to use brush wheel.	30/06/11	
3.2 Create checklist of durability of brush wheel	30/06/11	
3.3 Training on Brush and installation to operator	20/07/11	
3.4 Evaluation operator's skill	30/07/11	
3.5 Monitor the solution of brush preventive	30/07/11	
4 Risk treatment Plan 10 (P10): Assign In Process QC (P-QC)		
4.1 Establish In Process QC team	25/06/11	
4.2 Base on inspection standard, classify tasks of gear inspection and assign those tasks to the member of team	30/06/11	
4.3 Set up plan to check the quality of product in Gearing Process	20/07/11	
4.4 Control the usage of hob cutter and investigate other factor that can make the cutter become earlier expired	30/07/11	
4.5 Monitor implemented plan and compare the number of roughness NG	30/07/11	
5. Risk treatment Plan 11 (P11): To revise on standard document		
5.1 Check the correction of current data	30/06/11	
5.2 Revise the Standard document and reduce unimportant data	20/07/11	
5.3 Add information of brush wheel usage and the machine condition	20/07/11	
5.4 Control the tool life of brush	30/07/11	
5.5 Evaluate on quality of product	30/07/11	

Table 6.8: The summary action plan for Grinding Sector

Detail	Due Date	Remark
1. Risk treatment Plan 3 (P3): To revise the training and evaluation system for quality management standard		
1.1 Training on internal, surface, CNC, and centre-less grinding technique	20/07/11	
1.2 Full grinding machine instruction	20/07/11	
1.3 Training on measurement procedure	20/07/11	
1.4 Range to score of working technique	30/07/11	
1.5 Range to score of measurement skill	30/07/11	
2. Risk treatment Plan 4 (P4): Creating the quality awareness culture		
3.1 Set up meeting group on every Saturday	30/12/12	This plan is on going until year of 2012
3.2 Add the quality awareness issue into performance evaluation's list	20/07/11	
4.3 Create the check list of quality work and NG	30/07/11	
3. Risk treatment Plan 9 (P9): Set up system to control the usage of chemical		
3.1 Assign the officials to take responsibility	25/06/11	
3.2 Classify those chemicals by functions and name	30/06/11	
3.3 Tag the number on packaging	30/06/11	
3.4 Keep checking the condition of chemical	30/07/11	

After action plans from table 6.5 to table 6.8 have been applied, the teams have implemented Risk Management in each section on June to August 2011, the data of defects number are collected and compared to data before implementation of risk management.

6.2 Monitoring

According to last section 6.1.3 the plans of implementation, those 11 plans have been implemented during May to June 2011. To ensure the understanding of risk management procedure, each member from 4 sectors, chief of Material preparation, Chief of Machining, Chief of Gearing, and Chief of Grinding have been explained the objective of risk treatment plan, target to reduce defects, including new work instruction, training course, in-process quality control, preventive maintenance and check sheet. Therefore, those 11 plans can be monitored as detail below:

Risk treatment Plan 1 (P1): Apply 5-S activity to create the good working environment

Monitoring: The company has started to apply 5-S activity to the Gearing department to create the well organized condition. Since this department had poor working environments poor, unorganized and very difficult to find some stuff.

Firstly, the supervisor of 5-S activity was Assigned row of responsible to improve. Everyone in department would gather in order to proceed, those activities consist of eliminating those rubbishes and unusable stuff, rearranging those spare parts, tagging label for visual indication, customizing and maintain items. Another part is to keep this system is sustain, the company will check how improvement after apply 5-S, and set up the competition between each department.

It was found out that the operators are satisfy on the new recreation area since they have place to relax during break and reward from 5-S competition that make people can reduce stressful from working.

Risk treatment Plan 2 (P2): Emphasis on measurement technique and the skill evaluation by using skill map, then assign the right person to the job

Monitoring: Those skill checklists have been releases to all departments in three aspects. Those are: 'Ability to keep Quality Management', 'Maintenance Technique', 'Tools and machine's using Technique', the result are as below:

First, the ability to keep quality management, most of employee were passed the criteria, still there was 1 of 8 new employees who was graded as 'Unsatisfactory' level. This mean he/she did not realize the quality policy, bring to the implementation of plan 1 (O-R5-06), to revise on the training and evaluation for quality management standard, so that employee understanding would be developed.

Second, Maintenance Technique, this will assess operators' performance base on the machine checking technique. However, the qualification of 2 form 10 persons did not match to some job activities, as the job requires the person who is able to apply the tool call 'Dial Gauge'. According to the skill map, this showed both of them were rate as 'Unsatisfactory', that is, they did even know any technique. Linking to plan 5: PM training, the company had assessed both of them into specific course.

Third, tools and machine using Technique', this is the most important evaluation since the application of both machine and tool relate to quality of parts, directly. After applying skill map, the company found that there are 3 from 10 persons were unperformed skill of measurement, and 2 form 10 persons were able to work but still need supervisor to look over during they work. Also, specific course were individually required to improve what lacking.

Risk treatment Plan 3 (P3): To revise the training and evaluation system for quality management standard

Monitoring: At beginning, the company applied the quality policy and management course into On Job Training (OJT) to new employees. From the interviewing, every new employee realizes the goal and quality policy and able to describe the way achieve the target through their daily work. As well as, they are able to learn and develop themselves by applying that knowledge into their work. Therefore, the

performance of their outputs was less failure than 90% of total amount because they would like to keep their quality work pieces ratio to achieve target.

Risk treatment Plan 4 (P4): Creating the quality awareness culture

Monitoring: The follow- up of creating the quality awareness culture has been undertaken under campaigns, Through several campaigns, such as quality awareness training, Awareness poster campaigns, Site inspections, and Arrangements for reporting defects, these campaigns could enhance communicate and participation of all staffs as the increasing of their information sharing and experience during weekly meeting. Also many technical feedbacks had been placed to inform other supervisors any decisions that are likely to affect them.

Also, the adequate training and communication could gain the involvement for increasing fully understood and the consistency of response to quality problem across the company Specialist functions should play an advisory or consultancy role against problems which may affect the ability to on time deliver.

Risk treatment Plan 5 (P5): P5: Training on machine inspection and tool installation method

Monitoring: This plan has been undertaking continuously from first stage to final stage. In this case, the follow-up was based on Machining and Gearing department, as the company has started training course of Machine inspection and Tool installation on this sector first. Therefore the results as below;

Firstly, Identify the Gearing Machine measure criteria of Tool installation, the Machine had been found that they need precision of Clamp as 20 micron. The important element to check is the 'Arbor' which require run-out test for ensuring that they will product the gear in high class.

Secondly, the process of evaluating, measures how well employees perform their jobs when compared to a criteria. It can be found that operator who run the

machine program have well experience in the machine using which could check on, run out, and error of profile.

Thirdly the working standard of this gear machine process had been revised on 20011 which up-to date and tangible method already.

Last, the training and evaluation process are already undertaken. And, according to the record, the employees that have been passed the training courses, have all skill as requirement.

Risk treatment Plan 6 (P6): Revise calibration system

Monitoring: As there are three plans to reduce the risk of using error equipments, one of three plans have been developed, that is to assign official staff for controlling measurement tool since the company own large number of measuring devices that being used in vary processes. After, calibration equipments were taken responsibility by staff directly. Inaccurate tools that found in process were reduce, as a result the rework parts were decrease. Since, there is the person who could control and recall un-calibrated tools and track down on products verified using those devices. Also, company could gain precise parted as customer requirement.

For other two plans which are Database Collection System and The implementation of more precision equipment than product required, both plans are under developed. The company have assigned IT department to develop database software. Also, collect tools information comparing to work spec, in order to place new tool that more accurate and greater magnitude into the process

Risk treatment Plan 7 (P7): Review Preventive Maintenance Program and adding PM skill into one topic of the evaluation process

Monitoring: The Execution of Preventive Maintenance has been taken as three parts: Scheduling; Tangible Method; Operators' Motivation.

All machines were maintained as determined schedule, and those PM programs have focused on remaining internal equipment of machine by applying clearly technique

which includes cleaning, lubrication and other preventive maintenance program. Both schedule and technique had already been rechecked by maintenance staffs for ensuring the completion. The serious breakdown and un-notice shutdown haven't not found since the implementation of PM program had been revised. Later, explaining of reduced costs with improved up-time from good preventive maintenance program is going to be informed the long term benefit to everybody.

Risk treatment Plan 8 (P8): Coloured Visualization on raw material

Monitoring: By colouring on each side of raw material and set up the standardization on matched colour to type of steels, these enable the operators to know type of raw material, quickly and accuracy. Also, it can prevent the confusing in case of those steels have similar size and length. Moreover, the visual system enhance the new operators understand the category of steel, lead to less error on material feeding to the production line.

According to the historical data, the company found that there are errors of raw material using 4 times a year. After implementation of plan, the likelihood was reduced, there is no error were found.

Review: This stage will review on number of steels every week for 2 months, by comparing the actual number on shelve to the output record. There is correct relationship between both records. And, there is no error on incoming and out-going of steel grades.

In order to prevention the risk in future the company have implement the Work Instruction of material receiving and preparation (see appendix: Document 1) to control the risk by using standard procedure. This procedure provides a discipline and permit people to work as the standard rather than work as their individual method. Also, skill map of inspection from evaluate and develop the operators skill (see appendix: Document 2) this to ensure all operators have enough competency to select and manage each grade of steel.

Risk treatment Plan 9 (P9): Set up system to control the usage of chemical

Monitoring: After revise the chemical storage system, the system could check all existing container of chemical and reduce the loss time of seeking process. By collecting data for 2 month, it could be found there is no polluted water or dusts leaking into those chemical containers. And, the company can remain the condition of chemical Compare to before implement control system, there were many loss of rusty on steel which caused by coating oil. This stage will review on number of defect of rusty products every week for 2 month. It was found out that there is no defect of rusty after the implementation.

Risk treatment Plan 10 (P10): Assign In Process QC (P-QC)

Monitoring: The implementation of in-processed quality checking at CNC and Gearing department could enhance to company to block any defects going through other stations. Also the in line QC could quickly response to problems and report the data to manager within the same day as production was started.

Review: according to Final QC record, the percent tooth roughness error in of SprocketCamChain A was decreasing from 453 pieces to 322 pieces after implement this plan. From the monthly evaluation of customer, there is no defective parts will be shipped to them.

In order to prevention the risk in future the company have implement the Work Instruction and check sheet of in process inspection (see appendix: Document 4) to control the risk by narrowing point of checking and the procedure of inspection is the template that people need to follow the detail of standard Also, skill map of inspection from evaluate and develop the operators skill (see appendix: Document 2) This to ensure all operators have enough competency to inspect defects of those products.

In the long term, the company will earn a reputation for its reliability and the quality of parts. In future, the company decided to train and recruit more in-site QC staff for checking parts at all departments.

Risk treatment Plan 11 (P11): To revise on standard document

Monitoring: The new revision of Operation Standard (OPS) have been used recently in CNC department first, those document were cut off unnecessary details and used agreed terminology. According to internal audit, all employees could interpret spec and method as same as understanding of supervisors and production managers. Moreover, with a common language, the employees could spend time to read the document less than the old documents.

The company is continuously simplifying other documents for being less complicated details, so those are Work Instruction (WI), Lot Control Card, Tool Life Control Sheet and Machine Condition Check Sheet, respectively.

Remained Risk

After, having established those plans to mitigate those risks as table 6.1 to table 6.4, there are totally 3 risks than the company decided to remain them as an acceptable risk. Mostly those remained risks associated with cost, it is then important to define the tolerance limits for manufacturing to establish decision that whether the company should continuously accept, or not accept. In this case, a manager decides to accept risk since the costs actually outweigh benefits. Those of 3 remained risks are as below:

- MC-07: Parts are scratch and collapse with machine's wall
- GR-11: The high skill operators resign
- GR-02: Gears are clashed

From above 3 lists, both of 'scratched and collapsed parts' risk' (MC-07) and 'clashed gears' risk' (GR-02) are under discussion of purchasing the equipment which can be used to control form of those finished parts and improve process of oil's dipping. And, risk of resigning operators (GR-11) will be discussed on salary issue in annual meeting. The team has committed that they would temporarily remain those 3 risks since the method to reduce likelihood and consequence are need to be invested as a long term.

Risk Appetite

Those risk appetites have been discussed and agreed by Top Management, Based on the defects' target (Table 4.1 in Chapter 4), those risk tolerances have been established.

The risk appetite of 'using wrong material risk' (MP-03) and risk of 'expire cutter' (GR-01) have been assessed by measuring on the defective of the 6 products. If percentage of defects is lower than maximum tolerance, it means the company have some flexibility and able to keep that risk within company. On the other hand, if number of defect is over than maximum tolerance, other mitigation plan is repeatedly required to treat any uncertainty events. Those risk tolerance of 6 products are as next table 6.9:

Table 6.9 Risk appetite

Risk Code	Risk	Type of product	Maximum tolerance	Current level	Remark
MP-03	Using wrong grade of raw material	Collar D	10 %	3.00%	
		Collar C	10 %	2.81%	
		Pinion 9T	5 %	1.24%	
		Pinion 10T-23	5 %	2.09%	
			Avg.= 7.5%	**Avg. = 2.285%**	
GR-01	Hob cutters are expired	Sprocket A	9 %	10.45%	Over than tolerance
		Pinion 9T	5 %	4.67%	
		Pinion 10T-13	5 %	4.31%	
			Avg.=6.33%	**Avg. = 6.48%**	Over than tolerance

Source: established by Top Management of ABC Company

From table 6.9, most cases are acceptable since average current level is under average tolerance. However, the percentage of defects of Sprocket A is over than risk appetite which is indicated as 9.00 percent of total parts. Therefore, the company should take action to reduce score of consequence or likelihood in order to change the risk of expired hob cutters into acceptable level. During this research, the company has commitment to import the new spare parts of sharpening machine in order to reduce the likelihood of uncontrollable shape of hob cutters after first usage, however, the result of Sprocket A's defects reduction after implementation could not be collected during this thesis due to limitation of thesis timeline.

6.3 Evaluation of Operational Risk Management

After Risk treatment plans have been implemented from May 2011 to June 2011, those scores of consequent and likelihood from 12 major risks have been re-weighted for comparing between before and after implementation. The details of evaluation are discussed as the following:

6.3.1 Comparative Before and After of Two Major Risk Implementations

The comparison between before and after ORM project have finished, can be found that the percentage of risk number reduction ranges from 16 percent to 60 percent since the likelihood of risk occurring has decreased. Those reductions of risk number can be shown as next table 6.10:

Table 6.10 Comparison between before and after risk management

Risk Code	Risk	Consequences	C	Likelihood	L	Risk No,	Plan	Action Result			
								Action	C	L	Risk No.
MP-03	Using wrong grade of raw material	It is classified as the serious effect on process. All products in a whole batch (10,000 pieces) cannot achieve the customers' specification. Unable to modify to be the correct one, all have to eliminate into garbage because of wrong composite steel.	5	The likelihood of this risk may have are 4-8 times of miss using those raw materials. Since it was found that the using SCM 45: diameter 35 mm and SCM 420: diameter 38 mm had been switch during replacing new material on empty shelf on February and May, 2010. Another is the mistaking of Pinion Speedometer: 9 teeth and 10 teeth which have similar size on March and August. On 2011, those events may happen again since amount of products are still same as year 2010	4	5 x 4 =20	P8:Coloured Visualization	As recommend (See Doc 01)	5	1	5x1 =5
MC-01	Machine error	It's a huge loss since functions of machine relate to precision of products. Once this event happens, the percent of defect may be more than 5%. As in the past, there were 4,693 pieces of over diameter products	4	Medium likelihood; there are twice times a year that those 2 main functions which are feeding function and tool clamping may perform unusually since both component are frequent interfere with steel bar	3	4x3= 12	P5:M/C inspection & tool installation P6: Revise calibration P7:Add PM Skill evaluation	As recommend (See Doc 02) See Doc 03) (See Doc 02)	4	2	4x2 =8

Table 6.10 Comparison between before and after risk management (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk No.	Plan	Action Result			
								Action	C	L	Risk No.
MC-03	Malfunction of cutter condition	Extreme effect on quality because the ineffective cutting edge made the external diameter to become too small size. The consequent of this event may made defects of lower diameter more than limit of company (5%)	4	It's high number of likely. Related to the tool record on year 2011, numbers of holder are usually clash to the products, 12 pieces per month.	5	4x5= 20	P3: To revise the training and evaluation/T2: Warrantee	As recommend (See Doc 2)	4	4	4x4 =16
MC-07	Part are scratch and collapse with machine's wall	Medium: The finished parts are injected from clamper. Those parts have clashed against machine, leading to surface problem. As table 4.5 shows that the parts which have distort surface reach to 2,774 pieces.	3	The likelihood of this risk may occur every time that those products come out from machine. It almost certain of attacking between products and machine.	5	3x5= 15	R2: New Investment	As recommend Invest new complement equipment			3x5 =15

Table 6.10 Comparison between before and after risk management (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk No.	Plan	Action Result			
								Action	C	L	Risk No.
GR-01	Hob Cutter are expired	High impact; the worn out cutter have directly effect on quality of tooth surface, as an inefficiency hob cannot provide the shape and clear cutting. Once this event happens, the percent of defect may be more than 5%. As in the past, there were 3,428 pcs. of over diameter	4	Almost Certain; all piece of hob cutting have different tool life which depends on usage's condition. Therefore, this risk of hob's condition occurs every month. Lead to, the new tool's replacement of cutting tool is unpredictable.	5	4x5= 20	R3 Import new part ,P10 Process QC	As recommend (See Doc 4)	4	2	4x2 =8
GR-02	Gears are clashed	Medium impact; the consequence depends on the skill of people who clean those pieces of works. Mostly those gears still have complete shape, only some have distorted on tooth.	3	Almost certain; after cutting, all gear are sent to soak through the oil for prevent rusty. The risk of gear clashing usually occurs every day.	5	3x5= 15	R4: New Investment	As recommend) R4: New Investment	3	5	3x5 =15
GR-04	Exhausted operators	Major impact; the operators ignore to check the quality of products lead to the high amount of NG. Also, some processes have to be stopped because of lacking of staff to run the process.	4	High chance that people are exhausted one a month at least	5	4x5= 20	P1:To create good environment &P2 measurement technique	As recommend (See Doc 2)	4	3	4x3 =12

Table 6.10 Comparison between before and after risk management (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk No.	Plan	Action Result			
								Action	C	L	Risk Number
GR-05	The brushed wheel were worn out earlier than tool's life	High impact; The brush wheel is the major tool to eliminate the chips and burr on steel products. High defect of from those attached chips and burred that cannot be removed from surface have directly affected to Ng target for more than 1% of batch.	3	There are very high likelihood, since the chance of worn out condition of brush wheel happens every. Also, there is no control system of brush wheel's condition.	5	3x5=15	P5: Inspection &installation,P11: To revise standard document	As recommend (See Doc 2) (See Doc 5)	4	3	4x3=12
GR-09	Unable to capture new talent employees	High impact; low skill employ are not able to control the process as operation standard, leading to unreliable product's quality for more than maximum limits (5% of whole batch).	4	There is high chance of this risk, since only few people have applied for job. Also, the main obstacle is the company's location which far away and the transportation is not convenient to them.	4	4x4=16	T1: Hire the agent	As recommend	4	4	4x4=16

Table 6.10 Comparison between before and after risk management (Cont')

Risk Code	Risk	Consequences	C	Likelihood	L	Risk Number	Plan	Action Result			
								Action	C	L	Risk No.
GR-11	The high skill operators resign	High impact; lack of operators who have ability to perform the process, Also, there is no supervisor to control other staff, leading to unreliable product's quality.	4	This event is a possible case since the career path and salary are very important to the decision of people. The chance of high skill people resign is 2 times a year as same trend as year 2009-2010	3	4x3=12	R1: Wage Policy	As recommend	3	5	3x5=15
GD-01	Unable to remain quality control when the operators were rotated	Extreme impact; the operators have run inappropriate condition of process. This can make the incorrect product's specification.	4	High chance; the interviewing can show that 1 of 8 people are working without quality's target and direction to achieve target.	4	4x4=16	P3: To revise the training, P4: Creating awarenes	As recommend (See Doc 2)	4	3	4x3=12
GD-04	Lubricant was polluted	Extreme impact since all work pieces are made from steels which need to keep in controlled condition and coating with chemical to prevent from rusty and dusts	4	With current environment, there is high chance of leaking and contamination. As internal audit on Feb and June of 2011, all chemical products had been stored at outdoor with uncontrollable condition.	4	4x4=16	P9: Set up system to control the usage of Chemical	As recommend	4	2	4x2=8

As showing on table 6.10, there are 8 risk events that the likelihood scores are decreased. For other 4 risks, that are classified to the risk remaining and risk transferring have been no any changing of risk score.

As there are 8 risks that the risk numbers have been reduced, leading to the percentage of risk score reduction range from 16 percent to 60 percent. However, the scope in this thesis determines that 2 of risks would be implemented and evaluated. Therefore 2 results of implementation of action plan 8: Colour visualisation and Plan 10: Assign In-Process QC, have been generated as below:

Plan 8 for Risk of Wrong Raw Material

The implementation of plan 9 was be able to reduce likelihood score from 4 to 1, because of the increasing of ability of detection of misplace raw material. Moreover, new work standardization is generated and trained to operators. When operators understand and follow the work instruction, these prevent from confusing in using error on material feeding to the production line. As a result, the risk score was decrease from 20: Emergency level to 5: Medium level which is acceptable in organization.

Plan 10 for Risk of Hob Cutting Expired

The Implement of plan 10 had been dramatically reduced likelihood score from 5 to 2, as a result the company could achieve that total risk score was decease from 20: Emergency level to 8: Medium level.

From the strengthening control system, the early defects could be checked. The systematic data collection enhanced the staff to block any defects that going through other stations. Also the in line QC could quickly response to problems about hob cutting or the technical of installation problem, then would find any solution to fix defects' problem. Therefore the likelihood of overused of worn out cutter is reduce to 1 times per 3 months comparing to the old system which occur every month.

Next table 6.11 is the comparison risk level between before and after implementation of plan 9 and plan 10, as below table:

Table 6.11: Result of ORM implementation

Plan	Before			After			Difference	Percentage [(Difference*100)/25]
	C	L	C*L	C	L	C*L		
Plan 8 for Risk of Wrong Raw Material	5	4	20	5	1	5	15	60
Plan 10 for Risk of hob cutters are expired	4	5	20	4	2	8	12	48

From table 6.11, the reduction of risk score are as below explanation

Those percentages of reduction of ORM comparison between before and after both implementations are 60% and 48%, since the likelihood (the possibility of risk occurring) have been decreased. After implementation Operation Risk Management, those treatments could make the difference of total risk score which less than before as 54 percent as average.

6.3.2 Improvement of defect reduction in process

There are improvements of numbers of total defects that decrease from 25,077 pieces to 22,943 pieces. The ABC Company can reduce defects Material preparation and Tooth Roughness error for 2,134 pieces, or to 8.51% as table 6.12:

Table 6.12 Summary of defect before and after implementation ORM

Process	Type of defect	Before	After
Material preparation	Wrong type of steel	**2,576**	**908**
	Distorted surface	347	347
Machining	Over diameter	4,697	4,697
	Scratch& distorted surface	2,774	2,774
	Chips and Burrs	1,977	1,977
	Perpendicular error	698	698
	Lower diameter	320	320
	Shape error	97	97
	Parallelism failure	10	10
Gearing	Tooth Roughness error	**3,438**	**2,972**
	Incorrect size of tooth span	1,505	1,505
	Deviate profile of tooth line	267	267
	Pitch run out error	45	45
Grinding	Deviate circular run out	3,312	3,312
	Internal roughness error	2,509	2,509
	Rusty and decay surface	505	505
	Total defects	**25,077**	**22,943**

The total reduction of both defects' types (Wrong type of steel and Tooth Roughness error) are 2,134 pieces, or to 8.51% from overall 3 products.

The next figure 6.1 is showing the comparing base on each type of product to compare number of defect reduction to number of defects of before project starting.

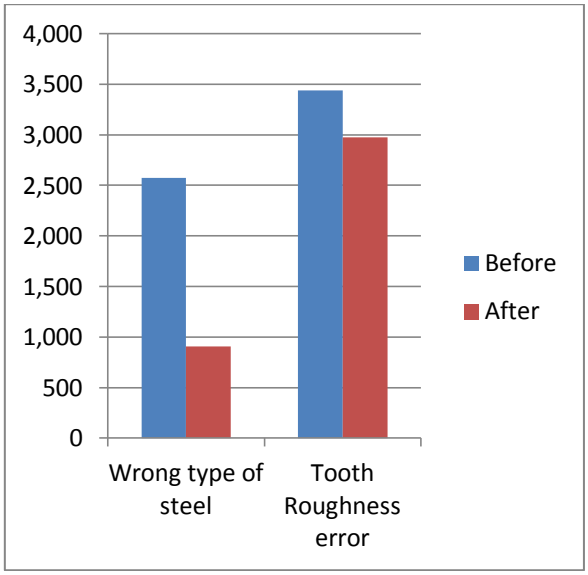


Figure 6.1 The comparison of defects between before and after ORM

Chapter VII

Conclusion and Recommendation

7.1 Conclusion

The main purpose of this project is to develop the operational risk management for controlling risk events in the motorcycle parts factory. The analysing of current situation is described in Chapter 3, and the data collection, has been collected, is explained in Chapter 4. Base on 4 manufacturing process, 29 risks have been generated as in Chapter 4 (Session 4.6: Risk Identification)

Refer to scale of likelihood and consequence, those 12 risks which have total score higher than 10 would be ranged as the 'high' and 'emergency' risks. It could be called as 'The Major Risk Events'.

The engineering tool, which used to analyze and identify root cause of those risks, is the Fault Tree Analysis (FTA). The result of analysis shows in Chapter 6 (Session 6.1.1 Risk Analysis tool and 6.1.2 Main cause of risk) which has 11 causes of risk. Also those cause of risk can be categorised, based 4 groups of failure which cause by Man, Machine, Material, and Method.

The risk treatment plans were introduced as the solution for reducing likelihood and consequence. Showing in session 6.1.3: The plan of Implementation, 2 plans of 13 risk treatment plans had been implemented. Those of plan 9: Coloured visualisation on raw material and plan 10: To assign In-Process QC were applied for reducing risk scale of the wrong material risk (MP03) and Cutters are expired (GR01), respectively.

The result of the implementation was the reduction of error of raw material. As collected the data, there is no NG products from miss using and confusing of raw material occurs again within 2 months. Also, risk of hob cutters that are expired can be decreased because the systematic of detective defects, tool life control and installation are traceable, therefore the tooth roughness error from worn out cutter can be reduced since the plan was effective.

As in session 6.3.1: Comparative Before and After of Two Major Risk Implementations, the risk of wrong material reduced as 60 percent. And, the risk of cutter expired as reduced 48 percent. As a result, the total average reducing of both score is 54 percent. Also, the ABC Company can reduce defects 14.83 percent

There are some recommendations for further development the implementation of Operational Risk Management was introduced. Those are reviewed in the next session:

7.2 Problem and limitation in research

Problem

1. Main obstacle is people's attitude which against the change in organisation. Therefore, they don't want to attend to this risk management project. The explaining about benefits of ORM is needed to be done individually for gain the cooperation.

2. The basic knowledge on each person are very different, leading to wrong data is filled in check sheet because of misunderstanding of data purpose.

3. There is the trouble to apply the plan to reduce those risks since operators who take responsibility to follow the plan are not stay at day shift for all month. On the other hand, they will change to work at night shift for every 15 days.

Limitation

1. Some risks have to be remained because of high cost of investment.

2. There are some error from the risk evaluation since those scores of consequence and likelihood are ranged based on own opinions of operators.

3. In order to achieve the target, the implementation of plan should take a year for complete all stages, monitor, evaluation, and adjust the plan. However, the time period of implementation is limited, some results that company expected cannot be fulfil during conduction of this thesis.

4. There is clearly improve in aspect of defect reduction as showing in the comparing between before and after, however those of improvement are not completely result from the implement of risk management. It was found out that there are other factors such as Psychology Effect which impact to people behaviour in organisation during conducting this research.

7.3 Recommendation

There are some of recommendations for ORM in motorcycle parts factory as following lists:

1. Improvement plans

As well as reduction of likelihood plans, suggestion of plan to reduce consequence of risk are required for decreasing impact from those risks. The implementation should be as below:

Plan to reduce consequence of wrong raw material

The organization should have developed plans to reduce the impact of risk. This plan is to select out and separate the defects that occur from risk of wrong material grade. Since it was found out that the wrong grade of material which is first initially stage are passed to other stage. Consequently, the company has proceeded on the unknowing parts (which are considered are defects of material later).

This plan is required to block those unqualified parts for decrease severity of this error by un-allowing those parts to affect to other process. The procedures of this plan are as below:

- Setup In-Process QC team to recheck the specification of material in first stage of every part.
- It is the responsibility of team member to check if lots of steel are controlled correctly.
- Monitor the result of controls respectively when reviewing these points.

- Comparing before and after implement if it work efficiently, this would offer a benchmark to the management of the company to use that

Plan to reduce consequence of hob cutter are expired

The consequence of using expired cutter can make the product become roughness error. In order to decrease the risk to low impact, the company have to improve gear cutting technique by designing new type on cutter. This type of risk reduction will allow the occurring of the risk of cutting error but reduce the extent of damage. Procedures of this implementation are as below:

- Applying the test of double thread of hob cutter to determine that new design of double thread can remove uneven surface that are left from first cutting blade.

- During test, the risk assessment should be score the consequences of risk are reduced in aspect of the number of roughness defects.

- Monitor the result of test if company discovers that higher NGs have been released from process, the company should reconsider and adapt new action plan.

- Comparing the potentially significant risks' number if it will be minimised, this solution should be extend to other processes.

2. Training of ORM should continuously proceed

The human potential is the key factor to drive all system, Insufficiency skill and misunderstanding may cause the failure of risk management process. Therefore, the training should be emphasised for operators who control the steel stock and tools warehouse. Those recommended courses include as below:

i. Colour selection- many tones of colours look similarity, such as bright red and dark orange, so operators should be trained for using specific tone in order to prevent misusing case.

ii. Work Instruction of stock management- to keep operators understanding all method to receive and supply raw material.

iii. List of all materials

iv. The method to recheck quality of raw material

v. The method to maintain raw material condition

vi. Recording and interpreting meaning of reference number

Also, the training course should be set up for tool warehouse staffs as following sessions:

vii. Stock management, since many tools required lead time delivery after ordering, the staff should estimated spending rate by using the number of tool spending per day.

viii. To keep record 'Tool life' data, in order to develop the technical use in future.

ix. List of tools.

x. The method to maintain tools condition

xi. Recording and interpreting meaning of reference number of tool grade.

Those training should be done directly to new employees and keep it up to date for existing employees.

3. Expansion concept of risk management to apply in other area

For efficiency of quality management, the implementation of Risk Management and FTA technique should be undertaken to every department, base on every risk type. Since this project referred to Operational risk and focused on production department.

With the same technique, this risk management concept can be used to others sectors, for example, to emphasis on financial risk management at accounting department, as well as to adapt strategic risk management to top management .

The implementation to whole segment of ABC Company will prevent company from uncertainty events which can cause the problems, defect, delay, unsatisfied customers and etc. Also, this enhances the productivity improvement in ever department.

5. Keep the system consistency and continuous improvement

The key aspect of Quality standard is consistency and continuous improvement. Linking to risk management, both of consistency and continuous improvement is enable the risk management alive and become up to date system.

One of efficient tool for continuous improvement is the application of Japanese technique 'KAIZEN', therefore, the integration of KAIZEN and Risk Management to ensure the consistency. By setting up the weekly meeting, the brainstorming, idea of Risk Management and improvement suggestion from each department will be accumulate as a well arrangement system. Not only, the company will gain the good solution, also gain people attendant which is the key factor to drive the system become consistency and steady improvement.

6. Incentive Piecework Standards

To motivate operators to increase effort on their jobs, HR system should change to the incentive system that link employee compensation to measure on amount and quality of products instead of working hours as the old traditional method.

This system would pay the compensation of the individual workers base on amount of quality product and if that they can complete produces over the required standard, they will earn a bonus over their base rate. There are two of incentive plan the company are able to implement:

Plan 1: Individual Incentive Plans

Individual Incentive Piecework is a type of incentive that employee is paid based on each unit of output. This allows that employees are paid a certain rate per unit times the number of units produced until they produce exceed norms of piecework, then they will gain the bonus.

Plan 2: Group Incentive Plans

Group incentives tie the bonus to the performance of the group as a whole. Examples of Group incentives are profit-sharing plans, stock ownership plans, bonuses based on aggregative indicators such as production or productivity.

Compare to measured day work systems, the piecework incentive programs will enhance the worker to earn over and above their hourly rate and have higher productivity levels. However, Piecework incentive systems may decline in popularity due to the fact of higher working pressure. In order to implement the company must consider the appropriate paying rate since there are vary work techniques which depend on personal skill and different person may take different time to complete those jobs.

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Appendix

ABC	No.	Revision	Revised by	Approved by
	01	0		
	Date	Page		
	30 June 2011	1 from 3	*K. Jakkrit*	*T. Sooth*
Document Number : 01		Work Instruction of Material Receiving and preparation		

1. **Purpose**

   -To determine the procedure to control raw material in manufacturing process and to able to track back source of raw material.

   -To protect raw material from defect and ensure that raw material will remain in good condition while it is stores.

2. **Scope**

   This document uses for controlling the material receiving activities, stored process, and the incoming-out going process.

3. **Definition/ Abbreviation**

   FIRST IN- FIRST OUT

4. **Reference/Material**

   N/A

5. **Instructions**

   5.1 Inventory staff rechecks on incoming of raw material, amount, steel length, diameter, comparing to the document from suppliers

5.2 In case of small amount of steel bar, place new lot of steel on the old lot and use divider to separate one lot and new lot.

5.3 In case of high amount of steel bar, the staff will place new lot on other shelves.

5.4 Mark the encircled of colour on double heads of steel bar as following:

i. SCM 415: Red

ii. SCM 420: Yellow

iii. SUP 9: Green

iv. S 15 C: Brown

v. S 20 C: Light Blue

vi. S 45 C: Dark Blue

vii. S 50 C: White

viii. STKM: Black

5.5 Enclose the steel's grade label on steel bar

"H" stands for stable hardness for all length of steel

"HV" stands for the controlled percentage of oxidation steel

"HR" stands for Hot Roll steel

"R" stands for Round Bar

"CR" stands for Cold Roll

5.6 The staff should record Steel grade base on specific colour, incoming date, Lot No., and amount in Stock Card (FQP-IVD-03:01). Then, the staff who receives Cutting Order Card (FWI-IVD-01:01) will cut the steel bar into smaller units as specific length, size and amount as indicate in Cutting Order Card. After cutting, staff has to keep record of cut steel unit into Record of Cutting Steel (FWI-IVD-01:02). (In case of continuous production, the cutting steel' inventory should not keep stock over than 3 days).

5.7 Those steel units after finished cutting should mark the encircled of colour on double heads as mentioned colour in topic 5.4 to indicated steel grade.

5.8 The operator who will use steel bay should fill the amount of steel bar, Grade, Size into Order Check Sheet (FQP-IVD-03:02)

5.9 The staff should record amount of steel, length, size, and grade that are passed to next departments into Stock Card (FQP-IVD-03:01).

6. **Quality record**

FQP-IVD-03:01 Stock Card

FQP-IVD-03:02 Order Check Sheet

FWI-IVD-01:01 Cutting Order Card

FWI-IVD-01:02 Record of Cutting Steel

# Training Schedule *Document 02*					Revised by *K.Jakkit*				Approved by *T.Sooth*				Approval date 20 Jun 11 Revision 3 Page 2 of 1				
No.	Topic	Period	Target Group	Follow up	Month/2011												Remarks
					1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	
5	P5:Training on brush inspection and tool installation method	30/06/2011-30/7/2011	Gearing Operator	Plan													
				Actual													
6	P3: Training Grinding Technique	20/7/11-30/07/11	Grinding Operator	Plan													
				Actual													

Document 02

Skill Evaluation

ชื่อ หน่วยงานผลิต		ชื่อแผนก										วันที่			
หัวข้อที่ต้องอบรมการฝึกอบรม (Training Topic) →		Working Standar of Machine PERFECT	Working Standar of Machine PERFECT (Z Axis)	Work Instruction PALMARY Model PC-12	Wrok Instruction SHIGIYA Model G-27	Work Instrution SHIGIYA	Work Instructiom PALMARY Auto	Work Instruction PALMARY PC-12 Manual	Work Instruction OKAMOTO	?Work In struction NAKASE	Work Instruction JACK MILL Model JMC -600H	Work Instruction JACK MILL model JMC -600A	Workl nstruction WASINO JAPAN	Work Instruction PALMARY รุ่นmodel PC-125 Manual	Work Instruction SHIGAYA SEIKI model G27
↓ ชื่อพนักงาน (EMPLOYEE NAME)	↓ Position														
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕

	0	1	2	3	4	5
Reviewed By: ____________	ไม่ต้องรับการฝึกอบรม, กรุณาปล่อยว่างๆไว้ NO PARTICULAR TRAINING REQUIRED	⊕ ต้องการการฝึกอบรม, แต่ยังไม่ได้รับการอบรม Need Training, But NOT Train	ผ่านการฝึกอบรม Pass Training	ผ่าน และทำงานได้โดย มี หัวหน้างานดูแล PASS & PERFORM WITH SUPERVISION	สามารถทำงานได้โดยไม่ มี หัวหน้างานกำกับดูแล PERFORMED WITHOUT SUPERVISIOR	สามารถสอนงาน ผู้อื่นได้ ABLE TO TRAIN OTHERS
Approved Bby: ____________						

Document 02

Skill Evaluation

ชื่อ หน่วยงานผลิต | ชื่อแผนก | วันที่

หัวข้อที่ต้องอบรมการฝึกอบรม (Training Topic) →		Company policy	Vernier skill	micro meter Skill	Check Sheet	Operation Standard Interpretation	Ng Seperating	PM Skill							
↓ ชื่อพนักงาน (EMPLOYEE NAME)	↓ Position														
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕

Reviewed By: ____________

Approved Bby: ____________

0	1	2	3	4	5
ไม่ต้องรับการฝึกอบรม, กรุณาปล่อยว่างๆไว้ NO PARTICULAR TRAINING REQUIRED	ต้องการการฝึกอบรม, แต่ยังไม่ได้รับการอบรม Need Training, But NOT Train	ผ่านการฝึกอบรม Pass Training	ผ่าน และทำงานได้โดย มี หัวหน้างานดูแล PASS & PERFORM WITH SUPERVISION	สามารถทำงานได้โดยไม่ มี หัวหน้างานกำกับดูแล PERFORMED WITHOUT SUPERVISIOR	สามารถสอนงาน ผู้อื่นได้ ABLE TO TRAIN OTHERS

Document 02

Skill Evaluation

ชื่อ หน่วยงานผลิต		ชื่อแผนก									วันที่				
หัวข้อที่ต้องอบรมการฝึกอบรม (Training Topic) →		Working Standar of Machine PERFECT	Working Standar of Machine PERFECT (Z Axis)	Work Instruction PALMARY Model PC-12	Work Instruction SHIGIYA Model G-27	Work Instrution SHIGIYA	Work Instructiom PALMARY Auto	Work Instruction PALMARY PC-12 Manual	Work Instruction OKAMOTO	?Work In struction NAKASE	Work Instruction JACK MILL Model JMC -600H	Work Instruction JACK MILL model JMC -600A	Workl nstruction WASINO JAPAN	Work Instructiom PALMARY รุ่นmodel PC-12S Manual	Work Instruction SHIGAYA SEIKI model G27
↓ ชื่อพนักงาน (EMPLOYEE NAME)	↓ Position														
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	พนักงาน	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕

Reviewed By: ______________

Approved Bby: ______________

0	1	2	3	4	5
	⊕				
ไม่ต้องรับการฝึกอบรม, กรุณาปล่อยว่างๆไว้	ต้องการการฝึกอบรม, แต่ยังไม่ได้รับการอบรม	ผ่านการฝึกอบรม	ผ่าน และทำงานได้โดย มี หัวหน้างานดูแล	สามารถทำงานได้โดยไม่ มี หัวหน้างานกำกับดูแล	สามารถสอนงาน ผู้อื่นได้
NO PARTICULAR TRAINING REQUIRED	Need Training, But NOT Train	Pass Training	PASS & PERFORM WITH SUPERVISION	PERFORMED WITHOUT SUPERVISIOR	ABLE TO TRAIN OTHERS

Document 3

					QCD
			6 Months		

LIST OF CALIBRATION STANDARD USED

SERIAL NO.	MANUFACTURED	DESCRIPTION	CAL DATE	MODEL	TEMPERATURE
010902	-	GAUGE BLOCK	11-Nov-10	GRADE 0	20 ° ± 2 °C

CALIBRATION RESULT		UNIT UNDER CALIBRATION					
ITEM	CONTROL No.	SERIAL No.	CAPACITY (mm.)	ACCURACY (mm.)	ACCEPT +/- (µm.)	APPLIED VALUE(mm.)	REDING ERROR(µm.)	RESULT
1	QCD-HM-045	09101080	25-50	0.001	± 4	25.000	0	OK
		(Digital)			± 4	30.000	0	OK
					± 4	40.000	-1	OK
					± 4	45.000	-1	OK
					± 4	50.000	-1	OK

THE REPORTED EXPANDED UNCERTAINTY IS BASED ON A STANDARD UNCERTAINTY MULTIPLIED BY A COVERAGE FACTOR K=2, PROVIDING A LEVEL OF CONFIDENCE OF APPROXIMATELY 95 %.

REMARK :

Document 3

(บัญชีรายชื่อเครื่องมือวัด)

เครื่องมือ... AIR MICRO...

Page ..1../..1..

แผนก...GDA...

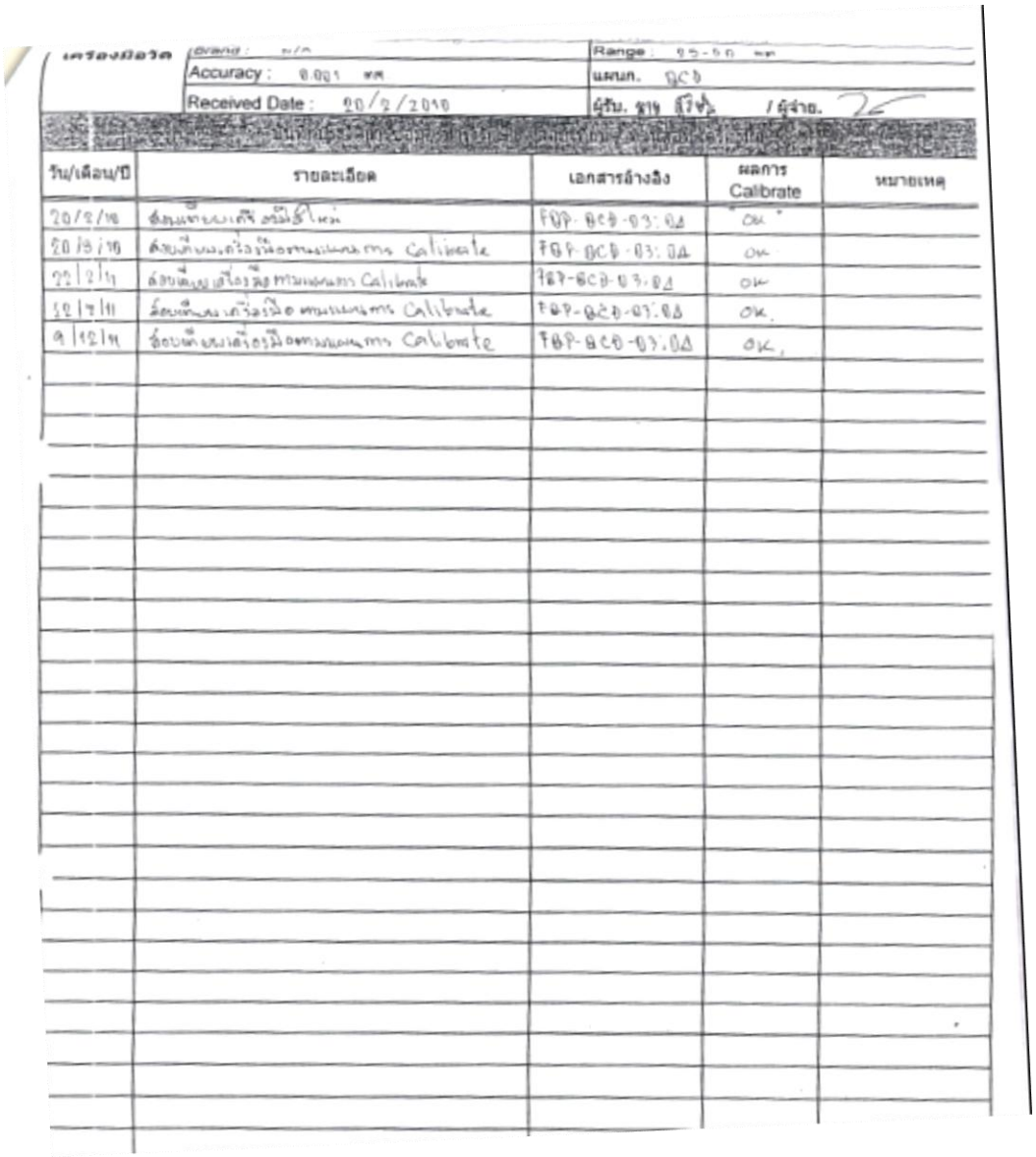
รายการ	หมายเลขทะเบียน (Control No.)	หมายเลขเฉพาะ (Serial No.)	ชนิด	ช่วงการใช้งาน (mm.)	ค่าความละเอียด Accuracy (mm.)	ความถี่ (Frequency)	หมายเหตุ
							หมายเหตุ GCD
R MICRO		1331	AIR	± 0.020	0.001	12 เดือน	✓
R MICRO	-	1332	AIR	± 0.020	0.001	12 เดือน	✓
R MICRO	-	1360	AIR	± 0.020	0.001	12 เดือน	✓
R MICRO	-	1359	AIR	± 0.020	0.001	12 เดือน	✓ ใช้งานได้

Document 3

...VERNIER CALIPER...

รายการ	หมายเลขทะเบียน (Control No.)	หมายเลขเฉพาะ (Serial No.)	ชนิด	ช่วงการใช้งาน (mm.)	ค่าความละเอียด Accuracy (mm.)	Accept + / - (mm.)	ความถี่ (Frequency)	หมายเห...
NIER CALIPER	CN-V-14	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	"NG" Cal. ไม่ผ่าน 13/1/10
RNIER CALIPER	CN-V-19	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	"NG" Cal. ไม่ผ่าน 13/1/10
NIER CALIPER	CN-V-20	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 05/11
RNIER CALIPER	CN-V-21	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 05/11
ERNIER CALIPER	CNC-VC-022	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	"NG" Cal. ไม่ผ่าน 14/6/10
ERNIER CALIPER	CNC-VC-023	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 04/11
ERNIER CALIPER	CNC-VC-024	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 04/11
ERNIER CALIPER	CNC-VC-025	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 04/11
ERNIER CALIPER	CNC-VC-026	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	"NG"เข็มไม่กลับที่เดิม18/3/10
ERNIER CALIPER	CNC-VC-027	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 12/10
ERNIER CALIPER	CNC-VC-028	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	"NG"เข็มไม่กลับที่เดิม2/6/10
ERNIER CALIPER	CNC-VC-029	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 12/10
ERNIER CALIPER	CNC-VC-030	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	"NG" Cal. ไม่ผ่าน 14/6/10
ERNIER CALIPER	CNC-VC-031	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 12/10
ERNIER CALIPER	CNC-VC-032	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 01/11
ERNIER CALIPER	CNC-VC-033	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	DUE 01/11
ERNIER CALIPER	CNC-VC-034	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	new DUE 01/11
ERNIER CALIPER	CNC-VC-035	N/A	Dial	0-150	0.02	± 0.030	6 เดือน	new DUE 05/11
ERNIER CALIPER	CNC-VC-036	SH8H58232	Digital	0-150	0.005	± 0.030	6 เดือน	new DUE 04/11
ERNIER CALIPER	CNC-VC-037	9169612	Dial	0-150	0.02	± 0.030	6 เดือน	"NG"เข็มไม่กลับที่เดิม30/9/10
ERNIER CALIPER	CNC-VC-038	9169613	Dial	0-150	0.02	± 0.030	6 เดือน	new DUE 12/10
			Dial	0-150	0.02	± 0.030	6 เดือน	new DUE 12/10

Document 3



เครื่องมือวัด Brand : -/-
Range : 25-50 mm
Accuracy : 0.001 mm
แผนก. QCD
Received Date : 20/2/2010
ผู้รับ. ชาย ศิริพันธ์ / ผู้จำย.

วัน/เดือน/ปี	รายละเอียด	เอกสารอ้างอิง	ผลการ Calibrate	หมายเหตุ
20/2/10	ส่งแคลเบรเตชั่น ครั้งที่ใหม่	FQP-QCD-03:04	OK	
20/8/10	ส่งเครื่องมือวัดแคลเบรเตชั่น Calibrate	FQP-QCD-03:04	OK	
22/2/11	ส่งเครื่องมือวัดแคลเบรเตชั่น Calibrate	FQP-QCD-03:04	OK	
12/7/11	ส่งเครื่องมือวัดแคลเบรเตชั่น Calibrate	FQP-QCD-03:04	OK	
9/12/11	ส่งเครื่องมือวัดแคลเบรเตชั่น Calibrate	FQP-QCD-03:04	OK	

ABC	No.	Revision	Revised by	Approved by
	01	0		
	Date	Page		
	30 June 2011	1 from 4	*C. BoonChai*	*T. Sooth*
Document Number: 4		Product Inspection		

1. **Purpose**

   -To determine the procedure to inspect products in processes to ensure that products have to be checked with appropriate procedure.

2. **Scope**

   This procedure is cover from material receiving, in process inspection until the final deliver to customers.

3. **Definition/ Abbreviation**

   N/A

4. **Reference/Material**

   OP-QCD-01 Procedure of Non-conforming Report

5. **Instructions**

   5.1 Raw material inspection

   -The quality control staff randomly rechecks on incoming of raw material, amount, steel length, diameter, container, certification, referring to the operation standard (FQP-PRO-01:02) of each product.

   -The staff should check on raw material qualification and keep incoming record Incoming Record (FQP-QCD-02:01)

ABC	No.	Revision	Revised by	Approved by
	01	0		
	Date	Page		
	30 June 2011	1 from 4	*C. BoonChai*	*T. Sooth*
Document Number: 4		Product Inspection		

-If there is any incorrect of qualification of raw material, the inventory staff is responsible to report to purchasing department for stop the delivery from supplier, and select those incorrect raw material to keep them, separately. Also, they need to issue the document of NCR management (FQP-QC-01:01)

5.2 The inspection during process

-Operators and In-process QC officer check on production activity and random some product to inspect by following the checking standard at Operation Standard (FQP-PRO-01:02)

- Production operator and In-Process QC keep record of products' condition in Inspection History Report (FQP-QCD-02:02) In case, products process have wrong condition, comparing to Operation Standard (FQP-PRO-01:02), they have to report to Chief of department to stop the process and reset the process, then separate NG products out of good products, following procedure of NCR management (QP-QC-01)

5.3 Final inspection

- Before delivery to customer, the final QC staffs have to randomly check quality of product by following Inspection Standard (FQP-PRO-01:03) and fill in the record in Inspection History Report (FQP-QCD-02:02)

ABC	No.	Revision	Revised by	Approved by
	01	0		
	Date	Page		
	30 June 2011	1 from 4	*C. BoonChai*	*T. Sooth*
Document Number: 4		Product Inspection		

- If there are over limit of Ng are found, the Operator have to report the chief tog department to stop the delivery, then carry on 100% checking and take all NG products out of good product. And, the staff should issue document of NCR management (FQP-QC-01:01).

5.4 Issuing Inspection Data

QC Operators collect product data and report in document of Inspection Data (FQP-QCD-02:03) and pass the report together with products to the customers.

7. Quality record

FQP-QCD-02:01 Incoming Record

FQP-QCD-02:02 Inspection History Report

FWI-QCD-02:03 Inspection Data

Document 4

FINAL INSPECTION HISTORY REPORT

Part No. 5P-E1549
Part Name SPROCKET A.....

M/Y_____ Jun-11

Date.	Incoming					Total (Pcs)	Defect (NG)						Total NG (Pcs)	Sent to PACKING		
	Lot No.	Quantity (Pcs)	Accumu-late (Pcs)	Reciever	Quantity (Pcs)		Over DIA / tooth span	Scratch / Internal roughtness	Shape / Rusty and decay	Lower DIA / Wrong material	Tooth roughtnss / Others	Total NG		GOOD (Pcs)	Total GOOD (Pcs)	Operator

FQP-QCD-02:02 Rev.00

Document 4

Dimension Results									
Part No: 5YP-E1549			Part Name: Sprocket A						
No.	Dimension/ Specification	Measurement	1	2	3	4	5	OK	NOT OK
1	Diameter: 8	Micrometer							
2	Diameter: 13	Micrometer							
3	Diameter: 20.4	Vernier							
4	Distance: 14.5	Vernier							
5	Distance: 3	Height Gauge							
6	Chamfer: 1.0	Profile Projector							
7	Chamfer: 0.9	Micro Scope							
8	Appearance No Crack, Burr, Dent	Visual							
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
Inspector…… Date…….. Approve By…….. Date……									

Biography

Miss Pariya Pornpattanaloeskul was born on 19 February 1984 at Bangkok, Thailand. In 2002, she finished her high school from Suankularb Wittayalai Rangsit. She graduated a Bachelor Degree of Engineering in Industrial Engineering, King Mongkut Institute of Technology's Ladkrabang (Thailand) since 2006. She joined with the Palmary Co., Ltd. (Taiwan) as a trainee. In 2007 to present, she has joined with PPA Co., Ltd. (Thailand), as a Purchasing Engineer. In 2008, she enrolled as a part-time student of the Regional Centre of Manufacturing Systems Engineering for the Master of Engineering in Engineering Management from Chulalongkorn University (Thailand) and Master of Science in Engineering Business Management from the University of Warwick (United Kingdom).