Introduction to World Class Machine Maintenance Methods

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INTRODUCTION

Why Study Factory Machine Maintenance?

A world of ever-increasing competition dictates that manufacturers be able to produce their goods reliably, consistently, and perpetually. Many factory managers find themselves faced with requirements for 24-7 operations to keep pace with customer demand. In such aggressive environments, it is imperative that manufacturing equipment be available, when called upon, to function as it was designed to for as long as it takes to get the job done.

Much has been written in recent years regarding world-class improvements in manufacturing methodologies. Record breaking demand for consumer goods has driven producers of such goods to implement aggressive changes in the way they do business. However, in their haste to effect positive changes in manufacturing disciplines, many managers have overlooked the importance of maintaining the equipment used to manufacture their products. Across many industries machine maintenance is still viewed as a necessary evil, almost a parasite, bleeding off valuable capital and expense dollars with nothing more to show for the investment than a sustained status quo in the production facilities. Under these conditions, maintenance organizations are relegated to the menial task of repairing equipment when it breaks. Simple preventive measures such as lubricating stress points or replacing worn parts are often viewed as unnecessary expenditures as long as a production asset is still functioning.

It is in this context that a study of maintenance becomes most valuable. In order for a company to achieve true World-Class performance, each of its processes (including maintenance) must be scrutinized, finely tuned, and equipped for success. This course focuses on the types of maintenance (specifically machine maintenance) practices that are available and how they can fit into a factory's overall operations plan to make it as successful as it can be. Just as innovations in manufacturing theory have led to increases in production speed, reductions in on-hand inventories, and improved customer satisfaction; innovations in maintenance operations can lead to increased machine uptime, reduced repair parts inventories, and improved production floor customer satisfaction.

This course begins with a quick review of the evolution of modern manufacturing theory and the requirements it places on manufacturing equipment. It then examines different maintenance management approaches used to address those requirements. Strengths and weaknesses of the different approaches will be presented and recommendations made regarding desired attributes to attain best in class maintenance management in support of World Class manufacturing excellence.

Maintenance Methods to be Studied

The first maintenance style to be considered is ***Corrective Maintenance*** referring to the "fix-it" approach. In this scenario, a factory asset is operated until it breaks, at which time the maintenance organization is called upon to repair it. After repair, the maintenance organization has no further contact with the equipment until such time as it malfunctions again. The goal of this type of maintenance is to repair the broken equipment and allow manufacturing operations to continue – nothing more.

A review of ***Preventive Maintenance*** comes next. This method includes repairing malfunctioning equipment as does Corrective Maintenance, but goes further to involve efforts to prevent equipment malfunctions. In this scenario, factory assets are monitored for proper operation within defined parameters and adjusted, tuned, lubricated, etc. to maintain proper operating characteristics. The goal with Preventive Maintenance is to keep equipment running in the best possible condition to prevent production-stopping malfunctions.

The last maintenance method to be considered is ***Predictive Maintenance***. Activities in this category transcend traditional methods of maintenance by actually predicting when equipment failure is likely to occur and taking steps to prevent it. Instrumentation is utilized to measure vibration, temperature, lubrication characteristics, etc. while a machine is operating. Careful records of equipment operating characteristics are then collected and examined for signs of deterioration. The goal with Predictive Maintenance is to anticipate equipment failure far enough in advance to schedule maintenance activities when they will have the least impact on production schedules and yet still allow for equipment repairs before breakdowns occur.

Scope of the Study

The factory maintenance discipline covers a vast amount of territory and it is beyond the scope of this course to address it in its entirety. Therefore this study will be limited to the realm of machine maintenance. Machine maintenance is concerned only with maintaining the operational integrity of assets used to manufacture a company's product. For the purpose of this study, product will be defined as a company's end-item, sellable product, or sub-assemblies that are incorporated into the end-item product. Areas of maintenance concerned with the physical plant (building and grounds maintenance, plumbing, HVAC, electrical wiring, etc.), plant security, vehicle maintenance, etc. are excluded from this study. It should be noted, however, that these areas are only excluded to make the study more manageable. The principles presented herein may be adapted to each of these areas as well.

Glossary

Following is a list of terms used throughout the course as defined in a maintenance management context.

Applications Parts List (APL): The APL is a list of parts required to perform a specific maintenance activity. This list is generally attached to a standard maintenance work order and allows known required parts to be pulled from inventory and available for use when the task is performed.

Asset: A term used in the maintenance context to refer to any item of equipment to be maintained.

Breakdown: Refers to the condition of an asset when it is unable to function as it was designed to.

Computerized Maintenance Management System (CMMS): This is a computerized system developed for organizing, documenting, and scheduling maintenance operations.

Corrective Maintenance: Maintenance activities focused solely on repairing equipment after a breakdown has occurred.

Data: Raw, untouched facts about processes, machines, or organizations. More often than not, data by itself has little meaning without further processing.

Downtime: This is the time that a manufacturing asset is not available for production use for any reason. Examples of downtime are an asset that is broken, an asset that is being modified or upgraded by Engineering, an asset that has been determined to pose a safety threat and is locked out, or an asset that is having periodic maintenance or calibration procedures performed on it.

Information: Facts (data) that have been distilled and formatted into a usable form.

Just-in-Time Manufacturing: A manufacturing philosophy focused on providing a work center with its required resources (manpower, material, equipment, etc.) when it needs them and not before.

Lean Manufacturing: A manufacturing philosophy that focuses on identifying waste in every manufacturing process and systematically removing that waste. A major focus is made on removing "wait" times associated with production and creating an environment where all process time is actual "hands on" time.

Maintenance: Refers to any activities performed on an asset to ensure that the asset continues to perform as intended or to repair the asset after a breakdown.

Predictive Maintenance: Maintenance activities that focus on continuously monitoring machine performance and predicting failures so that equipment may be serviced before it breaks.

Preventive Maintenance: Maintenance activities that focus on performing periodic tasks known to prolong equipment performance and life. These activities are typically planned for times that will present the least impact on production schedules.

Technician: Term used throughout this document to refer to a maintenance employee who performs any of the maintenance tasks describe herein. For purposes of this study, technician can be considered synonymous with tradesperson, craftsperson, or mechanic.

Theory of Constraints (TOC): An operation philosophy that focuses on identifying and eliminating the bottlenecks in a process. The bottlenecks are termed the constraints in a production system. The theory holds that removing the worst constraint in the system will cause another constraint to surface as the worst. Repeating the process continually improves product flow in a factory.

Total Quality Management (TQM): A methodology of quality improvement that stresses the need to continuously improve every aspect of a business process in order to effect greater customer satisfaction.

Uptime: This is a term used to describe the amount of time a production asset is actually operational and available for production use. The reader must bear in mind that this includes time when an asset is available for use but not actually in use by the operating department.

Work Order: This is the primary document used by maintenance departments to manage maintenance tasks. This document should include at a minimum a description of the work to be performed, a list of parts and materials required to perform the work, specific procedures to be performed, special skills required, and tools required. It may also include the priority, time expectations for job completion, and historical failure information.

World-Class Manufacturing: This is a term generally used to describe the best possible manufacturing techniques when a company compares itself to any manufacturing industry in the world.

HISTORICAL BACKGROUND

To understand the importance of machine maintenance in American industry, one must understand the manufacturing environment and the requirements it places on properly maintained equipment for its survival. The modern American factory environment owes much to techniques borrowed from post-World War II Japanese industry. For many years these techniques have been studied, dissected, and enhanced by numerous management specialists bent on delivering a pathway to World Class manufacturing excellence. Current literature abounds with manufacturing methodologies. A growing American trade deficit beginning in the latter part of the 20th century spawned a meticulous examination of what America's worldwide competitors were doing better and faster than American industries themselves. Japanese manufacturing centers became the focus of a steady stream of investigations to unlock the keys to their success. As the results of these studies became available, American manufacturers began to emulate what they considered to be the best of the Japanese techniques in an effort to regain lost market share.

American Market Share Lost

In the years following World War II, American industry entered a time of unprecedented prosperity. A nation driven by the promise of a secure future and a strong economy provided a seemingly unending demand for consumer goods. If a company could produce an item, they could sell it, almost without exception. Quantity was the driving force in manufacturing planning in an attempt to keep up with demand. Quality of workmanship was measured, as it had always been, but everyone knew (or at least thought they knew) that American quality was superior to anyone else's. As time went by, America's gluttony for consumer goods began to wane and consumers sought better quality for their hard-earned dollars. Having grown accustomed to the demand for ***quantity*** of goods, American industries were slow to respond to consumers' new demand for ***quality***. The result . . . foreign competitors began capturing market share.

Japanese Market Share Found

In contrast to the vast wealth of land and natural resources available to American industry, Japanese industry has long accepted its limitations of both space to expand and natural resources available for production. To compensate for these limitations, Japanese manufacturers were quick to incorporate ways to make their facilities more efficient. By maximizing production capabilities, they found they could effectively compete with American rivals many times larger than themselves. Recycling efforts allowed the re-use of valuable resources that would otherwise be wasted and replaced at great expense. Employee cross-training programs were instituted to allow the greatest flexibility in the work force, and individual employees were given the responsibility of inspecting their own work. This meant quality defects could be found and corrected before a product left the offending work center. Employees were even granted the authority to stop a production line if a problem could not be corrected in real time.

American Management Response

In response to eroding market share, American management scientists began to study Japanese innovations in production and management policies. At first American management teams simply began to copy things like Japanese Quality Circles in an attempt to emulate the success of their foreign competitors. Slogans appeared in advertising touting each company's commitment to quality first. But when the quick successes that were anticipated failed to materialize, American industry leaders realized they would have to dig deeper into the Japanese success story. The goal changed from looking for a magic cure to identifying what processes the Japanese were doing right that could be incorporated into American manufacturing culture.

One of the most important Japanese innovations to be "imported" to American industry was the JIT (just-in-time) philosophy of production. JIT calls for breaking down product manufacturing into distinct processes. Once the processes and their respective inputs are identified, JIT stresses an environment where the inputs to a process arrive just in time to be used in that process. Those inputs are then "processed" and become outputs to be fed to the next process, but only when the next process is ready for them. The success of a JIT factory requires meticulous planning to ensure that materials are in place when needed, that machines are in place and functioning, and that the right people (properly trained and equipped) are available exactly when needed. For small-scale operations, planning departments were able to manage the JIT process. For larger organizations, the level of effort required to manage a JIT operation was formidable and the sheer number of personnel involved tended to erode return on investment.

Fortunately computerized MRP (material requirements planning) systems revolutionized the planning function for procuring materials. Tedious calculations to determine how many production materials to purchase, and when, could be accomplished by MRP systems with far more speed and accuracy than had been possible before. The next generation automated planning tool known as MRPII (manufacturing resource planning) was able not only to calculate how much material to order and when; but could also be used to plan the activities of all manufacturing resources (including machines and people). Armed with these tools American factory staffs were able to incorporate the JIT philosophy and move their businesses closer to World-Class performance.

Traditional manufacturing philosophy in this country called for processing product in large batches. The setup time required for changing over from one product to another made running large batches seem like the best way to achieve economical manufacturing lot sizes. The Japanese, however, found that running smaller lot sizes decreased the risks of generating large quantities of defective product before the defects were found and corrected. This led to more frequent machine setups and more opportunity for lost time during setups. It also created a greater risk of equipment being damaged during changeover. Machine maintenance organizations were challenged to discover innovative ways to support faster and more reliable machine changeovers.

Incorporation of JIT, although certainly a step in the right direction, was not a panacea for American production woes. Many industry analysts and consultants continued to make improvements using the Theory of Constraints (TOC) concepts developed by Eliyahu Goldratt. TOC is discussed at length in The Goal co-authored by Goldratt and Jeff Cox and in a second book, The Race, co-authored by Goldratt and Robert E. Fox. The Goal presents the TOC concepts in the form of a fiction novel where the characters transform a struggling factory on the brink of being shut down into a thriving business unit by incorporating the common sense approaches of TOC. Basically, TOC concepts call for the identification of factory "bottlenecks" defined as "any resource whose capacity is equal to or less than the demand placed upon it." (Goldratt & Cox, 1986a, p. 138). Goldratt (1986a) stresses that time lost at a bottleneck is time lost for the entire manufacturing system while time lost at a non-bottleneck resource is a mirage. To clarify, time lost at a bottleneck results in time lost at every operation that follows the bottleneck as they wait for its output. Conversely, time lost at non-bottleneck resources can be made up during the wait times caused by the system bottlenecks. TOC embraces the notion of running smaller lot sizes for improved quality and less WIP inventory. The drawbacks of extra setup times on non-bottlenecks are viewed as perfectly acceptable because they only use time that would otherwise be spent waiting on the bottlenecks. For the maintenance organization this also means that preventive maintenance activities can be performed on non-bottlenecks without adversely affecting shipping schedules as long as they don't exceed the wait time inflicted on the system by the bottlenecks. On the negative side, however, bottleneck resources must be maintained in tip-top condition to prevent lost production time for the entire production line.

A third major manufacturing philosophy to be incorporated into A … referred to as Lean Manufacturing. Lean Manufacturing stresses the n… …ess. Special focus is placed on lost (wasted) time spent … sellable product or service. Empha… …e for dollars paid. Alt… …e material waits in que… …wishes to pay for. The… …ossible. Material hand… …entory at its point of us… …hat subassemblies requi… …strate some of the creati… …nce organization must … …essary delays in equipm… …ing preventive mainte… …instances, only emerge…

The Ul…
It has be… …in the present as well a… …tered the 21st century, … Total Quality Managem… …es. Among those item… …understand their jobs … …rkers in the decisions … …nvironment where peo… …measuring performan… …oving the organizatio…

The Role o…
If the goal … …certainly every orga… …es have evolved to i… …e begun their own ev… …have begun to view their ro… …waiting for a machine to break and th… …. Today's maintenance departments must team with pr… …machinery is kept running when it is needed. Following is a description of … …of machine maintenance and what each has to offer production operations.

MACHINE MAINTENANCE TOOLS

Corrective Maintenance
Corrective Maintenance (CM) refers to the traditional role of the maintenance department. It is also known as breakdown maintenance, or fix-it maintenance. In this mode, maintenance departments respond to calls to repair non-functioning production assets. It must be noted that in a pure CM environment, maintenance activities are