OSCILLATION IN MAINTENANCE PROGRAMS

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1. Problem Statement

Maintenance is one the major functions in production activities. It has a high direct cost and a profound impact on overhead cost through availability of equipment. Maintenance programs are either reactive or proactive. In reactive programs repairs are made when equipment fails. Proactive maintenance is a form of preventive or predictive maintenance. Preventive maintenance (PM) is the regularly scheduled process of performing certain types of maintenance, inspections, adjustments, and lubrications on equipment prior to failure. While it is being recognized that "the higher production uptime and product yields more than justify the expense of their preventive-maintenance programs", many plants experience frequent wanes in their preventive maintenance programs. Some plants have shown oscillatory behavior back and forth between preventive and reactive maintenance without much leaning about the causes. For example, as one of the managers of a refinery in Ohio explains:

> "A plant example of oscillation is our approach to preventive maintenance. In 1985 Lima Refinery had a pretty effective PM program. This worked to identify all upcoming failures early enough to plan repairs, shutdown before a failure event, etc. It worked. But this success had the side effect of lowering the amount of failures to the point where the inspectors weren't finding anything much to repair (this was good), such that management perceived them to "not be busy enough." The people responsible for lowering the failures (both salaried and hourly) were given other duties "to fill their idle time" such that they got away from the work of preventive maintenance and onto more immediate reactive repairs. This caused failures to increase again, and oscillation happened. Some anecdotal comments are that long term employees have seen PM programs come and go 4 or 5 times in their career. They wonder why we didn't stick with such a good thing." (Manus P., 1995, p.9)

Such oscillation in the maintenance system is not desirable. This paper presents a model to provide an explanation for such oscillation.

2. Model

Figure 1 shows the stocks and flows structure of a model of maintenance system that are relevant and sufficient for the purpose of this paper. Figure 2 shows the reactive decision making on staff within a major negative feed back of third degree. Figure 3 shows two other negative loops that operate in a reactive mode of decision making about desired equipment under preventive maintenance. In the reactive mode, maintenance staff is determined in reaction to percentage of broken equipment. When percentage of broken equipment is high, maintenance staff is increased to fix the broken equipment and when the percentage is low, maintenance staff is decreased to save cost. Also, as shown in Figure 3, in the reactive mode, equipment under preventive maintenance is set in reaction to staff availability and percentage of broken equipment. When staff availability or when the percentage of broken equipment is high, desired equipment under preventive maintenance is increased and vice versa. In the reactive decision making, the three loops shown in Figures 3 and 4 are active and generate an oscillatory behavior discussed in the next Section.

3. Model Behavior and Policy

Figures 4 show the behavior of the system under reactive policies when the three negative loops discussed before are active. The system oscillates with a periodicity of about eight years.

Under proactive policy, desired maintenance staff is set to be able to have all the equipment under preventive maintenance plan. As long as the total equipment is not changed, the desired staff will not change either. Then, maintenance staff is adjusted to become equal the desired staff. Management is not reacting to pressures to cut cost or decrease percentage of broken equipment. Desired maintenance staff is driven by total equipment. Figure 5 show the behavior of the system under proactive policy. The result of proactive policy is high uptime with stable and on average lower maintenance staff. Figures 6 and 7 shows the accumulated staff time and accumulation of non-operating equipment, as two performance indexes, under reactive and proactive policies during 40 years of simulation. In terms of both performance indexes, proactive policy results a better performance.

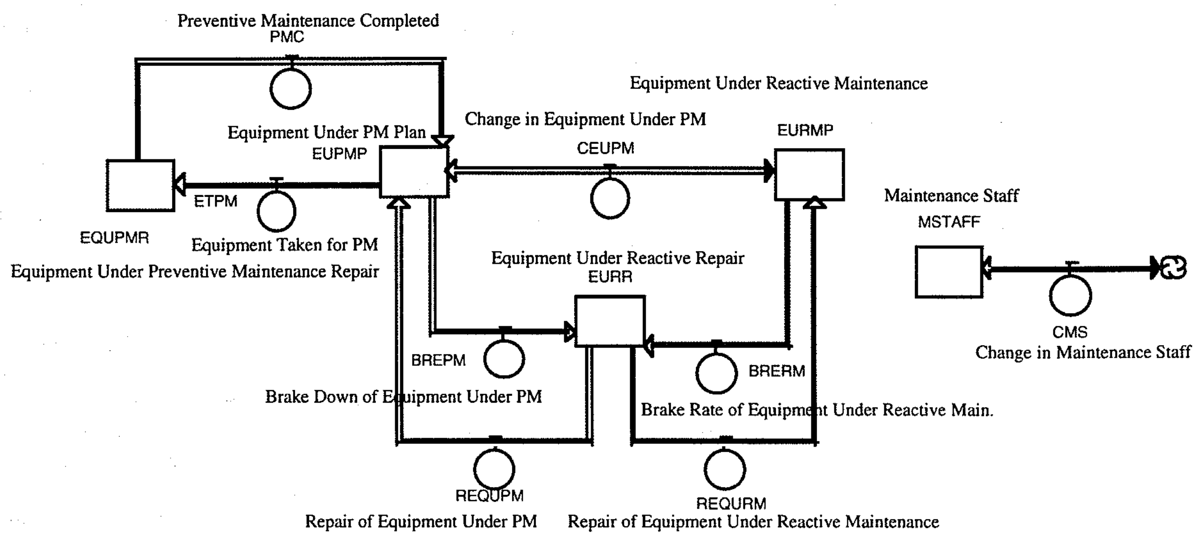

Figure 1: Stocks and flows structure of the model.

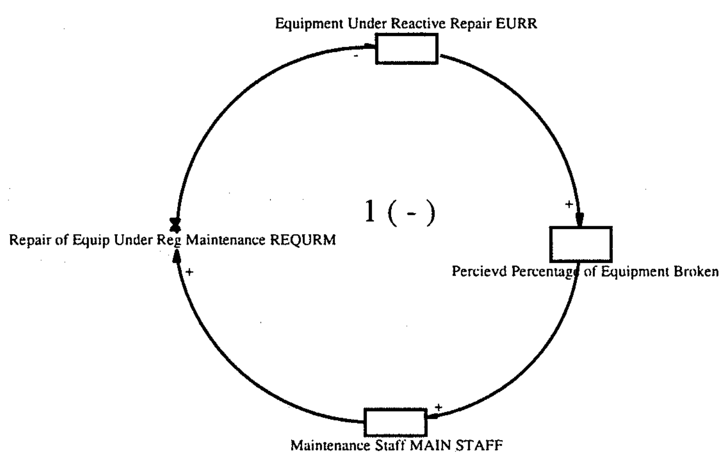

Figure 2: Reactive decision rules to change maintenance staff based on perceived broken equipment shapes the major negative loop that creates oscillation.

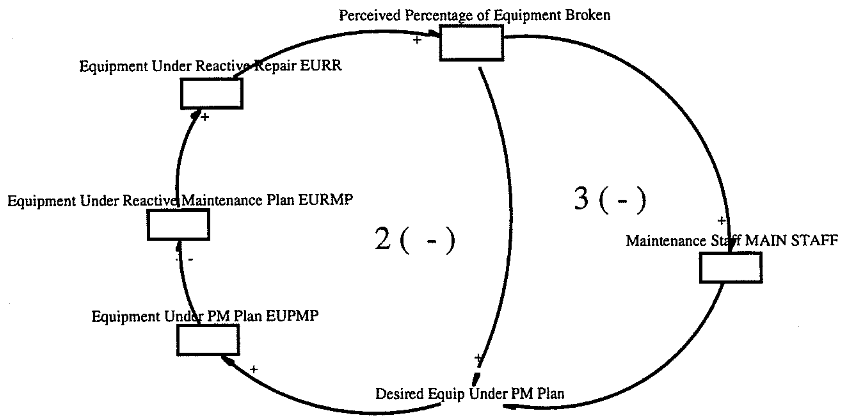

Figure 3: Reactive decisions on change in equipment under preventive maintenance based on availability of maintenance staff and the percentage of broken equipment accentuates oscillatory behavior of the reactive mode.

4. Conclusion

Lack of systems thinking combined with reactiveness causes the preventive maintenance programs not to last. Under reactiveness, maintenance programs can oscillate between reactive and preventive maintenance. Since reactive decision making usually lead to short run results, they become self approving as the causal linkages to the long run consequences are ignored. Fragmentation does not allow the full consequences of reactive actions to be appreciated. In order to understand the flaws of reactive decisions, a system perspective is necessary. With systems thinking, consequences of reactive actions that are far in time and location from the action point can be better understood. Such understanding facilitates improvement of decision makers mental models and learning.

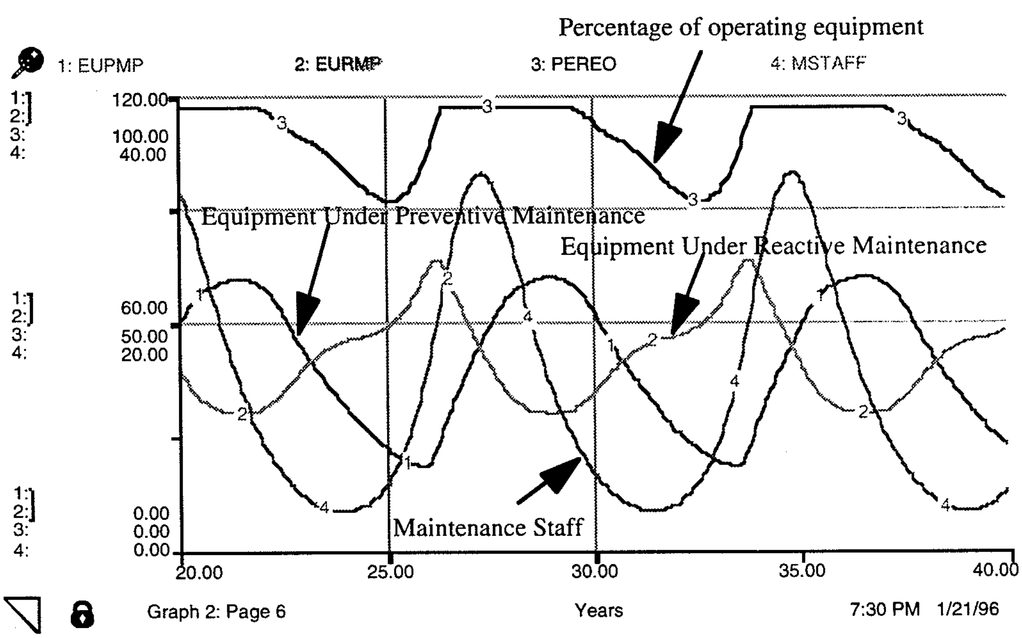

Figure 4: Behavior of the system under reactive policies.

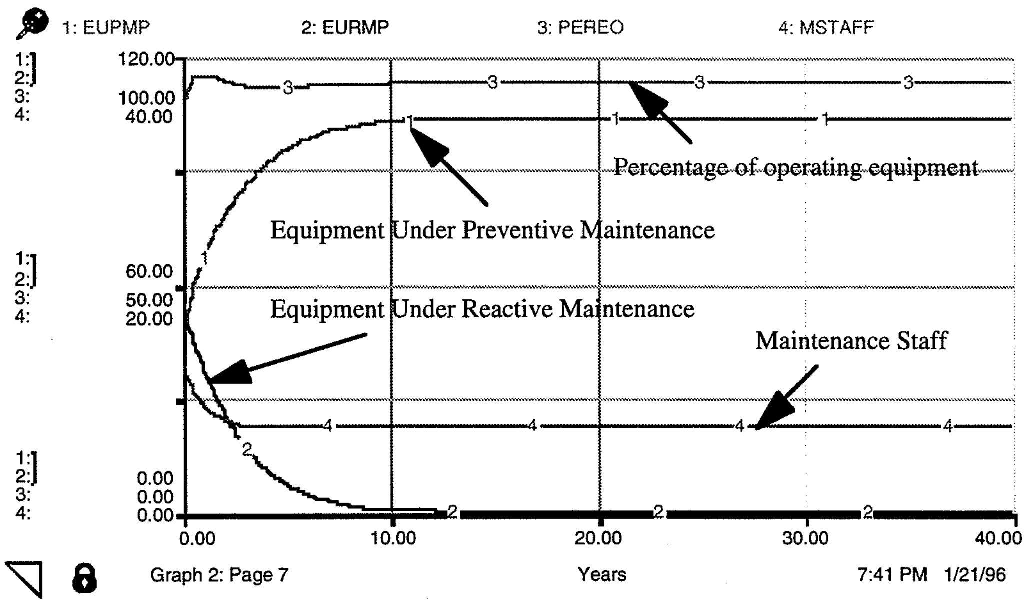

Figure 5: Behavior of the system under proactive policy.

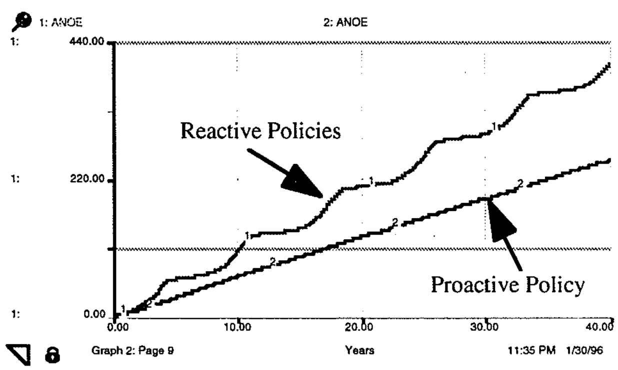

Figure 6: Accumulated non-operating equipment under different policies.

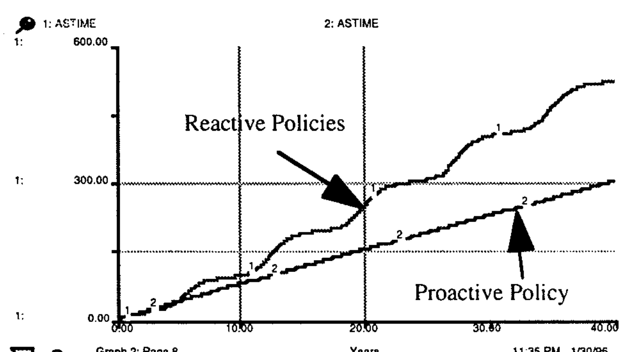

Figure 7: Accumulated maintenance staff time under different policies.

References:

- Monus Paul, 1995, Proactive Manufacturing Innovation: attachment, BP Oil Lima Refinery, Lima, Ohio, USA.