Chapter V

The Use of the DSMP for a Decision-maker

Before implementing the DSMP to the system, the users need to understand how to use the DSMP and its functions for the efficiently and effectively use of it. According to the objective in developing the DSMP, the functions of the system can be categorized into two main functions. These are to select and to make the suitable maintenance plan for the printing machinery. The use of each DSMP function is described as follows:

5-1 Selecting the Maintenance Plan

To optimize the costs and performance of the equipment, the DSMP provides ability to help a manager select the suitable maintenance plan by recommending the preventive tasks for the plan.

Recommendation of the preventive task: The preventive tasks are selected by considering the costs and effect of the related machine failure and the costs to perform the task. According to the decision model in the figure 4.2, the criteria for selecting the preventive tasks are

(1) The machine failure that relates with the preventive task effects the safety of the work.

(2) The costs per unit time of the preventive task are less than the costs per unit time of the machine failure.

In the DSMP, the user can use the job recommendation command in the maintenance cost menu to view the list of the recommended task for the maintenance plan. The steps in selecting the preventive tasks for the maintenance plan in the DSMP are described as follows:

(1) **Identify the relationship between the preventive task and the machine failure**: A decision-maker can identify the relationships between the preventive tasks and the machine failures through the relationship form in the input menu. He can view the relationships by using the cost relationship command in the maintenance cost menu. The figure 5.1 presents the relationship table file. The data in the relationship table are consisted of the number of the preventive task and the failure type, the

costs per unit time of the both preventive and corrective maintenance, and the effects of the machine failures.

Relationship

Mc_no	Job_no	Failure_no	Failure_effect	Pm_cost	Cm_cost
P01	P-P01-01	P01-002	PRODUCTION	0.83	0.00
P01	P-P01-01	P01-003	PRODUCTION	0.83	1.62
P01	P-P01-01	P01-007	PRODUCTION	0.83	0.00
P01	P-P01-02			0.28	0.00
P01	P-P01-03	P01-031	PRODUCTION	0.28	0.00
P01	P-P01-07	P01-001	SAFETY	0.28	0.00
P01	P-P01-07	P01-014	PRODUCTION	0.28	0.00
P01	P-P01-07	P01-015	PRODUCTION	0.28	0.00
P01	P-P01-08			3.33	0.00
P01	P-P01-09			0.28	0.00
P01	P-P01-10			0.28	0.00
P01	P-P01-11			0.28	0.00
P01	P-P01-12			3.33	0.00
P01	P-P01-13			3.33	0.00
P01	P-P01-14	P01-019	QUALITY	3.33	0.00
P01	P-P01-15			0.28	0.00
P01	P-P01-16	P01-018	QUALITY	3.33	0.00

Figure 5.1 Relationship Table File.

(1) **Calculate the costs of the preventive maintenance tasks and the machine failures**: A decision-maker can calculate the costs of each preventive task and machine failure by using the preventive and breakdown maintenance cost commands in the maintenance cost menu. The details of the costs of both maintenance policies are presented after using these commands as presented in figure 5.2 and 5.3.

In the figure 5.2, the costs of preventive task are consisted of the labor cost and the material cost. These costs are represented in the PM labor cost and PM material cost fields respectively. The data in the frequency field represent the frequency in performing each preventive task. The PM costs per day presented in the relationship tale are calculated by dividing the total costs of preventive task with the frequency.

In the figure 5.3, the costs of machine failure compose of the loss from machine downtime, the cost of hiring the subcontractor, the cost of labor overtime due to failure, the cost of material used in the maintenance work, and the opportunity loss from the production stoppage. These data are presented in the cost fields in the CM costs table. The data in the MTBF field are represented the mean time between failure of each failure type.

The CM costs per day presented in the relationship tale are calculated by dividing the total costs of machine failure with the MTBF.

Pm_cost

Mc_no	Job_no	Frequency	Pm_labor_cost	Pm_mat_cost
P01	P-P01-01	30	25.00	0.00
P01	P-P01-02	30	8.50	0.00
P01	P-P01-03	30	8.50	0.00
P01	P-P01-07	30	8.50	0.00
P01	P-P01-08	30	100.00	0.00
P01	P-P01-09	30	8.50	0.00
P01	P-P01-10	30	8.50	0.00
P01	P-P01-11	30	8.50	0.00
P01	P-P01-12	30	100.00	0.00
P01	P-P01-13	30	100.00	0.00
P01	P-P01-14	30	100.00	0.00
P01	P-P01-15	30	8.50	0.00
P01	P-P01-16	30	100.00	0.00

Figure 5.2 Costs of Preventive Maintenance Task.

Cm_cost

Mc_no	Failure_no	Mbf	Downtime_loss	Subcontract_cost	Overtime_cost	Mat_cost	Production_loss
P01	P01-001	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-002	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-003	1210.83	175.50	610.00	0.00	2366.67	1170.00
P01	P01-004	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-005	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-006	1206.67	799.50	3330.00	675.00	4333.33	5330.00
P01	P01-007	0.00	300.00	0.00	0.00	1500.00	2000.00
P01	P01-008	132.50	300.00	0.00	225.00	2800.00	2000.00
P01	P01-009	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-010	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-011	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-012	2418.25	862.50	3250.00	337.50	45130.00	5750.00
P01	P01-013	2421.75	337.50	1250.00	0.00	2790.00	2250.00
P01	P01-014	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-015	0.00	0.00	0.00	0.00	0.00	0.00
P01	P01-016	120.50	600.00	2000.00	0.00	0.00	4000.00

Figure 5.3 Costs of Machine Failure.

(2) **Recommend the preventive tasks**: A decision-maker can compare the preventive tasks and the machine failures by using the job recommendation command in the maintenance cost menu. The relationship data in the figure 5.1 are used for comparing and recommending the suitable preventive task from the criteria that are defined in the DSMP programs.

In the figure 5.1, the preventive tasks are represented by the job number field in the relationship table, while the machine failure are represented by the failure number field in the same table. The effects of the machine failures are shown in the failure effect field. The costs per day of the preventive and corrective maintenance of each task are presented in the PM and CM cost fields in the figure 5.1 respectively. By using these data, the DSMP programs will recommend the suitable preventive tasks for the maintenance plan. For example, the DSMP programs add the job P-P01-07 into the recommended list, since the effect of the machine failure related to this task is the safety. While the PM costs per day of the job P-P01-01 is 0.83 Baht, the CM costs per day of related failure P01-003 is 1.62 Baht. The DSMP programs select the job P-P01-01 in the recommended list, since its costs per unit time are less than the costs of the related failure.

(3) **Add the recommended tasks to the preventive job list**: After using the job recommendation command, the list of the recommended tasks will be presented to a decision-maker. A decision-maker needs to manually add these recommended tasks to the preventive job list through the job list form in the input menu.

5-2 Making the Maintenance Plan

The DSMP software provides the abilities to help a manager in making the maintenance plan. These abilities are composed of the direct command for making the maintenance plan and the indirect commands for supporting the maintenance planning. The three main commands for making the maintenance plan in the DSMP are to identify the optimum frequency of the maintenance task, to schedule the maintenance plan, and to measure the performance of the maintenance plan and work.

Identification of the optimum frequency for the maintenance task: The frequency to perform the preventive task can be optimized by using the frequency model command in the frequency model menu. The steps in determining the optimum frequency are presented as the following.

(1) **Input the preventive and the related machine failure data**: A decision-maker must input the data of the preventive task and the related failure through the parameter form in the frequency model menu. These data are the preventive task number and the costs of the preventive task and the related machine failure.

(2) **Determine the frequency for the preventive task**: The costs of the preventive tasks and the related failure are used with the machine failure data from the database to determine the optimum frequency for the preventive task. These data are used to replace in the optimal maintenance model in the section 4-3-4 for determining the expected costs of the maintenance and the optimum frequency. The figure 5.4 presents the optimum frequency and the expected cost for the specific preventive job number. These data are presented in the interval and expected cost fields respectively. The expected cost in the figure 5.4 is calculated by the optimal maintenance model. Several frequencies ranged from 1 to 365 days are replaced into the optimal model to find the minimum expected cost. By the trial and error method, the optimum frequency that minimizes the expected cost can be identified. For example, the optimum frequency of the job number P-P01-01 is 2 days, while the expected maintenance cost per day of this task is 45.21 Baht. A decision-maker can use this frequency to schedule the maintenance plan by changing the frequency of the specific task in the job list form.

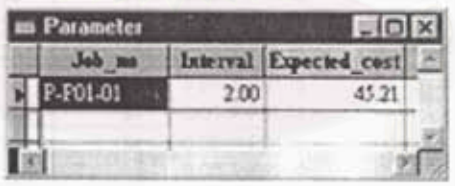


Figure 5.4 Optimal Frequency and Expected Cost of Preventive Task.

Scheduling the maintenance plan: The DSMP can help a decision-maker in scheduling the preventive maintenance tasks from the job list table. The steps in scheduling the maintenance plan can be described as follows:

(1) **Identify the specific dates to perform the maintenance tasks**: Before scheduling the maintenance plan, a decision-maker has to identify the specific dates to perform the maintenance tasks of the same frequency. This can be done through the year plan parameter form in the year plan menu. For example, the specific date for the maintenance tasks to perform every month is on the seventh day of the third week of every month.

(2) **Set the primary or yearly maintenance plan**: After the dates for performing the tasks are specified, the primary or yearly maintenance plan is set by using the setting plan command in the year plan menu. A decision-maker can identify the number of hours to perform the maintenance work for each day in the question form before setting the plan. The figure 5.5 presents the primary maintenance plan the in year plan table. The data in this table contain the date, the available hours, the machine number, the job number, the work hours, and the workforces of each task. These data present the information of dates to perform the preventive tasks and the data of the preventive tasks. For example, the date to perform the job number P-P01-01 is January 2nd, 1999. In the figure 5.5, the available hour of this date is 8 hours. The frequency to perform the task is every 30 days. The work hour used to perform the P-P01-01 task is 0.50 hour or 30 minutes, while the only one workforce is required to perform this preventive task.

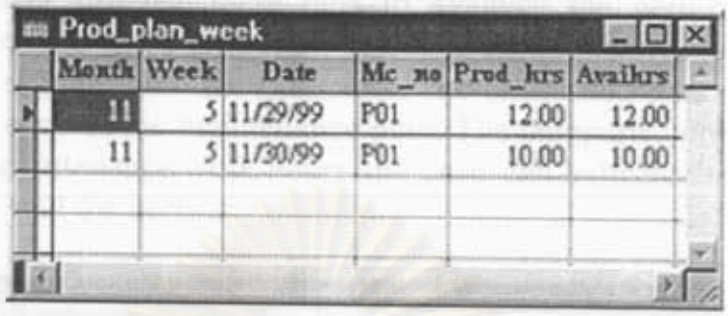
Year_plan

Mc_no	Exp_2	Week	Date	Day_no	Availhrs	Job_no	Frequency	Workforces	Workhrs
P01	1	1	01/02/99	7	8.00	P-P01-01	30	1	0.50
P01	1	1	01/02/99	7	8.00	P-P01-02	30	1	0.17
P01	1	1	01/02/99	7	8.00	P-P01-03	30	1	0.17
P01	1	1	01/02/99	7	8.00	P-P01-07	30	1	0.17
P01	1	1	01/02/99	7	8.00	P-P01-08	30	2	1.00
P01	1	1	01/02/99	7	8.00	P-P01-09	30	1	0.17
P01	1	1	01/02/99	7	8.00	P-P01-10	30	1	0.17
P01	1	1	01/02/99	7	8.00	P-P01-11	30	1	0.17
P01	1	2	01/04/99	2	8.00	P-P01-12	30	2	1.00
P01	1	2	01/05/99	3	8.00	P-P01-13	30	2	1.00
P01	1	2	01/05/99	3	8.00	P-P01-14	30	2	1.00
P01	1	2	01/05/99	3	8.00	P-P01-15	30	1	0.17
P01	1	3	01/15/99	6	8.00	P-P01-16	30	2	1.00
P01	1	3	01/15/99	6	8.00	P-P01-19	30	1	1.00
P01	1	2	01/06/99	4	8.00	P-P01-20	30	1	0.50
P01	1	2	01/06/99	4	8.00	P-P01-21	30	1	0.17
P01	1	2	01/06/99	4	8.00	P-P01-22	30	1	0.17
P01	1	2	01/06/99	4	8.00	P-P01-23	30	1	0.08
P01	1	2	01/06/99	4	8.00	P-P01-24	30	1	0.08

Figure 5.5 Yearly Maintenance Plan.

(3) **Identify the weekly production plan**: From the yearly maintenance plan in the figure 5.5, a decision-maker can use the information in this plan to set the more accurate plan by considering with the weekly production schedule. A decision-maker can record the information of the weekly production plan into the database through the production plan form in the weekly plan menu. The figure 5.6 presents the example of weekly production plan in the production plan table. The data in this table are

consisted of the date to perform the production, the machine number, the production work hours, and the available hours. These data are used to compare with the maintenance schedule.

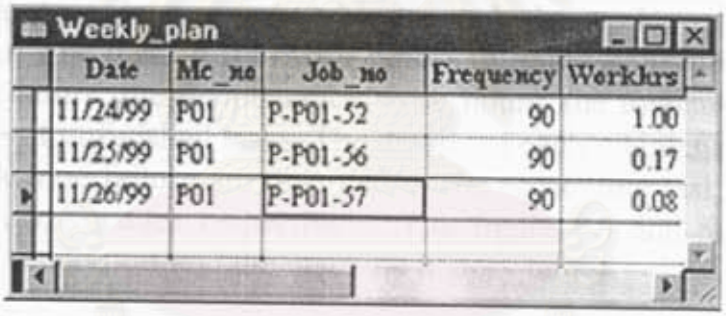


Prod_plan_week

Month	Week	Date	Mc_no	Prod_hrs	Availhrs
11	5	11/29/99	P01	12.00	12.00
11	5	11/30/99	P01	10.00	10.00

Figure 5.6 Weekly Production Plan.

(4) **Set the weekly maintenance plan**: The weekly maintenance plan is scheduled from the primary plan and the weekly production plan. By using the setting plan command in the weekly plan menu, the maintenance plan is rescheduled to match the production plan. The example of the weekly maintenance plan is presented in the figure 5.7.



Weekly_plan

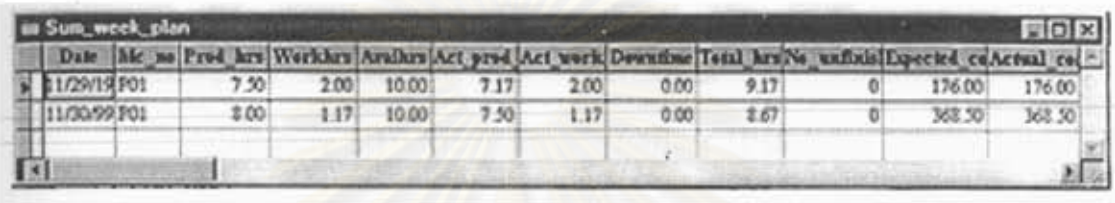
Date	Mc_no	Job_no	Frequency	Workhrs
11/24/99	P01	P-P01-52	90	1.00
11/25/99	P01	P-P01-56	90	0.17
11/26/99	P01	P-P01-57	90	0.08

Figure 5.7 Weekly Maintenance Plan.

In the figure 5.7, some of the important data from the primary plan are presented in the weekly plan. These data are the date to perform each task, the machine number, the job number, the frequency, and the work hours. The decision-maker can order the operators to perform the maintenance tasks following the dates of the task numbers in this plan.

(5) **Identify the expected values for the maintenance plan**: After setting the weekly maintenance plan, the plan is summarized into the maintenance report. The expected values, such as costs and work hours, are calculated for comparing with the actual work results. The maintenance summary table is presented in the figure 5.8. This table presents the data of the date, the machine number, the expected and actual production hours, the

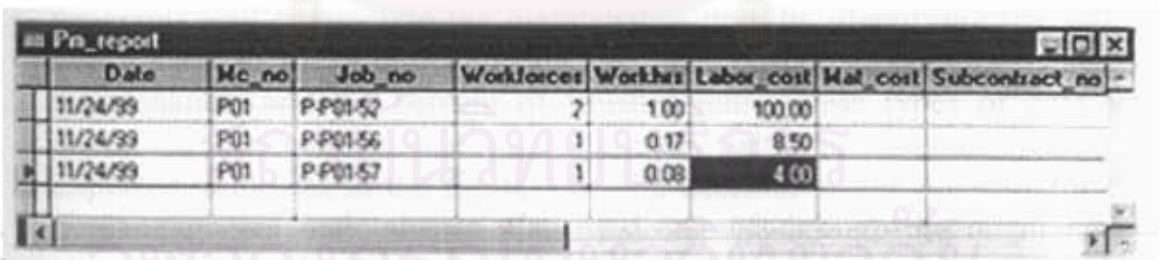
expected and actual maintenance work hours, the available time for each day, the machine downtime, the total hours, the number of jobs and the unfinished jobs, and the expected and actual costs of maintenance. The decision-maker can use these data to evaluate the performance of the maintenance plan and work. The number of the preventive jobs to perform is used to compare with the number of the unfinished jobs for evaluating the performance of the maintenance plan. The comparison of the expected and actual maintenance work hours and costs can indicate the performance of operators and the accuracy of the plan.


Sum_week_plan

Date	Mc_no	Prod_hrs	Workhrs	Availhrs	Act_prod	Act_work	Downtime	Total_hrs	No_unfinis	Expected_co	Actual_co
11/29/19	P01	7.50	2.00	10.00	7.17	2.00	0.00	9.17	0	176.00	176.00
11/30/99	P01	8.00	1.17	10.00	7.50	1.17	0.00	8.67	0	368.50	368.50

Figure 5.8 Maintenance Summary Report.

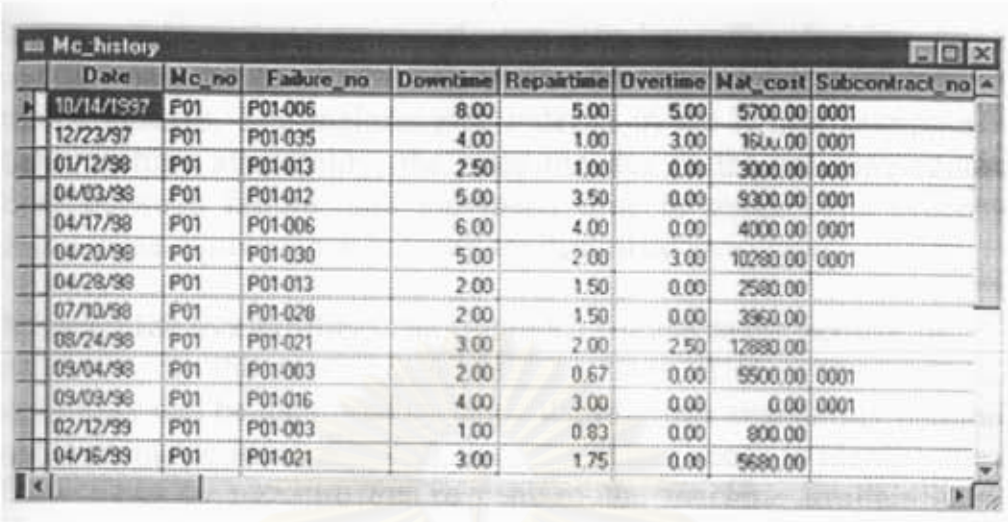
(6) **Report the maintenance work results**: After the maintenance tasks are performed, the actual maintenance work results are recorded into the weekly maintenance summary table through the work report form in the input menu. The data in the work report form are consisted of the actual production hours, the maintenance work hours, the total work hours, and the number of unfinished tasks. The details of each maintenance task report and the machine failure are recorded in the preventive task report and the machine history tables respectively. The figure 5.9 and 5.10 present the preventive task report and the machine history tables.


Pm_report

Date	Mc_no	Job_no	Workforces	Workhrs	Labor_cost	Mat_cost	Subcontract_no
11/24/99	P01	P-P01-52	2	1.00	100.00		
11/24/99	P01	P-P01-56	1	0.17	8.50		
11/24/99	P01	P-P01-57	1	0.08	4.00		

Figure 5.9 Preventive Task Report.

The figure 5.9 presents the data of the preventive task results. The data in this table are the date, the machine number, the job number, the workforces, the work hours, the frequency, the labor cost, the material cost, and the subcontract number. These data are used to summarize into the maintenance work report for comparing with the expected values in the maintenance plan.



Mc_history

Date	Mc_no	Failure_no	Downtime	Repairtime	Overtime	Mat_cost	Subcontract_no
10/14/1997	P01	P01-006	8.00	5.00	5.00	5700.00	0001
12/23/97	P01	P01-035	4.00	1.00	3.00	16uu.00	0001
01/12/98	P01	P01-013	2.50	1.00	0.00	3000.00	0001
04/03/98	P01	P01-012	5.00	3.50	0.00	9300.00	0001
04/17/98	P01	P01-006	6.00	4.00	0.00	4000.00	0001
04/20/98	P01	P01-030	5.00	2.00	3.00	10280.00	0001
04/28/98	P01	P01-013	2.00	1.50	0.00	2580.00	
07/10/98	P01	P01-028	2.00	1.50	0.00	3960.00	
08/24/98	P01	P01-021	3.00	2.00	2.50	12880.00	
09/04/98	P01	P01-003	2.00	0.67	0.00	9500.00	0001
09/09/98	P01	P01-016	4.00	3.00	0.00	0.00	0001
02/12/99	P01	P01-003	1.00	0.83	0.00	800.00	
04/16/99	P01	P01-021	3.00	1.75	0.00	5680.00	

Figure 5.10 Maintenance Failure History.

In the figure 5.10, the data of the machine failure record are presented. These data are consisted of the dates of failures, the machine number, the failure number, the downtime, the repair time, the overtime due to failure, the costs of material, and the subcontract number. The decision-maker can view these data to consider the characteristics of machine failures. These data are used for calculating the costs of maintenance and the maintenance indexes.

(7) **Update and Summarize the maintenance report**: When the data of the daily maintenance work report is recorded into the DSMP database, the users can reschedule the unfinished tasks and update the maintenance plan by using the update plan command in the work report form. The DSMP programs will summarize the maintenance plan by identifying the actual hours used in the production and the maintenance works, the costs of maintenance, and the percent of finishes jobs. These types of data are stored in the maintenance plan summary table to compare with the expected values as in the figure 5.8. The decision-maker can monitor the performance of maintenance plan as discussed through the maintenance summary report by using the report commands in both yearly and weekly plan menus.

According to the figure 5.8, the expected and actual maintenance work hours on the November 29th, 1999 are 2 hours, while the expected and the actual of costs of maintenance on the same date are 176.00 Baht. From these results, the maintenance plan of this date can be considered to be accurate, since the actual results are as same as the expected values.

Identification of the maintenance performance indexes: The decision-maker can measure the performance of the maintenance plan by considering the maintenance indexes. The maintenance indexes in the DSMP compose of the percent of machine availability, the overtime due to the machine failure, the mean time between failure, and the mean time to repair. The processes in determining these maintenance indexes are described as follows:

(1) **The machine availability**: The figure 5.11 presents the percent of machine availability in the machine availability table. The percent of machine availability can be identified by using the machine availability command in the maintenance index menu. A decision-maker needs to identify the range of the dates to measure the percent of the machine availability before calculating. The percent of machine availability helps a decision-maker to measure the effectiveness of the maintenance plan in maximizing the use of the company equipment. A decision-maker can compare the percents of the machine availability at the different ranges of time to evaluate the utilization of the machine.

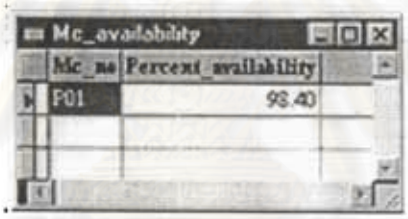


Figure 5.11 Percent of Machine Availability.

(3) **The percent of the overtime due to failure**: The overtime due to the machine failure is used to evaluate the performance of machinery and maintenance operations. The percent of machine overtime due to failure can be identified by using the machine overtime command in the maintenance index menu. In the figure 5.12, the percent of overtime for the specific range of time is presented in the machine overtime table. The decision-maker has to specify the range of dates to measure the percent of machine overtime before calculating. The percent of overtime can indicate the decrease of the number of machine failures. It may reflect the performance of the operators or the subcontractor in repairing the machine.

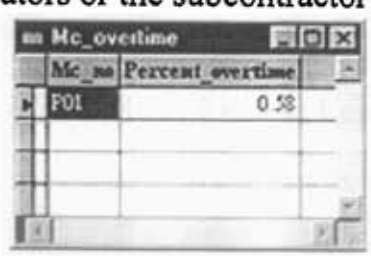


Figure 5.12 Percent of Machine Overtime due to Failure.

(3) **The mean time between failure and mean time to repair:** The figure 5.13 and 5.14 present the days of the mean time between failure and the mean time to repair for each type of failure. For example, the average time that the failure number P01-003 is occurred are 1,210.83 days, while the average repair time of this failure is 0.39 hours. These index values are calculated from the past data of machine failures by using the models in the DSMP programs. They can be identified by using the mean time between failure and mean time to repair commands in the maintenance index menu. The mean time between failure and the mean time to repair are used in the optimal maintenance model for finding the optimum frequency of the preventive task. The decision-maker can use the mean time between failure indexes to measure the effectiveness of preventive task in reducing the chance of related machine failure. For the mean time to repair index, a decision-maker can use to monitor the performance of the maintenance work in correcting failure.

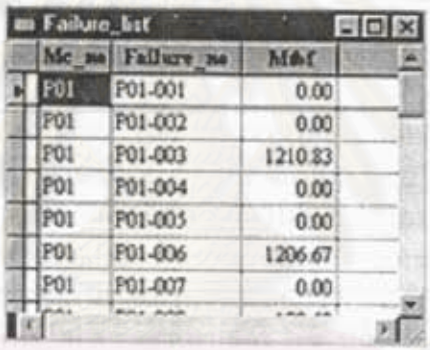


Figure 5.13 Mean Time between Failure.

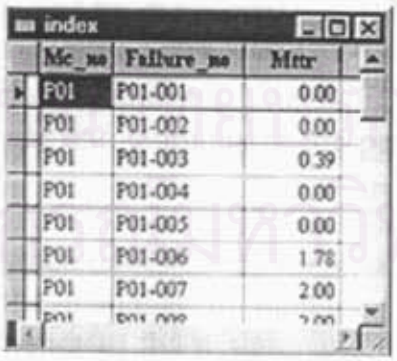


Figure 5.14 Mean Time to Repair.