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Looks like there's a reliability-centered maintenance process to fit any company, regardless of size.

RCM For All

Heretofore, reliability-centered maintenance (RCM) may have been thought of as a strategy best left to large, non-lean organizations. That may have been a perfectly logical assumption. Small- to medium-sized enterprises (SMEs) and lean operations simply seem to have less money to invest in and/or fewer resources to cope with the many activities required for RCM success. Now, however, out of joint academic/industry collaboration in Spain, comes information that may help begin to put these types of popular misconceptions to rest. The RCM methodology described in this overview of the Spanish research has been adapted to meet the specific needs of today's smaller, leaner organizations. And it is not just a theory, either. The practicality of this approach is being confirmed through actual testing in three small- to medium-sized and/or lean companies.

Although reliability-centered maintenance (RCM) has gained increased acceptance in industrial companies around the globe over the past few decades, it often has proven to be a difficult fit for small- to medium-sized enterprises (SMEs) and those in the advanced stages of lean production. For SMEs, the problem appears to be the substantial investment that is required for RCM to achieve the expected outcome. The challenge for lean companies is the fact that they typically manage fewer resources than are needed to successfully implement RCM.

Thanks to a recent academic/industry collaboration, however, a process for overcoming these roadblocks to RCM implementation has been put forward. Developed at Spain's Mondragon University, this approach has been successfully tested in three small- to medium-sized companies with advanced lean operations. These sites include:

- A medium-sized industrial plant of the Mondragón Corporación Cooperativa (MCC) corporation (a supplier to automotive and home-appliance OEMs and Spain's third-largest company);
- Inquitex S.A. (Inquitex), a maker of various products using polyamide, polyester and PET;
- Goizper S. Coop. (Goizper), a cooperative serving industrial and agricultural markets, and maker of a popular hand-held sprayer for houseplants.

The RCM process

The RCM process is designed to enhance assets' availability and safety by recommending design improvements or maintenance and operation tasks. It entails asking the following seven questions about the system under review:

1. What are the functions and associated performance standards of the asset in its present operating context?
2. In what ways does it fail to fulfill its functions?
3. What causes each functional failure?
4. What happens when each failure occurs?
5. In what way does each failure matter?
6. What can be done to predict or prevent each failure?
7. What should be done if a suitable proactive task can't be found?

Large companies may spend vast amounts of money (and deploy extensive resources) to accurately answer these questions. Most SMEs and lean-structured companies cannot. The major constraints SMEs face include restricted financial resources, a lack of personnel and time, little or no experience and limited confidence in implementing new systems [1]. Companies engaged in lean production, by definition, are trying to accomplish production "with minimal waste due to unneeded operations, inefficient operations or excessive buffering in operations" [2]. Consequently, it can be quite difficult to obtain funding for systematic optimization approaches in lean environments. Testing at the MCC, Inquitex and Goizper facilities shows that the adapted RCM process can indeed be effective in dealing with these challenges.

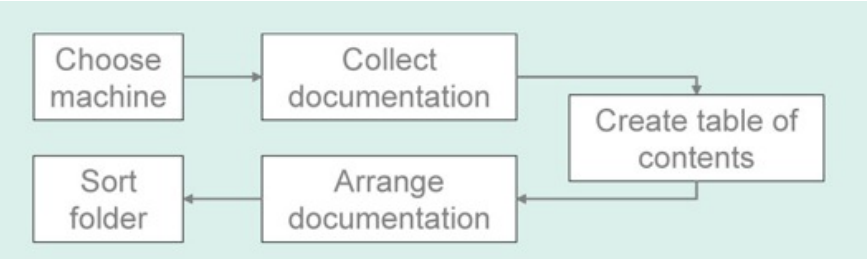


Fig. 1. Procedure to analyze and sort machine-related documentation

The following sections outline the adapted methodology using some of the documentation developed during the site studies. Implementation in the three subject sites encompassed the following phases:

- Document control
- Analysis of failure modes and causes
- Development of the preventive maintenance (PM) plan
- Development of the maintenance management system
- Continuous feedback and results

Document control…

Any SME or lean-centered operation wishing to implement RCM must first prioritize the equipment to be studied. In this case, it is recommended that Saaty's generic Analytic Hierarchic Process [3], or specific prioritization initiatives [4], be applied in order to generate a prioritized equipment list.

PREVENTIVE MAINTENANCE 0013 CORREA MACHINE

Work Order Number	Instruction Number	ACTIVITY TO BE PERFORMED	Daily	Weekly	Monthly	Quarterly	Semi-Annual	Annual
1	1	**Audit** autonomus maintenance						■
	2	**Clean cutting fluid** pumps and tanks						■
	3	**Clean (and substitute, if necessary)** the filters of the **cutting fluid** tank						■
	4	**Cutting fluid treatment equipment:** lubricate bearings (6 bearings)						■
	5	**Clean** the buoy of the **micro-buoy**						■
	6	**Correa global**, maintain the electric installation: **Overhaul** (and change if necessary) **cables**						■
	7	Overhaul and clean **detectors**						■
	8	**Correa global** lubricate moving parts: grease gears						■
	9	Lubricate the **warehouse chain**						■
	10							■
	11	Lubricate the **manipulator** of the crane						■
	12	Lubricate the **interchanger**						■
	13	Lubricate the **pins** of the manipulator						■
	14	Lubricate the **chain** of the manipulator						■
	15	**Check** that the **input voltage** is %±5 from its nominal value						■
	16	**Global inspection of the electric parts**; mass, connections and transformers						■
	17	**X, Y, Z axis movements**, revision of the micro switches						■

BE CAREFUL!!!! MAKE SURE THAT THE **MACHINE** IS **SWITCHED OFF** WHILE MAINTENANCE OPERATIONS ARE EXECUTED.

Fig. 2. Example of a systematic PM plan.

Next, all knowledge of the prioritized equipment must be collected. This task comprises gathering all the documentation related to the machine, including catalogs, manuals, instructions and related material. All documentation related to maintenance and production also must be compiled, following the procedure shown in Fig. 1, so as to guarantee that the documentation related to a machine will always be available and easy to find if an incident occurs.

Analysis of failure modes and causes…

All information collected in the preceding phase is oriented to answer the first three questions of the seven steps of RCM. Equipment suppliers and designers invest a great deal of resources defining how equipment should be operated, in which way it may fail and why it can fail. Then, considering these facts, they perform design modifications or plan activities oriented to reduce or avoid these failures. As a result, maintenance instruction manuals bring together several PM actions and will save the project team from wasting time doing a previously performed task. This provides a substantial basis for the PM plan.

Development of the preventive maintenance plan…

This phase covers steps four through seven of the RCM analysis. Furthermore, in this phase, equipment-related failure modes are revised to include the implicit knowledge and experiences of maintenance and production operators. This is important because the PM actions included in the equipment operation and maintenance manuals are usually designed to cover the most general spectrum of possibilities, as equipment designers do not have information about specific consequences of failure modes and causes to be avoided.

PREVENTIVE MAINTENANCE 0013 CORREA MACHINE

Work Order Number	Instruction Number	ACTIVITY TO BE PERFORMED	Daily	Weekly	Monthly	Quarterly	Semi-Annual	Annual
1	1	**Main axis, cleanup** the surface between the arbor and the surface of the tool	■					
	2	Test the pressure (right 70 b /left 130 b) and check the levels of the **hydraulic power station**	■					
	3	**UAD head;** Verify the pressure and the lubrication level of the oil pumps (fill up if necessary)	■					
	4	**Hydraulic compensation.** Test if the pressure is 115 b. Check possible leaks	■					
2	5	**Clean up** the machine and leave each thing in its place		■				
	6	Elimininate **shaving and pollution** using the special liquid, and grease the plain parts. Clean up the telescopic protection (the cleaning has to be done while the telescopic is opened, lubrication will be performed once it is cleaned.)		■				
	7	**Verify** if the connections of the hydraulic and pneumatic flux of the divisor are right		■				
	8	**Check** if the oil level and the pressure (80 b) is adequate		■				
	9	**Check** whether the hydraulic installation has leaks		■				
	10	Safety: Machine cannot work in auto mode if its doors are open		■				
	11	Verify emergency buttons (stop)		■				
3	12	**Air filtering.** Verify the filtering device. Call maintenance if there is a water leak.			■			
	13	Check how much consume the **X, Y, Z axis and the main axis** (approximate values should be %X=%12; %Y=%13;)%Z= %; %S=%4.)			■			
	14	Clean up the entrance and the outflow of the **electric group**			■			

NOTE: IF YOU PERCEIVE SOMETHING STRANGE WHILE THE MACHINE IS OPERATING, PLEASE CALL THE MAINTENANCE DEPARTMENT

BE CAREFUL!!!! MAKE SURE THAT THE **MACHINE** IS **SWITCHED OFF** WHILE MAINTENANCE OPERATIONS ARE EXECUTED.

Fig. 3. Example of an autonomous PM plan. Note that the color of each instruction represents its periodicity.

With these facts in mind, the maintenance team can define and prioritize the most negative events compiled during the whole process, analyze the consequences, their impact and the actions to be taken. Considering the impact of the consequence and the probability of failure, maintenance technicians will then be able to adjust the periodicity of PM actions—which can include modifying or even removing activities.

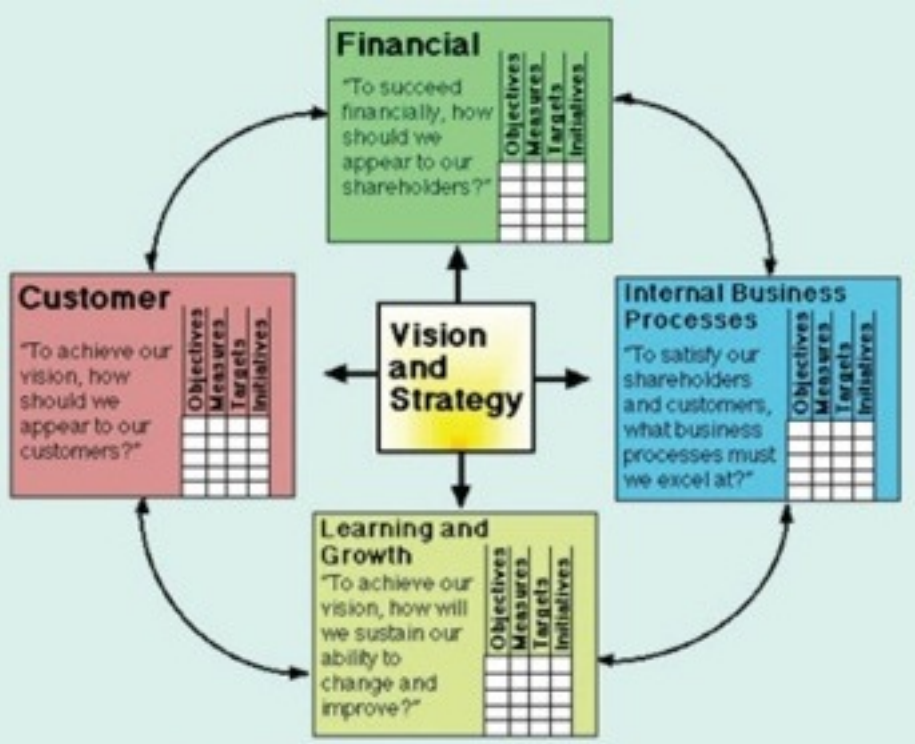
Based on these actions, it is possible to establish an initial PM plan that should be updated periodically. PM activities should be shared among production operators and maintenance technicians. This means a systematic PM plan executed by maintenance technicians and an autonomous PM plan performed by production operators should be designed for each piece of equipment.

An example of both the systematic and the autonomous PM plans of a turning machine of Goizper are shown in Fig. 2 and Fig. 3. In addition to the global PM plans shown in Fig. 2 and Fig. 3, it is essential to define each of the tasks to be performed. This definition must consider the complexity of the task and the experience of the person executing it. To accurately describe the tasks to be performed, the following levels of detail can be used:

1. For tasks that do not need detail to be properly carried out, the line included in the global PM plan will be sufficient for its execution.
2. For operations needing a brief description to be completed, instruction documents describing only key points of the operation will be provided.
3. For actions that call for a detailed procedure, an exhaustive operating procedure will be documented and included in the PM documentation developed for the technician. Using the precise descriptions in this procedure, all operators should be capable of completing the necessary PM activities. From this point, management needs only to establish a control system to analyze whether the actions are executed.

Obtaining An Operative Scorecard

The reasearch on which the accompaning article is based considers that maintenance has to be managed as a business unit. This means that the maintenance scorecard has to include the four business perspectives defined by Kaplan & Norton [6], detailed in Fig. 4.


Financial
"To succeed financially, how should we appear to our shareholders?"
Objectives
Measures
Targets
Initiatives
Customer
"To achieve our vision, how should we appear to our customers?"
Objectives
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Targets
Initiatives
Vision and Strategy
Internal Business Processes
"To satisfy our shareholders and customers, what business processes must we excel at?"
Objectives
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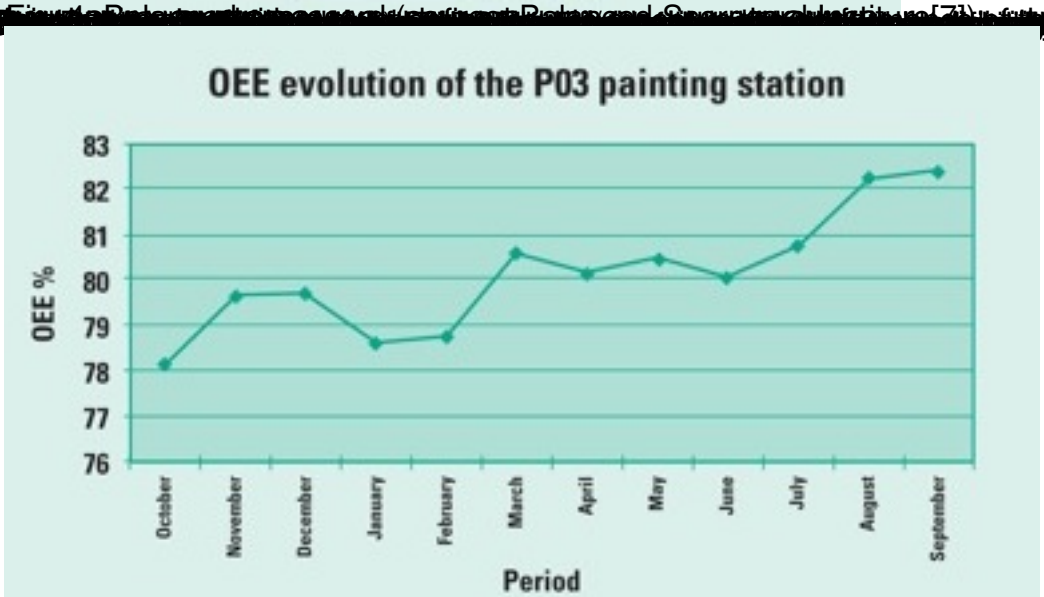
Targets
Initiatives
Learning and Growth
"To achieve our vision, how will we sustain our ability to change and improve?"
Objectives
Measures
Targets
Initiatives


OEE evolution of the P03 painting station
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