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Abstract

To succeed in our increasingly competitive global economy, many companies have implemented lean manufacturing, a step beyond just-in-time production systems. Other companies claim they're "lean" but hedge on the concept. They maintain work-in-progress inventories because they fear the consequences when critical-path machines go down for maintenance breaks—a familiar and time-consuming nightmare.

Lean Maintenance Using Six Sigma DMAIC

Downtime cripples production.

by Howard Cooper

To succeed in our increasingly competitive global economy, many companies have implemented lean manufacturing, a step beyond just-in-time production systems. Other companies claim they're "lean" but hedge on the concept. They maintain work-in-progress inventories because they fear the consequences when critical-path machines go down for maintenance breaks—a familiar and time-consuming nightmare.

Some managers simply bolster their maintenance department with people, training, equipment and spare parts so they can quickly address problems when downtime occurs. Or they'll increase their expenses in order to hand maintenance responsibilities to outside subcontractors. Regardless of whether these vendors service you better than you could, it's comforting to be able to blame someone outside the company when downtime cripples production.

Still, it's your downtime.

Inevitably during your progress toward lean manufacturing, you'll be faced with the necessity of combining new machinery with decades-old equipment. Do you know how to get the near 100 percent uptime that lean manufacturing requires for both? Or will maintenance become the tail that wags your dog? This article describes how lean maintenance can help prevent equipment downtime and all its accompanying costly frustrations.

Overcoming entropy

Equipment reliability and uptime—also known as "maintenance reliability"—are two fundamental maintenance problems whose solution involves finding ways to eliminate unscheduled downtime. Most maintenance people think of downtime as inevitable. "It just happens," they shrug. "Then we fix it." You can monitor downtime indefinitely by measuring, logging, reporting, tracking or delegating it, but it won't go away until you eliminate it—that is, prevent it from happening in the first place.

How is it possible to fix a machine so it doesn't break down again? The answer is to eliminate the basic stresses that cause the problem and resulting downtime. To do this, a methodology is required for protecting computers, automation controllers, PLCs, CNC machines and their electronic and hydraulic control systems from the stresses that cause malfunctions and failures.

This methodology is called lean maintenance for lean manufacturing. A practical and cost-effective system, lean maintenance can help nearly any facility, whether it's a data center, semiconductor manufacturer or metal-production factory. Within a couple of months using this method, your company can avoid or minimize malfunctions, failures, unscheduled downtime, scrap parts, rework and missing delivery schedules. You'll reap the 100 percent reliability, repeatability, yield and uptime needed to increase profits.

Improved uptime is necessary for companies seeking to lower costs by shedding:

- On-site spare parts
- On-site board or component repair
- On-site technicians and maintenance engineers

Skilled maintenance technicians are an increasingly rare breed. In three to seven years, most of them will be retiring and their replacements aren't currently in training. Lean maintenance can help bridge this personnel gap by reducing maintenance support and overhead—often by 50 percent or more—while significantly and permanently reducing unscheduled downtime. Typically, lean maintenance will achieve the following reduction percentages:

- 50 percent reduced mechanical downtime
- 80 percent reduced hydraulic systems downtime
- 92 percent reduced electronic systems downtime

Cost of downtime

How much does downtime cost on average? Is it an amount worth eliminating? Different companies calculate different figures, but typical downtime costs average the following:

- $500 per hour for a stand-alone machine
- $1,500 to $8,500 per hour for a cell or line of machines
- Up to $3,500 per minute (that's $181,500 per hour) for an entire auto factory line

One practical way to check your cost-of-downtime figures is to compare them to the price you'd pay a subcontractor to repair a part or assembly because your capacity is temporarily or permanently limited. How much do outside service vendors charge per hour? Consider that the cost of your downtime. Any profit margin these companies calculate into their services is quickly offset against your own organization continuing to pay support and regular production personnel. Add to this your scrap and rework costs, and you're looking at the true hourly cost of downtime.

You can figure your downtime costs with the help of this formula: Cost of scrapped parts + error cost + hourly cost of downtime x downtime hours = $_____.

Only after you've assessed the cost of your company's downtime can you then calculate the importance of lean maintenance methods on increasing your profits, decreasing cost of goods sold and increasing market share.

According to lean manufacturing principles, the cost of a single machine out of action for maintenance is multiplied by the number of machines in that cell. With no parts in inventory, a single machine going down results in no parts shipped. Assuming the next parts are manufactured "just in time," then it's not possible to make up previously missed delivery schedules. This results not only in lost sales, but also in decreased trust and satisfaction on the part of your customers. Over the long term, loss of sales revenue due to these issues can be disastrous. Downtime can also result in a higher cost of goods sold, which reduces your ability to expand or even maintain sales and business volume.

Increased uptime, reduced stress

Lean maintenance's key objective is to give companies near 100 percent equipment uptime and reliability while cutting maintenance expenses. This is done by systematically surveying or analyzing each machine and control system to determine the basic stresses affecting them over time, then developing a scheme to protect them from the stresses to which they're subject. This certainly includes, but goes far beyond, the normal oil and filter change or other periodic maintenance procedures outlined in the equipment's operating manual.

The causes of downtime fall into three categories:

- Operator or programmer error
- Inadequate periodic maintenance procedures or performance
- Chronic wear and stress (e.g., from heat, vibration, oxidation, corrosion, hydraulic contamination and power surges) to circuit boards, hydraulic and other system components

Although Six Sigma, ISO 9001 and TPM books and strategies cover the first two issues, organizations often ignore them. Lean maintenance takes into account all three and particularly focuses on the third. If you eliminate chronic stresses that cause maintenance problems, then you also eliminate malfunctions, errors, failures, rework, scrap and downtime. Moreover, lean maintenance generally requires only a one-time installation of protective devices to produce ongoing savings. It in no way changes your current product flow, personnel scheduling, procedures, operations or policies. Yet it enables you to reclaim older or less reliable systems to near 100 percent uptime. You might call this kaizen for maintenance reliability, or jumping from four sigma to six.

Lean maintenance and DMAIC

Let's apply Six Sigma's define, measure, analyze, improve and control steps to the problem of equipment downtime and see how it can promote lean maintenance.

- *Define the problem*—unscheduled equipment malfunctions and the resulting rework, scrap parts, downtime and lost production. Why is this a problem? Because machines and computers do most of our work. If you don't believe this, then unplug all your computers and machines for two or three days, observe the 99 percent decrease in information or services provided, and see how much production slouches out the back door.

We must consider machines and computers as productive employees. Each is paid a per-hour wage based on its value to a company's products and services. Usually the machine's wages are much higher than human wages. When machines make mistakes or take a day off, the company loses profits, and that's the problem.

- *Monitor and measure the problem*—Monitor your downtime and measure or calculate what it really costs, per the discussion above. For example, if you have a computer maintenance management system or a good purchase and work order system, then you can estimate the potential savings and increased profits that should result from addressing this problem.

From your past year's records, measure and report the following:

- How many work orders or tickets for maintenance assistance on unscheduled downtime have you had during the past year?
- Based on your computer maintenance work orders, how many hours of unscheduled downtime have occurred? How many maintenance hours did in-house or contracted support personnel spend on equipment? How many electrical, hydraulic and mechanical hours?
- From your purchase orders, how many dollars were spent in equipment repair?
- How many dollars were spent in electronic module repair (either in-house or outsourced)?
- How many dollars were spent in hydraulic module repairs (either in-house or outsourced)?
- How may dollars were spent on hydraulic fluid?
- How many dollars were spent on hydraulic oil disposal?
- How many dollars were spent on hydraulic systems?
- How many machines or computer-controlled systems are employed at your company?
- Which areas or departments are in most need of equipment reliability (i.e., where are the critical-path machines located)?
- What's your average cost-per-hour for equipment downtime?
- Multiply this hourly cost of downtime by the total downtime hours listed under the first two items above. If you were able to eliminate 70 to 92 percent of this total, would it be a number worth your company's attention?
- *Analyze the problem*—Ask your maintenance engineer or an experienced consultant to analyze and identify the most cost-effective ways to protect each computer, machine and control system from the stresses listed above. Have them explain in a written report the necessary preventive maintenance procedures for each machine, including protective device model numbers, connection points, installation instructions, costs for each and a total cost summary. The investment needed for this analysis can then be justified against increased uptime and profits.
- *Implement the solution*—Installation instructions from the report should be specific enough that your own maintenance personnel can easily and quickly install the needed protective devices or implement methods and changes.
- *Control the project*—Controlling your lean maintenance program in the future should require little effort. Steps taken to avoid hydraulic system malfunctions and downtime can actually reduce by 90 percent current labor for periodic maintenance and scheduled downtime while prolonging machine tool life. Most other methods are single-step protective measures that need no future monitoring or periodic maintenance.

Conclusion

Lean maintenance helps companies maximize uptime, yield, productivity and profitability. The method builds in equipment reliability to existing production systems and reduces the need for maintenance troubleshooting and repairs. It protects against the real causes of equipment downtime, not just their symptoms.

Circuit board and hydraulic system failures and other malfunctions are only symptoms, not the underlying cause of unscheduled equipment downtime. Maintenance engineers or managers can begin implementing lean maintenance by protecting automation, electronics, hydraulics and computer-controlled equipment from chronic stress, the true cause of malfunctions, failures and downtime.

A lean maintenance program can be implemented in 30 to 60 days and contribute to your company's increased profits, near 100 percent uptime required for lean manufacturing, reduced maintenance overhead and reduced dependence on outside support.

About the author

Howard Cooper is a 20-year veteran consultant and founder of Amemco (AutoMation Equipment Maintenance Consulting). He consults with manufacturers, hospitals, telecom and data centers, office complexes and oil companies to achieve uptime and maintenance reliability during periods of chronic stress, (e.g., lightning storms, power surges, summer heat waves, vibration, oxidation, corrosion, and gradual or immediate injections of contamination to hydraulic systems.

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