PREVENTIVE MAINTENANCE POLICY ON LARGE ENTERPRISE WITH CELLULAR MANUFACTURING SYSTEM

- 셀루라 제조시스템을 운영하는 대기업에서의 예방보전정책 -

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요 지

본 연구는 셀루라 제조방식을 갖고 있는 대기업에서의 예방보전에 관한 연구이다. 특히 24 시간운영하는 생산시스템을 갖고있으며, 보전요원이 충분한 업종이나 기업을 연구대상으로 하였다. 새로운 예방보전 절차를 제시하고 하나의 셀을 모델링하였다. 이 모델을 대상으로 시뮬레이션기법을 사용하여 기존에 절차와 비교분석하였다.

1. INTRODUCTION

The availability of production systems has become an important issue in today's industry. The success of process oriented manufacturing techniques, and highly automated production processes heavily depend on the reliability of the equipment. At the same time, a growing interest can be observed in the literature concerning the modelling of reliability of production systems and the analysis of the impact of disruptions on the performance. Consequently, the problems of repair, maintenance and replacement of a system component or an entire system are of interest to many researchers and production managers. Since the beginning of preventive maintenance modelling, papers have been published in the literature.

Sherif and Smith[8] reviewed the literature related to optimal maintenance models of systems subject to failure. The idea espoused by the loving care concept was that the reliability of the equipment is directly proportional to the frequency of maintenance. Flynn[4] presented a paper of critical machines preventive maintenance policies for group technology shops. These policies designated certain machines in the shop as critical. When a critical machine breaks down, it is repaired and preventive maintenance is applied to a block of machines. Hsu[7] researched Optimal preventive maintenance policies in a serial production system. He analyses the impact of a preventive maintenance policy on a serial production system without resorting to simulation.

The purpose of this study is to develop some preventive maintenance policies that are designed under cellular manufacturing circumstance.

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2. CHARACTERISTICS ON MANUFACTURING SYSTEMS

2.1 PM ON JOB SHOP MANUFACTURING

Job shop is a general manufacturing system. It is characterized as batch manufacturing. A batch of parts is started in the first bank of machines in the process. All the parts are machined in the first bank of machines, either on one machine or setup on multiple machines, before they are moved to the next bank of machines in the process

The whole batch moves from one bank of machines to the next until the parts are completely processed. The key in the job shop is the fact that all the machines in a specific bank are basically identical and therefore capable of performing the same operation. As a machine is required so that preventive maintenance can be performed, or a machine breaks down, the production supervisor has the flexibility to move a job from one machine to another within the bank of machines based do the priority of the job and the projected duration of the interruption.

With this kind of flexibility, the challenge to keep a PM program current and up to date is greatly reduced.

2.2 PM ON CELLULAR MANUFACTURING

Cellular manufacturing poses a totally different for production and maintenance. Instead of a bank of identical machines where a batch of parts moves from one bank to the next as in the job shop environment, the cell has an arrangement of different machines. As a schedule of parts is started, each part moves from machine to machine in the process until the part has been completely processed.

Unlike the job shop manufacturing environment where all parts are basically at the same stage in the process, parts manufactured in a cell are at varying stages of completion in the process ranging from still in the rough to completed.

If one machine breaks down or is given to maintenance for the purpose of preventive maintenance the whole cell is down. Therefore, the challenge to production and maintenance alike is to be able to keep the PM schedule current while having as little effect on production as possible. Policies must be put in place to address the issues related to keeping production going, but at the same time keep preventive maintenance current.

3. PREVENTIVE MAINTENANCE POLICIES

There is some of the major types of preventive maintenance policies. Failure-based maintenance is a necessity, at least as an emergency measure, in any shop. Use-based maintenance was ruled out as a candidate in this study because its assumptions of stochastically and economically independent failures are not met in group technology shops. Since equipment is grouped into manufacturing cells, machines in the same cell will have approximately the same utilization rate. Thus, their failure times will not be independent.

Further, if there is only one of each type of machine within a cell, as is common in group technology, and alternative routeing is not possible, failures will not be economically independent, either. When a machine in a cell fails, any machines which tend to be used after th failed machine are going to be starved for work, eventually, depending upon the amount of buffer stock.. In cellular manufacturing, there is also often minor interaction between cells. It may not be possible to group all of the machines to perform the necessary operations on a family of parts, so ther may be some routeing between cells. Thus, the breakdown of a machine may also have a minor impact on operations in a different cell.

This study combines the idea of condition-based maintenance, opportunistic maintenance and block replacement. Condition-based maintenance tests to determine whether boundary has been crossed. If so, perform preventive maintenance. Opportunistics maintenance uses Failure of one component as the trigger for some preventive maintenance. Block replacement replaces or repaires simultaneously all components of a given type.

Researchers that try to address this problem must not lose themselves in theory where they lose touch with reality.

Hsu[7] Proposed the assumption that there is no restriction on the waiting room capacity at each workstation within the cell. However, the realities of most cell layout show that space is at a premium and to make such an assumption is ill-advised and brings the whole theory into question.

Flynn[4] deals with the assumption of a critical machine within each cell. In this research a simulation model was produced to look at the effect of different PM policies on the overall operation. The policies were based on how to react when a critical machine breaks down. The policies tested are as follows:

Policy 1 - Conduct PM on all machines in the effected cell.

Policy 2 - Conduct PM on all machines like the machine that is broken down

Policy 3 - Conduct PM on all machines in the shop whenever a critical machine breaks down.

In this research, Policy 1 has the most merit as a viable policy. It might require pulling some maintenance personal to accomplish PM on the machines in the cell while the broken machine is being fixed, but it is possible. Policy 2 would present the same problems for large corporations as policy 3, although it might be slightly more feasible to implement. However, it too would require a very large maintenance force to accomplish the work. Policy 3 presented the best overall results for uptime and production. Policy 3, while fine in theory, if put to practicable use would require an army of maintenance personal. This policy might work out fine for very small businesses, but for large corporations it would be impossible to implement. Implementation is made even more difficult in light of the fact that most major industries are downsizing and requiring people to do more with less. For these reasons Policy 3 is totally unrealistic. Even if Possible, Policy 3 would disrupt production in cells where the operation is running very smoothly. It stands to reason that all the machines in the cell become critical if the part must pass through each machine during the process.

4. PREVENTIVE MAINTENANCE PROCEDURE

We propose a preventive maintenance policy. The idea of policy is that make the most of a cell's down, whenever machine is broken down. It is necessary that time is spent for performing repair or replacement. Thus during this necessary time simultaneously, we do our best for PM about other parts. PM procedure[5] is as follow

STEP 0 : When a machine is down in cell.

STEP1 : Identify repair or replacement time on part(s) of stopped machine.

STEP 2 : List up parts that equal or less than repair or replacement time of failed part for all machine.
If they are exist, go to STEP 3, otherwise go to STEP 4.

STEP 3 : Check parts which there much possibility of failure among list up parts.
If they are exist, go to STEP 5, otherwise go to STEP 4.

STEP 4 : (For failed part) -> The necessary repair or replacement is performed on the failed machine.
And then do operate cell.

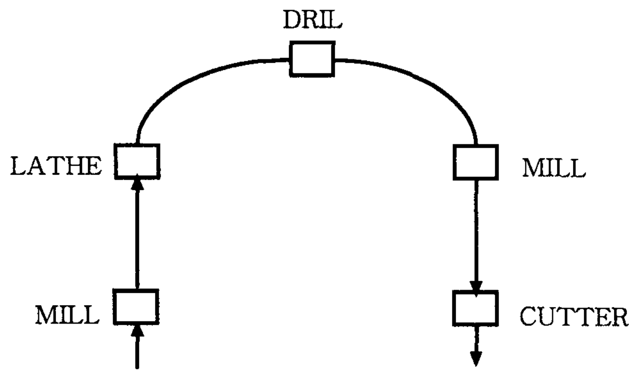
STEP 5 : (For failed part) -> The necessary repair or replacement is performed on the failed machine.
(For checked part)-> PM are performed on checked parts.
And then do operate cell

For implementation, It is require that time list of full maintenance of each machine. Also, the repair and replace time of parts that compose machines are need.

5. SIMULATION

5.1 MODEL

A simulation model was developed using Visual C++. The model designed a hypothetical cell with 5 machines including 2 identical < Figure 1 >. It was assumed that each machine was made up four parts. Parts in machine were subject to random breakdown. Each of parts of machines had its own erlang distribution of the mean time between failure < Table 1 >. The time required to repair or replacement a part are known < Table 1 >.



< Figure 1 > Manufacturing Cell

5.2. SIMULATION RESULT AND ANALYSIS

The model was run for 100 simulated years. < Table 2 > and < Table 3 > listed all of the values which were obtained.

< Table 1 > MTBF and Repair/replacement time on machines

Mach	Part	MTBF(min)	Repair/ replacement time(min)
MILL	M1	86400	700
	M2	432000	1440
	M3	194400	450
	M4	144000	230
LATHE	L1	100800	360
	L2	230400	200
	L3	172800	980
	L4	288000	720
DRILL	D1	151200	70
	D2	115200	1200
	D3	129600	180
	D4	187200	80
CUTTER	C1	360000	480
	C2	216000	240
	C3	136800	350
	C4	93600	400

< Table 2 > Mean failure interval and Mean PM interval on machines

Mach.	Mill 1	Mill 2	Lathe	Drill	Cutter
Mean Failure Interval(min)	45274	44200	49257	40148	46743
Mean PM interval(min)	221747	228536	229003	216914	199102

<Table 3 > Time values obtained on Cell

		Time(min)	Ratio(%)
CELL	Total Up Time	49536995	94.24
	Total Down Time	3026590	5.76
	Total Operation time	52563718	100

For same model, we made Flynn's Policy 3 an object of comparison. We assume Mill as critical machine. In this case, notice that only obtained Mean failure interval < Table 4 > and < Table 5 > listed all of the values which were obtained.

< Table 4 > Mean failure interval on machines - Flynn's policy

Mach.	Mill 1	Mill 2	Lathe	Drill	Cutter
Mean Failure Interval(min)	40973	40023	46608	36562	42221

< Table 5 > Time values obtained on Cell - Flynn's policy

		Time(min)	Ratio(%)
CELL	Total Up Time	49318032	93.81
	Total Down Time	3256300	6.19
	Total Operation time	52574332	100

With results, comparing proposed procedure with Flynn's as follow

< Table 6 > Improvement effect on machines

Mach.	Mill 1	Mill 2	Lathe	Drill	Cutter
Mean Failure Interval(%)	△ 10.5	△ 10.4	△ 5.7	△ 9.8	△ 10.7

< Table 7 > Improvement effect on Cell

		IMPROVEMENT EFFECT (min)
CELL	Total Up Time	△ 218963

Comparing with simulations' results, We can see Mean Failure Interval of each machines is improved. Also, on the cell, Total Up Time are improved.

This result shows that proposed policy are more effective than Flynn's

6. CONCLUSION

In this paper, we proposed a preventive maintenance policy on large enterpise with cellular manufacturing. We assumed a model and did simulation it using PM procedure. Also, for same model, We made Flynn's policy an object of comparison and got simulation result. We showed that proposed policy is better than Flynn's work in point of availability. We expect that this PM procedure is appied many enterprise.

As further research, PM policy considering several cells in shop can be studied

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