TPM at the heart of Lean - March 2005

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Total Productive Maintenance (TPM) has been a very important tool for equipment intensive manufacturing sectors. It is a key means for increasing machine availability, and a vital step in linking machines to create better flow. Most companies however have failed to achieve the program's full potential and instead capture only partial benefits. Toyota Motor Corporation has developed its own unique style of TPM actions over the past 30 years that are critical both in terms of supporting its lean production system and delivering industry leading maintenance results.

The essence of TPM was developed in Denso a tier one automotive supplier in the Toyota group of suppliers during the 1960's and 70's in Japan. The central thrust of the program is the complete elimination of what are called the "six major machine losses" i.e. breakdowns, set up time, cycle time losses, minor stoppages, scrap and rework, and yield or start up losses. While lean thinking strives to eliminate waste in terms of man, machine, material, and method, TPM dives deeper into the specific realm of losses that relate to the "machine" component of manufacturing.

Each letter in the acronym of TPM is subtle yet critical. **Total** implies a comprehensive look at all activities that relate to maintenance of equipment and the impact each has upon availability. **Productive** relates to the end goal of the effort i.e. efficient production not merely efficient maintenance as is often mistakenly assumed. **Maintenance** signifies the directional thrust of the program in ensuring reliable processes and maintaining production.

Operational availability has long been recognized as critical in many process intensive industries. Oil drilling petroleum companies, airlines, chemical process plants, for example and many other asset intensive industries simply can not afford to have any down time. Each minute an oil well is down represents lost barrels of output and a tremendous amount of foregone revenue to the parent company. Airlines also can not afford any downtime for obvious reasons of passenger safety as well as revenue. It is not surprising therefore that these industries are often the benchmarks in terms of operational availability although it is often accomplished via extensive redundant systems as well as excellence in maintenance methods.

Other companies however, should also examine the benefits of TPM as well for additional reasons. First TPM is critical as a precondition for many elements of lean manufacturing to flourish and secondly there are financial benefits as well.

The most famous elements of lean manufacturing tend to be the concepts of flow, takt-time, standardized work, and pull production. Simple examination

of all these methods however highlights the fact that they all *assume* sufficient machine availability exists in the first place. For many companies attempting a lean transformation however this assumption is simply is not true. Many companies that I visit struggle to achieve sufficient uptime and average 60-70% availability at best during a typical production shift. It is worth while noting that from a historical perspective during the 1960's and 70's while lean manufacturing was being perfected in Toyota significant time and attention was placed upon developing both robust quality processes and maintenance systems. In most Toyota literature today these are commonly referred to as "pre-conditions" for elements of lean such as flow or standardized work. Quite simply those of us struggling with lean transformations should step back and see if the root causes for our inability to flow or produce 100% on-time paced to takt time stem from problems relating to these non-trivial preconditions.

Secondly, there are significant financial as well as operational benefits for a company that successfully implements TPM. Consider the simple case of two companies producing a similar product. One company is plagued by equipment downtime and the other produces without significant equipment trouble. The company with the greater equipment downtime will face the following disadvantages; more defects are likely to occur, more overtime and expedited shipments will result, more human resources are required to run and maintain the equipment, and on average more capital assents are required in the company to support the production line (to cover up for the losses). Clearly the company with fewer equipment troubles in the long run is more likely to have satisfied customers, employees, and shareholders.

In Toyota, the more asset intensive the shop the greater the amount of time and resources devoted to maintenance and TPM style activities. The reason is quite simple. In primary operations such as casting, forging, and machining it is the equipment and tooling that perform the value add portion of the process and not the human operator as in a final assembly shop. In order to eliminate waste and maximize the value add component in these equipment intensive processes the machine losses (breakdowns, set up, cycle time losses, minor stops, scrap and rework, and yield losses) need to be reduced and eliminated over time. TPM activities are a key way to eliminate many of these losses.

There are four key points that Toyota has emphasized regarding TPM implementation over the past couple of decades. These points are critical for long term success of the program. These points include a total life cycle approach, total pursuit of production efficiency, total participation, and a total systems approach.

1. Total life cycle approach

A total life cycle approach recognizes that much like humans equipment requires different levels of resources and types of attention during the life

cycle. During production start up is when initial trouble is most likely to occur and significant time is spent debugging equipment and learning to fix and maintain processes. Toyota starts this learning process long before the equipment ever reaches the production floor by extensively researching previous processes and continuing what worked well and improving weak points in the machine design.

After machine installation and product launch Toyota employs different maintenance techniques in order to efficiently maintain production. As a last resort breakdown maintenance (BM) is employed when all else fails until the root cause is thoroughly identified and the problem can be prevented from recurring. During most of the equipment life cycle time, frequency, or condition based preventive maintenance (PM) methods are employed to stop problems before they occur. PM intervals and contents are adjusted as experience is gained about the equipment over the life cycle. Daily maintenance (DM) is practiced by the operators of the equipment and involves checking lubrication levels, conducing daily cleaning of equipment, observing tooling conditions and providing early detection of abnormal conditions. Often this last action is a vital input into the PM system.

Occasionally equipment reliability problems result that require the time and attention of the original equipment manufacturer or specialists to resolve. In these instances involving changes to fixtures, jigs, tooling, etc. corrective maintenance (CM) is practiced and fundamental improvements to the design of the process are implemented. Toyota considers this machine kaizen (as opposed to motion or work method kaizen) and considers in an importance process improvement activity. Lastly, all processes are studied at length over the entire life cycle to see where time, spare parts, and money are being consumed. When future equipment is ordered a list of required improvements are identified for the vendor and analyzed jointly in terms of maintenance prevention (MP) activities.

2. Total pursuit of production efficiency

Total pursuit of production efficiency relates to the goal of eliminating all the aforementioned six types of production losses associated with a piece of equipment. Different situations and types of equipment require different improvement activities. For example during the 1950's the primary source of production loss in a stamping department was the changeover process from one stamping die to another. Frequently this change over from one die to the next might require anywhere from one to two shifts. Over time however, by studying the changeover and identifying the waste in the process teams were able to improve this loss downward over a ten years period to a few minutes at worst. In some cases the changeover can now be done in seconds.

Today in other processes such as machining lines the predominant equipment loss is machine breakdown time and minor stops which are often

hard to identify. Analyzing years of data in Toyota has highlighted the simple the fact that up to one third of production downtime in equipment intensive areas is caused by simple limit or proximity switch type confirmation failures. Emphasis is of course placed upon eliminating the cause of the problem however in some cases it has not yet been entirely eradicated. As a stop gap measure, priority is placed upon rapid repair of this type of problem and a goal of single minute maintenance (i.e. less than 10 minutes lost to production) is put into practice. In a similar fashion the type of manufacturing environment you work in and the type of loss you experience should drive your improvement actions.

3. Total participation

The total participation aspect of TPM is often much trumpeted by consultants and displayed in articles as a team based event where a single piece of equipment is cleaned and checked from top to bottom to improve availability. The projects are noble and excellent learning activities. They should not be mistaken however as the primary way to implement participation.

Toyota's style of participation focuses on everyone knowing their exact roles, responsibilities and executing them accordingly on a day to day basis. For example with respect to equipment intensive areas operators have a well defined check list and set of simple maintenance activities that can be monitored or performed during the shift. Abnormalities are recorded and communicated to maintenance for repair. Maintenance technicians respond to breakdown calls as needed and constantly look for ways to either prevent the problem from recurring or establish some type of PM activity. Engineering aids maintenance in ongoing equipment improvement areas that require special analysis or coordination with outside vendors. Managers provide the discipline in the system by ensuring that metrics are collected, the top problems on the Pareto chart are being identified, and that implementation items to correct the problem are being follow up on in a timely fashion.

4. Total systems approach

Lastly, critical to Toyota's success in maintenance is the notion of the total systems approach. Like a chain composed of multiple links the total strength of the system is only as good as the weakest link in the chain. Constant effort and management attention is placed upon improving the described aspects of the equipment life cycle, pursuit of efficiency, and participation by all in accordance with their responsibilities. A total systems approach also means effectively linking and improving all support activities such as employee training and development, spare parts and documentation management, maintenance data collection and analysis, and feedback with equipment vendors.

Regardless of whether your company kicks off a complete TPM program or not, all these points are critical in terms of supporting a lean manufacturing rollout. Lean thinking attempts to banish waste in all aspects of the production process. TPM activities can help tremendously in an equipment intensive facility where the machine performs the value add portion of the work, and hence plays a vital roll in terms of enabling flow, pacing to takt time, standardized work, and pull production to flourish.