One the last week of the 12-week schedule, the system was run over and over again. The idea was to get the engineers used to the system, develop confidence and de-bug the system for minor faults. One more additional week was taken to train all engineers of the plant in the system. All engineers were trained and live examples were shown as to how the system would help them in their day-to-day jobs. With such a system in place the vision and mission of the top management was easily communicated to the grass root level and all employees were involved. The time came for the CBM system to work and show the results.

What were the results? The management conducted a through audit of the system performance after two years of rigorous operation of the CBM system.

The results are tabulated to make comparative observation easier. All objectives set out in the beginning were more than achieved.

Sr. No	Parameters of Audit	Before 1998	After (May 01)
1	Failure rate	24 per month	Zero per month
2	Mean Time To Repair after a failure	4 hours	2 hours
3	Spares cost	195 units of money	150 units of money
4	Maintenance Budget	0.34 million units of money	0.14 million units of money
5	Speed of operation	95%	129%

It is also interesting to note that before the introduction of CBM, the selling price was around 98 units of money. During this time competition forced the company to sell at 78 units of money. Even with this, the company did not suffer a cash flow problem and could pay their employees in time.

Conclusion

Hence performance of a manufacturing operation can be substantially enhanced through the innovative application of CBM, especially when companies want to turn around in the shortest possible time by controlling their machines. But it has to be done correctly, with great awareness and with enough 'knowledge adequacy'. Otherwise the system would fail and would unnecessarily earn a bad name, which is not meant to be so. It is designed to make companies successful and impact their bottom line.

Knowledge and technology are there to help. It just needs a change in mind-set with full awareness and realization to reap the benefits from innovative application of CBM. But that is a tall order!

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ENHANCING BUSINESS PERFORMANCE THRU CONDITION BASED MAINTENANCE

Abstract

The only activities that add value for any organization are 'marketing' and 'innovation at the work place'. All other activities are costs. This paper discusses one of the possible innovations that may be implemented by any manufacturing organization at their work place, i.e. application of Condition Based Maintenance (CBM).

Any manufacturing organization produces profits through the effective utilization of their machines or physical assets. But profits can only be produced if we are in control of the machines. In most cases, the machines, so to say, control us. Therefore, there is a constant crisis. We may get over this crisis if we are able to bring the machines under our control by applying the innovative concept of Condition Based Maintenance. By doing so both profitability and business performance are boosted. The objective of this paper is to enable Top Management to see the obvious link between business performance and control of 'failures' very clearly. This paper presents a live situation from the real world of business where business survival was achieved through the application of Condition Based Maintenance (CBM). It also highlights the 'thorns' that impede effective implementation and results.

Introduction

The only objective of CBM is to bring the machines under our control. If a machine is out of our control random failures take place. When random failures take place, it is not possible to achieve any of the following business objectives:

a) **Produce the designed capacity** - This may lead to loss of customers or erosion of market share
b) **Achieve the desired quality** - Again this may lead to loss of customers and market share
C) **Reduce costs** - Economy of scale is soon lost and operational and product costs escalate.
d) **Going lean** - When machines fail randomly, more and more manpower is needed to keep the show going. Such excess manpower does not add any value but eats into profitability.
e) **Low inventory -** If innovation is not followed, spares inventory can be as high as 15% of the total sales. Most of it is dead investment. And to meet the fluctuation in demand cycle, more finished goods inventory is to be kept, provided it can be produced in the first place.
f) **Achieve high morale** - With lower profitability, the morale of the workforce decreases exponentially.

How do we control machines through CBM? Through CBM we control machines in the following manner:

a) Develop awareness about the machine and its behavior by studying the signals of the machine
b) Once such awareness develops, people acquire the knowledge of the typical failures and specific patterns of failures of a particular machine.

c) With such knowledge it would be possible to predict two aspects accurately. First, the problems that slowly start developing can be predicted much before the problems manifests as failures. Second, it is also possible to predict accurately the inherent weaknesses in the machine that causes the failures to take place.
d) As soon as it is possible to predict in advance, it immediately becomes possible to respond appropriately and take measures to prevent or eliminate a problem from manifesting and disrupting the entire business of producing quality products in the right quantity.

So, these are the four basic steps of application of CBM. However, for this innovation to really happen in the workplace two things must be managed wonderfully well. These are:

A) Knowledge

The present level of knowledge on CBM is quite deep and wide. However, it requires great skill to master this body of knowledge. In other words the domain is large. And one has to become a 'deep generalist' to be really successful and effective. For example, to be fairly competent, an engineer should have at least an integrated working knowledge in domains like machine design, tribology, vibration, structures and foundations, flow dynamics, metallurgy, thermodynamics, corrosion, electrical engineering, information processing and sensors and great skills in observation, thinking, analysis, synthesis, communication and creativity. Unfortunately, engineering education lays stress on specialization in fairly narrow domains of knowledge. Most engineers often go deep but not wide enough and therefore suffer from the syndrome of 'knowledge inadequacy' to analyze problem accurately or visualize the problem in depth. Most either do not have the time or are unable to give the needed effort to master the 'knowledge interface domains'. Unable to master the knowledge they soon lose interest in the practice and as a result are deprived of the useful contribution CBM can make to enhance their own performance as competent engineers. This problem can be obviated when 'knowledge adequate' experts help you design knowledge-based systems for the specific problems of your machines and then keep guiding and training the practicing engineers over a period of time. This is the only way any practicing engineer would be able to come to grips with this problem of 'knowledge inadequacy'. Otherwise, people would continue to think that CBM is nothing but 'vibration monitoring and analysis' and is useful for chronic problems and has little or nothing to do with business performance.

B) Technology

Practically, in the last two decades the technology that supports CBM activities has been developed to a very high level of quality and integrity. But here again we have three issues to tackle. First, it is often confusing for practicing engineers to make a choice of the appropriate technology from a basket of various options. It would definitely need expert advice to make the right choice for the particular machines one has to control. Second, understanding and mastering this technology takes time and effort both of which are in short supply in modern industries. Expert help is again needed to tackle this problem like the way we use experts to install and run ERP systems for us in the initial stages. Third, the present technology is so specialized that these do not seamlessly merge with the enterprise resource planning systems. It is therefore not surprising that modern ERPs cannot incorporate CBM though this is one of the best possible industrial practices. The only way to get around this problem is to have the specialized system work alongside the ERP system till there comes a time when these can be really put together.

Now, let us observe how business performance can be enhanced by its innovative application in the real world of business.

The Real World Business Situation

A chemical fibre company, using latest Japanese technology and machines, was losing its market share since it could not produce enough to satisfy the demand of its customers. The customers were few but stable and loyal. But what can they do if they don't get their material in time for them to complete their jobs. They had to switch over to competitors in time of need. The company could not produce the right quantity since their equipment broke down randomly and that too quite often. It was as high as 24 times (average) a month.

On the other hand the company did not have the money to install another line to make up for the loss in production. There was also an urgent need for the company to reduce the price of their products to ward of competitors though their quality was better than most. Since this was happening for a long time, the company was eating into shareholders' money and accumulated losses increased to the extent that there was hardly any time left to create a positive cash flow that could ensure that employees get their salaries in time.

Fortunately for the company, a dynamic Director stepped in at this time. He saw through the problem straight away and decided that such random failures are to be stopped by any means and that too quickly if this company has to survive and keep breathing. Small arithmetical calculation also showed him that if only he could only produce 15% more with the existing machines he would be much better off to face the tough competition in the coming days. Time was the essence. If something can't be done within six months to a year the company would go under. At this point of time he decided to go for CBM and use it as weapon to get out of this crisis. He understood the problems of implementation of CBM and then took necessary steps to get over the problem. He then provided the energy and leadership to roll out the plan in the shortest possible time. Appropriate and cost effective technology was procured. 'Knowledge adequate' experts were engaged. Teams were formed and a tight 12-week schedule was drawn up (though it looked a little crammed) to implement the entire process meticulously, swiftly and effectively.

On analysis, they found that 36 machines out of a total of around 145 machines create the crisis. Work started on war footing. Each of these 36 machines was studied in depth from all possible angles. The idea was to know what weaknesses these machines had and the factors that individually or in combination would create the problems. This exercise alone took about five precious weeks. There was still nothing to show on the table and the management was getting anxious. However, this essential exercise was a must and had to be done with care if results were to be ensured.

The next task was to find the right signals and techniques that would warn of an impending failure. It had to be such that the signals would not only pick up the scent of a problem in time but also warn the management of the factors going out of specifications that would create a possible problem. The problems were listed as faults in the computer system. Against each fault the right signal that would trigger the warning was selected. For these signals warning and alarm levels were estimated and placed. Along with this they also decided as to who would collect the signals, when and how frequently. One may be led to think that vibration signals were the only signals that were used for this purpose. This system collected all type of signals like vibration (in different forms), lubricant analysis, wear debris analysis, temperature measurements and most importantly the daily human observations of even minor abnormalities, errors and inaccuracies. That in fact, made the system well rounded and strong. This was relatively the easy bit, which took four weeks of the tight 12-week schedule. Trials were conducted and the results were positive. Now they would know much, more before hand when a problem would strike them.

But the management still did not have enough reasons to break their grim look into a smile. It is all right to say that 'look, here is a problem that is going to hit us in ten days time' but it doesn't help. If the problems keep cropping up quickly, one after the other, then the management is still in a crisis. Though they can now avoid any sudden or surprise failures the time would go in constantly repairing the machines, when problems appear almost back-to-back. Achieving 'reliability' was the main issue. The machine should not keep failing quickly! The other main issue was to increase the speed of operation beyond the rated speed.

It seemed a daunting task! But CBM makes it easy. By now, not only the signals were understood but also the behavior of each machine was studied in-depth. With this deep and wide knowledge it was possible to look into the possibilities of extending the life between the failures (improving reliability). At the same time, with the same analysis it was also possible to identify the weak spots that prevented them to achieve higher speed of operation. Quickly and effectively these imperfections were addressed. Contrary to usual expectation, this analysis took only two more weeks. It is useful to note that without the help of an effective knowledge adequate CBM system it may take months, even years to analyze the weak spots and inherent defects. In the meantime, eleven weeks had passed.