CHAPTER I

INTRODUCTION

In the furniture manufacturing business, quality has taken a major role in today's competitive domestic and international markets. In order to survive and stay competitive in the business, manufacturers have to improve their capability and performance and do so continuously. Quality improvement, efficient production, efficient production process, and cost control are crucial factors for manufacturers. These can be achieved with many tools and techniques.

This thesis is to conduct a study about the reduction of the defect in aluminum casting by using Design of Experiment or DOE as a tool. DOE is a structured, organized method for determining the relationship between factors (Xs) affecting a process and the output of that process (Y).

The objective of the DOE is to identify significant factors that affect output response and help suggest the better levels of factors to be operated.

DOE is built on the foundation of the analysis of variance, a collection of models in which the observed variance is partitioned into components due to different factors which are estimated and/or tested.

The benefits of employing DOE in aluminum casting business are twofold, firstly, it helps company to reduce product and process variation. Secondly, it helps the company to optimizing product and process performance and consistency.

1.1 Company Background

Suwan Supply Co., Ltd., established in 1972, is a family-owned business specializing in manufacturing cast aluminum home and garden furnishing products, such as gates, fences, balusters, patio & garden furniture, and accessories. The market for company is from both domestic and international market.

The production process consists of casting, assembling, smoothing There are 80 workers in the production process. The maximum capacity can meet an average of 25.5 tons per month.

The following are the descriptions for each production processes.

Casting

The casting process is the core production for the business. Aluminum alloy will be melted in the furnace under the temperature of 500° C. While waiting for aluminum alloy to be melted the worker will press the pattern to the fine sand to make the sand mold. After the alloy is melted it will be poured into the sand mold to make the product. As soon as the alloy is cool down the product will be transferred to the grinding process.

Grinding

Grinding is the process that is done to remove unnecessary or extraneous elements on product part produced from the casting process.

Assembling

The assembly process is the process that joints the parts that have been cast separately from the casting process together by using welding machine. After all the parts are jointed together it will be transferred to the smoothing process.

Smoothing

After the welding process the product will pass though the smoothing process. This process consists of milling, painting filling, and filing. The reason to do this process is to smooth the surface before goes to next process.

Primer Coating

Before a product is painted with actual color, it has to be coated with the primer in order to make final finishing adhered to the product. Primer coating will allow the operator to investigate the tidiness of the product. If the product is not well smoothed it will become apparent in this process. The defective product will then be returned to the smoothing process for some rework.

Coloring

Coloring process is the final production process. There are two coatings that are sprayed on the product. Primarily, the product is coated with base color, which is applied to make the final coating or the actual color better adhere to the product. Then, the product is coated in actual color.

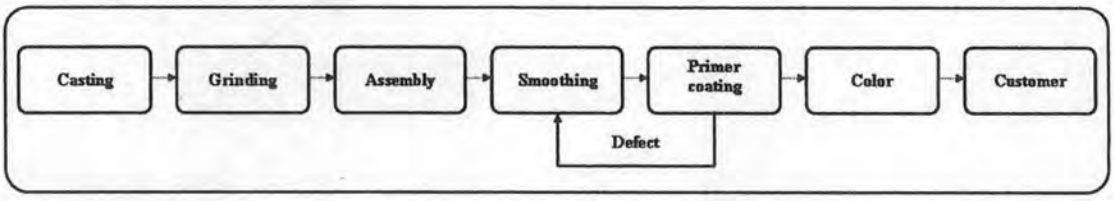

Figure 1.1: Production Process

1.2 Statement of Problem

After studying the production process of the company, many defects are found in every production process. Some defects do not happen regularly but some defects happen on almost every piece of the product. The following are examples of defects that occur during production process.

The defects that occur from the casting process are

- Weight of identical pieces is inconsistent that it is not acceptable since some of the products is sold by weight.
- Misshape/irregularity in products is found, for example, some product is too thin or has some details missing.
- The product element is too loosely.
- Cavities in the product that reduces strength and durability of product.

The defect that occurs from the assembly process is

- Joint spots are too apparent and unsightly.

The defects that occur from the coloring process are

- Wrong color from the order form is mistakenly painted on products.
- Cracked/chipped color
- Blister on surfaces of products
- Some products are not fully painted

The defect that occurs from the transporting process is

- Color cracks/chips during transportation

The table below shows defective report of the production process. The table shows the number of defects that occur in each process, which the most of the defects occur during the casting process. As a result, the company loses the most amounts of resources and time in this process.

Table 1.1: Defective report of Production process

Process	Inspection Quantity (pcs)	Defective (pcs)	Defective (%)
Casting	341	341	100
Grinding	46	0	0
Assembling	46	3	6.5
Smoothing	46	16	34
Primer Coating	46	6	13
Coloring	46	2	4.3
Total	571	368	64.49

Refer to defect list in the casting process from above statement, defects can be categorized into 7 categories as follow.

1. Metallic Projections
2. Cavities
3. Discontinuity
4. Defective Surface
5. Incomplete Casting
6. Incorrect Dimensions
7. Inclusion or Structural Anomalies

The following table illustrates the number of pieces that have defects in each category during the casting of a Flamingo garden set.

Table 1.2: Number of Defect in the casting process

Part Name	Inspection Quantity (pcs)	Defect Type						
		A	B	C	D	E	F	G
Chair's Front Leg	74	69	54	0	74	0	0	0
Chair's Back Leg	74	71	42	0	74	0	0	0
Seat	37	37	35	5	37	0	0	1
Backrest	37	37	31	1	37	1	0	0
Left Arm	37	37	33	0	37	0	0	0
Right Arm	37	37	35	0	37	0	0	0
Table's leg	36	35	34	0	36	0	0	0
Desktop	9	9	7	1	9	0	0	0
Total	341	332	271	7	341	1	0	1

Remark: A = Metallic Projections
B = Cavities
C = Discontinuity
D = Defective Surface
E = Incomplete Casting
F = Incorrect Dimensions
G = Inclusion or Structural Anomalies

Refer to *Table 1.2*, the top three defects of the casting are Defective surface, Metallic Projections, and Cavities, respectively. *Table 1.3* shows level of severity of top three defects type.

Table 1.3: Level of severity of top three defect types

Part Name	Quantity (pcs)	Metallic Projection	Cavities	Defective Surface Level of Severity				
		AD/P	AD/P	1	2	3	4	Mean
Chair's Front Leg	74	1.89	1.66	0	14	44	16	3.03
Chair's Back Leg	74	2.03	1.06	0	17	34	23	3.08
Seat	37	2.32	1.81	0	4	22	11	3.19
Backrest	37	5.08	2.03	0	2	21	14	3.32
Left Arm	37	2.03	2.24	0	10	20	7	2.91
Right Arm	37	2.16	2.22	0	6	21	10	3.11
Table's leg	36	1.86	1.97	0	9	20	7	2.94
Desktop	9	2.11	2.44	0	2	6	1	2.89
Total	341	2.36	1.76	0	64	188	89	3.07

Remark: AD/P = Average Number of Defect per Piece

$$\text{Mean} = \frac{(1 \times \text{No. of Level A}) + (2 \times \text{No. of Level B}) + (3 \times \text{No. of Level C}) + (4 \times \text{No. of Level D})}{\text{Inspection Quantity}}$$

Defective Surface: Level of Severity

1 = 0% - 25% of surface part is defected
2 = 26% - 50 % of surface part is defected
3 = 51% - 75% of surface part is defected
4 = 76% - 100% of surface part is defected

In *Table 1.3* the number of defects in categories of Metallic Projection and Cavities represents the average number of defects per piece but the number of defects due to Defective surface represents the number of pieces that fall into each level of severity.

1.3 Objective

The objective of this research is to reduce defect rate in alloy casting process.

1.4 Scope of the Study

1. The scope of the study is focused on casting process of 'Flamingo' garden set. The parts this experiment will focus on are chair's front legs and back legs.
2. Top three defect types, which are Metallic Projection, Cavities, and Defective Surface, will be studied and reduced.

Figure 1.2: Flamingo garden set

1.5 Research Methodology

1. Study literature related to DOE technique.
2. Study in depth about causes of defects in casting process from academic source.
3. Collect all available background information.
4. Define the objectives of the research.
5. Identify responses and potential factors.
6. Prioritize factors and select factors to include in the experiment.

7. Conduct the Design of Experiment to test whether the factors under study significantly affect the responses of interest.
8. Select levels of factor to operate.
9. Measure defect rate after the improvement.
10. Make conclusion and recommendations.
11. Write up thesis and submit thesis.

1.6 Schedule

Table 1.4 Gantt chart of thesis schedule

Task description	Week											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Study DOE.												
2. Study casting process.												
3. Collect the background information.												
4. Define the objective.												
5. Identify responses and potential factors												
6. Prioritize factors and select factors to include in the experiment.												
7. Conduct the Design of Experiment.												
8. Select levels of factor to operate.												
9. Measure defect rate after the improvement.												
10. Make conclusion and recommendation.												
11. Write up and submit thesis.												

1.7 Expected Results

The expected benefits from the research are the acknowledgement of factors that significantly affect the defect rate of the three defect types under study and the chosen level of factors to be operated.

1.8 Expected Benefits

The expected results from the research are the reduction of defect rate in alloy casting products, subsequently, increase productivity and quality of products.