Chapter VI

Implementation

After developing the DSMP, the system is implemented by applying in the environment of the maintenance work of the printing machinery. The case of Bangkok Printing Company is used in this research. The DSMP is evaluated for its capabilities in solving the problems of maintenance planning and scheduling in the printing process. It is applied to support the manager in planning and scheduling of the maintenance tasks of the printing machinery in the case study company. The characteristics and problems of the maintenance and related works of the printing machinery in Bangkok Printing Company are described as follows:

6-1 Characteristics and Problems of the Maintenance Work of the Company

In the case study company, the corrective maintenance policy is mostly applied to maintain the performance of the equipment. The maintenance tasks are performed, when the failures occur to the equipment. The operators who control the machine are responsible for the simple corrective tasks. These tasks normally require the simple skills to perform. The complex maintenance tasks that require the expert skills are performed by the subcontractors outside the company. The examples of these tasks are the electronic and electrical works. Some of the preventive tasks, such as the lubricating and cleaning works, are performed occasionally. These preventive tasks are done without planning and scheduling. They are performed by the operators. There is no record of the data regarding the preventive activities. The only data to be recorded are the maintenance tasks for correcting the machine failures. There is no activity in analyzing the data to monitor and summarize the performance and the costs of the equipment.

According to the characteristics of the maintenance work in the company, there are difficulties for the manager to manage the maintenance activities. Since the costs and performance of the maintenance of the machinery cannot be monitored, the effectiveness of the maintenance policy applied in the company cannot be evaluated. For the case of the company, to apply the corrective maintenance policy can increase the costs of maintenance, since it allows the failures to occur without prevention. The machine breakdown causes many losses to the company. These losses are the loss in performance of equipment, the loss in production, the loss in the quality of products, and the opportunity

loss. The machine breakdown decreases the performance and availability of the printing machinery. This effects the production of the company to be not on the schedule.

To increase the performance of the printing machine and to reduce the losses from the machine breakdown, the preventive policy needs to be applied. It can help to reduce the loss from the unprepared machine breakdown. However, the preventive maintenance has a lot of expenses. Some of the preventive tasks have higher costs than the related corrective maintenance tasks. In order to optimize the costs and the performance of maintenance, the DSMP can help a decision-maker to select the suitable preventive tasks that minimize the costs of maintenance. It also helps a decision-maker to set the maintenance plan and schedule by considering with the production schedule. The DSMP can support a decision-maker by analyzing and summarizing the maintenance data in order to monitor the performance and the costs of maintenance.

6-2 Implementation of the DSMP Software

The purposes of implementing the DSMP software in maintenance planning and scheduling of the printing machinery are:

(1) To determine the capability of the DSMP in solving the problems of maintenance planning and scheduling.

(2) To identify the limits and errors of the system software for improvement, suggestion, and further development.

To implement the DSMP software in the real work requires a lot of time to collect the data and information for evaluating the results. While the time of the research is tight and limited, the DSMP software can also be implemented by simulating the situations that occur in the maintenance work of the printing machinery.

In order to simulate the situations in the maintenance work, the data regarding the maintenance and production of the printing process in Bangkok Printing Company are used. The different situations in the maintenance planning and scheduling are simulated to measure the capability of the DSMP. The results from running the system software are the maintenance plan, the costs of maintenance, and the maintenance performance indexes. These results will be used to consider and to compare for determining the limits and errors of the system.

To measure the capability of DSMP in the different conditions, the software is run by applying the two maintenance policies: the corrective and preventive maintenance. These policies are applied in the DSMP software by using the same simulated production situation. The past production schedule and the machine failure history are used as the inputs to simulate the production process and the machine failure situations. The various situations are simulated in order to determine the limits and errors of the system for improvement. The tight production schedule, the machine downtime, the special jobs, and the overtime will be simulated while running the system. The output results from running the system software are used to prove and to evaluate the capability of the system. The examples of the output results are the maintenance plan and the job summary.

The processes in implementing the DSMP software by applying the corrective and preventive maintenance policies are described as follows:

(1) For the preventive maintenance policy, the preventive tasks are selected by using the job recommendation command in the maintenance cost menu as shown in table 6.1. The processed data in the table 6.1 are based on the information of the past failure records. For corrective maintenance policy, the process starts at (3).

Table 6.1: List of Recommended Maintenance Tasks

mc_no	job_no	failure_no	failure_effect	pm_cost	cm_cost
P01	P-P01-01	P01-003	PRODUCTION	0.83	1.62
P01	P-P01-07	P01-001	SAFETY	0.28	0
P01	P-P01-19	P01-024	QUALITY	1.67	19.06
P01	P-P01-20	P01-028	QUALITY	0.83	17.36
P01	P-P01-21	P01-003	PRODUCTION	0.28	1.62
P01	P-P01-22	P01-024	QUALITY	0.28	19.06
P01	P-P01-28	P01-016	PRODUCTION	13.33	58.24
P01	P-P01-39	P01-037	SAFETY	0.28	3.42
P01	P-P01-47	P01-003	PRODUCTION	1.11	1.62
P01	P-P01-56	P01-016	PRODUCTION	0.09	58.24
P01	P-P01-71	P01-003	PRODUCTION	0.05	1.62

(2) After selecting the preventive tasks, the yearly maintenance plan is set by using the year plan command in the year plan menu. The example of yearly maintenance plan is presented in table 6.2.

Table 6.2: Sample of Yearly Maintenance Plan

mc_no	date	avaihrs	job_no	frequency	workforces	workhrs
P01	2/1/99	8	P-P01-01	30	1	0.5
P01	2/1/99	8	P-P01-02	30	1	0.17
P01	2/1/99	8	P-P01-03	30	1	0.17
P01	2/1/99	8	P-P01-07	30	1	0.17
P01	2/1/99	8	P-P01-08	30	2	1
P01	2/1/99	8	P-P01-09	30	1	0.17
P01	2/1/99	8	P-P01-10	30	1	0.17
P01	2/1/99	8	P-P01-11	30	1	0.17
P01	4/1/99	8	P-P01-12	30	2	1

(3) By using the past data of the production schedule, the production plan is simulated weekly as presented in table 6.3. For the preventive maintenance policy, the DSMP software will schedule the weekly maintenance plan by considering with the simulated production plan. The example of the weekly maintenance plan is shown in table 6.4.

Table 6.3: Weekly Production Plan

month	week	date	mc_no	prod_hrs	avaihrs
11	4	22/11/99	P01	12	12
11	4	23/11/99	P01	10	10
11	4	24/11/99	P01	7.5	8
11	4	25/11/99	P01	5.5	8
11	4	26/11/99	P01	7	8
11	4	27/11/99	P01	7	8

Table 6.4: Weekly Maintenance Plan

date	mc_no	job_no	frequency	workhrs
24/11/99	P01	P-P01-52	90	1
24/11/99	P01	P-P01-56	90	0.17
24/11/99	P01	P-P01-57	90	0.08

(4) After setting the production and maintenance plans, the production and maintenance reports are simulated. They are recorded daily in three report forms by using the past production report data. The types of data recorded in the work report form are: (1) the summary of hours used for the production, the maintenance tasks, and the machine failures, (2) the information of the maintenance tasks, and (3) the information of the machine failures.

(5) The DSMP programs will summarize the reported maintenance data. These data are the actual hours used for each activity, the costs of maintenance, and the number of jobs finished. The reported data will be compared with the expected data in the maintenance plan. The DSMP programs are executed by the update plan command in the work report form. For the preventive maintenance policy, this command is also used for rescheduling the unfinished maintenance tasks into the new specific dates. Table 6.5 presents some parts of the maintenance summary report.

(6) The processes (4) and (5) must be performed daily in order to update the maintenance plan and the summary report. The information of the maintenance summary report is recorded into the annual summary report (see appendix B, table B.1 and B.3) every week, when the process (3) is performed.

Table 6.5: Parts of Maintenance Summary Report

date	mc_no	prod_hrs	workhrs	act_work_hrs	downtime	expected_cost	actual_cost	breakdown_cost
1/2/99	P01	6	1.34	1.34	0	176	176	0
4/1/99	P01	7	1	1	0	100	100	0
5/1/99	P01	5	3	2	0	358.5	208.5	0
6/1/99	P01	7	0.5	0.5	0	50	50	0
7/1/99	P01	6	2	2	0	100	100	0
8/1/99	P01	8	0	0	0	0	0	0
9/1/99	P01	8	0	0	0	0	0	0
11/1/99	P01	8	0	0	0	0	0	0
12/1/99	P01	8	0	0	0	0	0	0
13/1/99	P01	8	0	0	0	0	0	0
14/1/99	P01	8	0	0	0	0	0	0
15/1/99	P01	5	1	2	0	150	150	0
16/1/99	P01	6	0	0	0	0	0	0
18/1/99	P01	6	5	4	0	500	483.5	0
19/1/99	P01	7	6	6	0	654	654	0
20/1/99	P01	7	4.17	4.17	0	4012.5	4012.5	0

(7) After the plan and the actual production and maintenance data are simulated, the maintenance indexes are identified by using the maintenance index commands in the index menu. These indexes are consisted of the maintenance costs, the machine availability, and the overtime due to failures The summary of the maintenance indexes for both preventive and corrective maintenance policies are presented in table 6.6.

Table 6.6: Maintenance Summary Indexes

	Corrective Maintenance	Preventive Maintenance
Preventive maintenance costs (Baht)	0.00	10,537.50
Breakdown maintenance costs (Baht)	185,902.50	125,002.50
Percent of MC availability	98.40	99.00
Percent of overtime due to failures	0.68	0.37

In order to run the DSMP software, the past production schedule records from 1st January to 30th November 1999 are used to simulate the weekly production plan and the situations. By applying the corrective maintenance policy, the maintenance tasks are performed only when the failures occur. There is no preventive maintenance task to be scheduled. The data of the machine failures from January to November 1999 is recorded in the maintenance failure report form. The machine downtime, the repair time, the costs of materials, and the over time due to failures are used for calculating the maintenance indexes. The total hours and costs of the maintenance activities are summarized and reported in the maintenance summary. The details of the daily maintenance summary for the corrective maintenance are presented in appendix B.

To apply the preventive maintenance policy in implementing the DSMP software, the preventive tasks are assumed to effect in the prevention of the machine failures. As a result, the machine failures that relate to the preventive tasks will not occur in the simulation. The preventive maintenance tasks are planed and scheduled by the software programs. The maintenance planning and scheduling are based on the information of production plan and the backlog orders. The maintenance plan and the summary report from 1st January to 30th November 1999 are presented in details in appendix B.

6-3 Results of the Implementation

The output results from implementing the DSMP software indicate the capability of the software in planning and scheduling of the maintenance tasks. When the corrective maintenance policy is applied, the DSMP software helps to

summarize and calculate the breakdown costs and the maintenance performance indexes. These costs and indexes are identified through the maintenance summary and the maintenance index reports. The summary of the total costs and indexes are presented in the table 6.6. These values help a decision-maker to monitor and measure the performance of maintenance and equipment when applying the corrective maintenance. The costs of the each machine failure type indicate the significance of the failure to the machine. They can be used to determine and select the suitable preventive maintenance tasks to minimize the total costs of maintenance. The percent of the machine availability and overtime due to failure are used to determine the performance of the machine. They also indicate the effectiveness of the maintenance policy that is applied in the system.

When the preventive maintenance policy is applied, the DSMP software is used to select the suitable preventive tasks for the maintenance plan. The list of the recommended tasks is used for maintenance planning. The selected preventive tasks are planned and scheduled based on the maintenance data and the production schedule. In the implementation process, the preventive tasks are scheduled into the primary year plan by the DSMP programs. The DSMP helps to update the maintenance primary plan into the more accurate weekly plan by considering with the weekly production plan. While the situations, such as the production schedule change, the backlog orders, and the machine breakdown, are simulated, the DSMP helps to update and reschedule the maintenance plan. The DSMP software is used to calculate the expected costs for each preventive task. This helps a decision-maker or manager to estimate the costs of the maintenance plan before performing the tasks.

After the maintenance tasks are performed, the DSMP helps to summarize and calculate the costs of these tasks and the performance indexes from the maintenance reports. In the summary report, the DSMP compares the actual values of the maintenance tasks with the expected values. These values are the costs of maintenance and the number of preventive tasks to perform daily. The comparison helps to evaluate the performance of the maintenance plan and works. The maintenance work is evaluated by comparing the expected costs, work hours, and workforces to perform each task with the actual values. The maintenance plan is evaluated by comparing the number of the tasks in the plan with the number of the finished tasks. The effectiveness of maintenance plan can also be measured through the maintenance indexes. The percents of the machine availability and the overtime due to failure can indicate the performance of the machine. By comparing these indexes between two points of time, a decision-maker can measure the performance of the maintenance plan in improving the equipment performance.

According to the data in the table 6.6, the breakdown costs, when applying the preventive policy, are decreased from 185,902.50 Baht to 125,002.50 Baht comparing with the breakdown costs of the corrective policy, while the preventive costs increase only 10,537.50 Baht. The increase of 10,537.50 Baht for performing the preventive tasks helps to reduce the breakdown costs of 60,900 Baht. This can save the money of 50,362.50 Baht or 27 % of the total costs of maintenance. This indicates the capability of the DSMP in reducing the total costs of maintenance.

The DSMP can be developed to decrease the total costs of maintenance by updating the failure and preventive task data. By inputting the data of the machine failures and the related preventive tasks in the database, more recommended tasks for the maintenance plan can be listed. The number of machine failures will decrease by performing those recommended tasks. As a result, the breakdown costs and the total costs of maintenance can be reduced.

The costs of preventive maintenance calculated by the DSMP do not include the downtime loss due to the stoppage of the operation. Since some of the preventive tasks are performed by the operators who control the machine, the operation has to stop when these operators perform the preventive tasks. However, the production schedule in the case study company is always tight during the middle and the end of the month, while there are some idle time during the rest of the month. As a result, the downtime loss can be avoided by scheduling the preventive tasks to perform during the idle time. This can be done by specifying the date for performing the maintenance tasks in the year plan menu. In addition, the DSMP program is defined to postpone and reschedule the maintenance tasks, when there are the job orders. For the long term, in order to avoid this downtime loss problem, the company needs to hire the maintenance staffs who are directly responsible for the maintenance work.

From the implementation, the DSMP can support a manager in setting the maintenance plan and schedule. It helps a manager to select the suitable maintenance tasks to minimize the total costs of maintenance. These maintenance tasks can be planned much more convenient and faster through the DSMP software. They are systematically and reliably planned, since the plan is based on the maintenance data and the production schedule. The manager can manage and control the information regarding maintenance much easier through the forms and the database in the DSMP. The manager can monitor and evaluate the performance of the maintenance plan, the maintenance work, and the equipment by considering the maintenance costs and the performance indexes from the DSMP.

From to the implementation of the DSMP software, the limitations of the DSMP can be identified as follows:

(1) The DSMP software cannot automatically reschedule the maintenance tasks that are once rescheduled from the back order list. The decision-maker needs to schedule these tasks manually in the DSMP database.

(2) The optimal frequency maintenance model in the DSMP program can identify the frequency of each preventive task in the limited range from one day to one year.

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