p-Tools

Productivity methodologies, tools, and techniques

Management of physical assets for higher capital productivity

Modern, high-speed, large-scale, continuously running, highly automated, complex plant and machinery require advanced asset management systems. To maximize the productivity of these physical assets, we have to ensure very high asset utilization, along with operational reliability, safety, and security. The deterioration of those costly assets should be minimized by increasing their economic life through appropriate maintenance.

Physical assets deteriorate with age or hours of operation. In the wear-out stage, random breakdowns increase and operation gradually becomes uneconomical. A decision must then be made to recondition the asset or procure a new one. The capital cost and degree of wear vary in inverse proportion. The best strategy is to determine the proportionate combination that minimizes their sum. This methodology was developed by the Machinery & Allied Products Institute of Ohio, USA, and can be used for almost all equipment.

The deterioration of equipment leading to failures and breakdowns is mainly due to "corrosion" and "wear and tear." Surveys showed that 3% to 4% of a country's GDP is lost due to corrosion and about 5% due to the wear and tear of physical assets. Corrosion is destruction of physical assets due to reaction with the environment or destruction of materials by means other than mechanical. Common examples are rusting of steel via uniform attack and galvanic, crevice, pitting, intergranular, erosion, and stress corrosion. Wear is damage to surfaces caused by loss of material or by plastic deformation due to interactions between surfaces in relative motion. Common examples of wear are bearing failure, gear failure, failure of pistons and crank shafts, etc. Multiple wear mechanisms can occur in an asset, like abrasion, adhesion, erosion, cavitation, and surface fatigue.

For maximizing returns on net assets and the productivity of physical assets, their availability must be maximized at minimum cost. At the same time, efficiency and effectiveness must be maximized at minimum life cycle cost. This can be achieved by increasing operational reliability and maintainability of the asset and by controlling maintenance and operation costs. Therefore, an optimum maintenance strategy for physical assets is needed to ensure value-added output, product quality, prompt delivery, employee safety and motivation, and minimal manufacturing costs. Different maintenance strategies are explained below.

Breakdown maintenance

Breakdown maintenance is a reactive approach. The asset is operated until it fails or breaks down. This approach is uneconomical as it leads to long asset downtimes, frequent failures, poor product quality, long waiting times, high capital expenditure on repair, and reduced safety and morale. The maintenance cost for assets becomes very high. The damage to assets is also heavy, and accidents causing injury and environmental problems may occur. Generally, the average direct cost of maintenance is about 4% of the fixed asset and 28% of manufacturing cost. Some 40–60% of direct maintenance cost is due to spare parts.

Preventive maintenance

Preventive maintenance (PM) is essential for slowing the deterioration of components and subassemblies of assets. It comprises routine activities like cleaning, lubrication, and periodic replacement of failure-prone components so that basic conditions can be maintained, wear and tear kept under control, and unplanned forced outages of assets avoided. PM activities should be planned according to the asset failure history and original equipment manufacturer's recommendations. Such activities should be based on production plans so that assets are available for PM without disrupting production. This strategy has some disadvantages. A tendency to overmaintain will incur high costs. Fixed-time component replacements may cause suboptimal utilization, with the probability of breakdowns remaining. If the mean time between failures is not assessed properly, planned outages for replacing components cause losses in capacity utilization. One study revealed that 40% of PM is unnecessary. This strategy needs proper documentation such as work orders, assessment and documentation of maintenance time standards, maintenance of asset registers, failure history cards, inspection checklists, and maintenance instructions.

Predictive or condition-based maintenance

Maintenance carried out based on actual operating conditions of assets instead of time is called predictive or condition-based maintenance (CBM). Corrective actions are carried out in a planned way to maximize availability and minimize cost. Combining CBM with online in-situ maintenance can achieve zero breakdowns and zero downtime. Figure 1 shows maintenance costs per horsepower for rotating machines using different strategies. The CBM strategy can reduce maintenance costs by 50%. CBM can be done offline or online, such as checking the tension in a V-belt drive system while the asset is shut down and vibration monitoring of a machine in operation, respectively. Parameters that can be measured and monitored in a running machine are noise, vibration, shock pulses, temperature, clearance, wear rate, contaminants, etc.

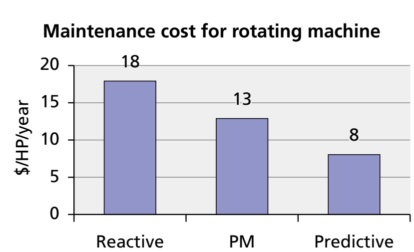

Figure 1. Comparison of maintenance strategy costs per horsepower (HP) for a rotating machine.

The investment for procuring CBM instruments is about 1–5% of the capital value of the asset being monitored, and the cost-to-benefit ratio is usually 1:5. For example, in a 132/33-kv switch yard of a captive power plant, the operational reliability of the equipment could be increased to 99.99% with zero downtime by thermography (monitoring hot spots on components like transformer bushings, isolator joints, circuit breakers, bus-bars, cable terminations and joints).

Proactive maintenance

In proactive maintenance, the life cycle cost of capital assets is minimized. Equipment design and selection are based on reliability and maintainability requirements. Tools such as failure mode and effect analysis, fault trees, and fishbone diagrams are used to determine the root cause of failures and take corrective action. Maintenance prevention features can be built in the asset. Figure 2 shows current versus benchmark maintenance practices and gaps in asset care strategies.

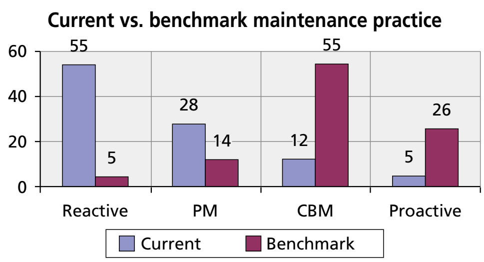

Figure 2. Current versus benchmark maintenance strategies.

Conclusion

In managing physical assets productively, the optimum maintenance strategy should be selected depending on asset criticality. Criticality can be determined based on the downtime cost, direct cost of maintenance, and costs due to quality problems and safety risks. Another criterion is the type of failure, for example, random or wearout. For critical assets, a breakdown maintenance strategy cannot be adopted, whereas for non-critical assets even breakdown maintenance can be more economical than other strategies. If failures are random and observable, CBM is the best strategy, but if they are random and not observable, proactive maintenance is better. Similarly, if wearout failures are observable, CBM is the best strategy; when not observable, time-based PM is the best choice.

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