DEVELOPMENT OF A MAINTENANCE METHOD USING MOTIVATION PROGRAMS FOR THE OPERATOR FOLLOWING THE WORLD CLASS MANUFACTURING GUIDANCE

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Abstract. *The maintenance in industrial plants is greatly important to the company's productivity. It is desirable the equipment always available and presenting a high value for the OEE (Overall Equipment Effectiveness). An efficient maintenance plan uses several advanced methods, such as Reliability Centered Maintenance (RCM), the World Class Manufacturing (WCM), Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA) and DMAIC method (Define-Measure-Analyze-Improve-Control). The combination of several methodologies results in an optimized maintenance plan based on the philosophy of "Zero Break." For the RCM application is necessary the failure data collected during the maintenance (maintenance history). The management of these data is a responsibility of the operator and maintainer of the equipment. This work aims to develop a maintenance method labeled Maintenance Management System (MMS). This method uses motivation and incentive programs to the operator, following the WCM guidance. The goal is to encourage the operator to report these errors and to properly feed the MMS, applying continuous improvement in the maintenance plan.*

Keywords*: Maintenance method, Reliability Centered Maintenance, World Class Manufacturing, maintainer.*

1. INTRODUCTION

The MMS (Maintenance Management System) aims to manage all parameters that refer to the tangible and intangible maintenance. Integrating several hierarchical levels on maintenance process, by the end of all activities proposed by the MMS, it is expected to take an action plan so that this process could be done or adjusted based on the WCMôs premise of continuous improvement. In the future, when the companyôs differential will be on details, the innovate concept is the big bet. It is important to remember that just innovate is not enough and methodologies as WCM, DMAIC and PDCA are essential. They enable to plan and control the way that the innovation is used.

1.1. WCM applied to human reliability

WCM is a value creation philosophy to allow sustainable development and profit through waste and variability systemic elimination on several organizationôs levels, directed to make the company more effective and efficient on all of its activities.

As a WCM's premise, productivity and quality problems come from inefficient processes and not from inefficient people. That is the main WCM philosophy's point, since that, a well trained and motivated operator, with pattern conditions to work (it includes tools, ergonomics, fitting place) will not make the process inefficient.

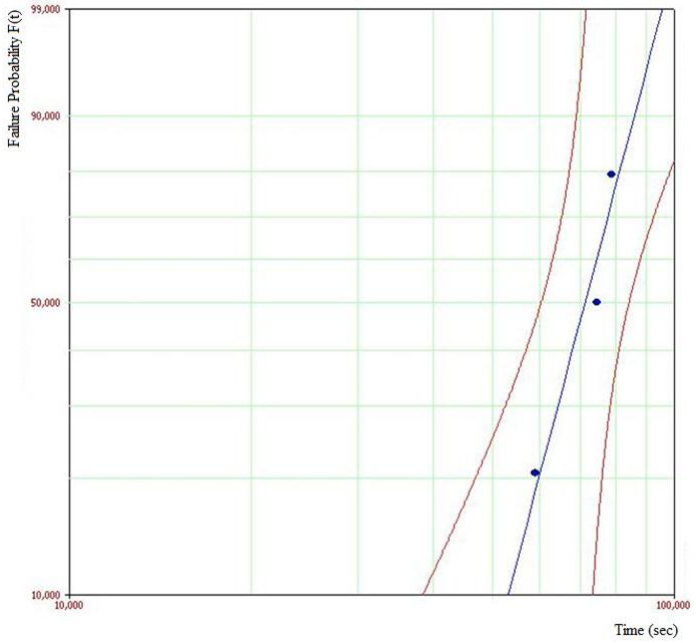
Another premise is that the process's improvements need to be simple, fast, and with low costs. This is a crucial point to the philosophy application, since that the industry wants fine results with low costs in a short period of time. It must remember that simple solutions are the one that get better results because of its simple applicability.

2. MATERIALS AND METHODS

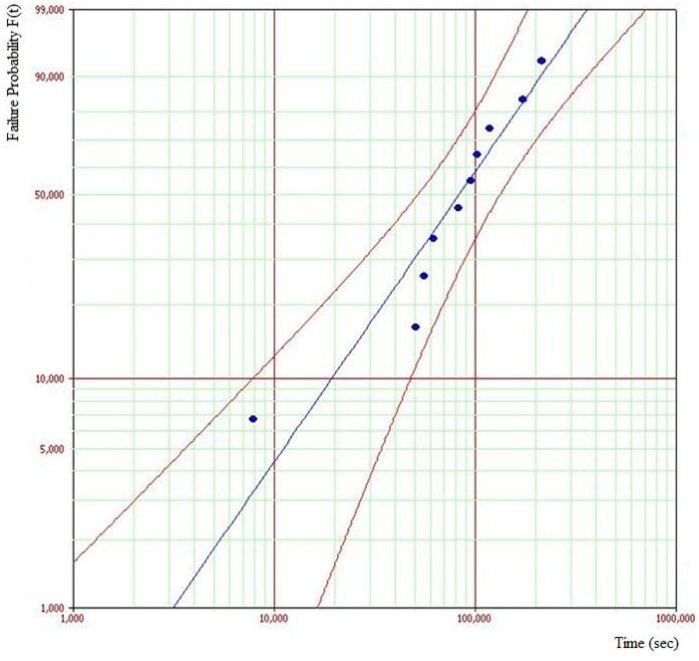
2.1 ï Maintenance management system (MMS)

Through PDCA, DMAIC and others RCMôs methodologies, MMS was developed based on maintenanceôs control and management allowing implementation of continue improvement. Itôs divided in two main points: corrective and planned maintenances. One efficient control of incidents resolved by the corrective maintenance will permit to take anticipated actions for the planned maintenance (Bloch, 1997).

At maintenanceôs control and management the collected corrective interventions data must be rightly registered and stored, once they are the support to study correctly the equipment behavior and reach the expected results to the proposed system. A concise database with large sampling let to a narrower confidence interval, which brings better results to the study. Figure 1 (a) to (d) shows the dependency between the confidence interval at reliability analysis and database: It is possible to see that the increase of the collected data, improve the representation of study system by probability curve, since the confidence interval becomes narrower at increased data sampling. The fault management and the standardization of the database store will enable all remaining MMS phases.



(a)



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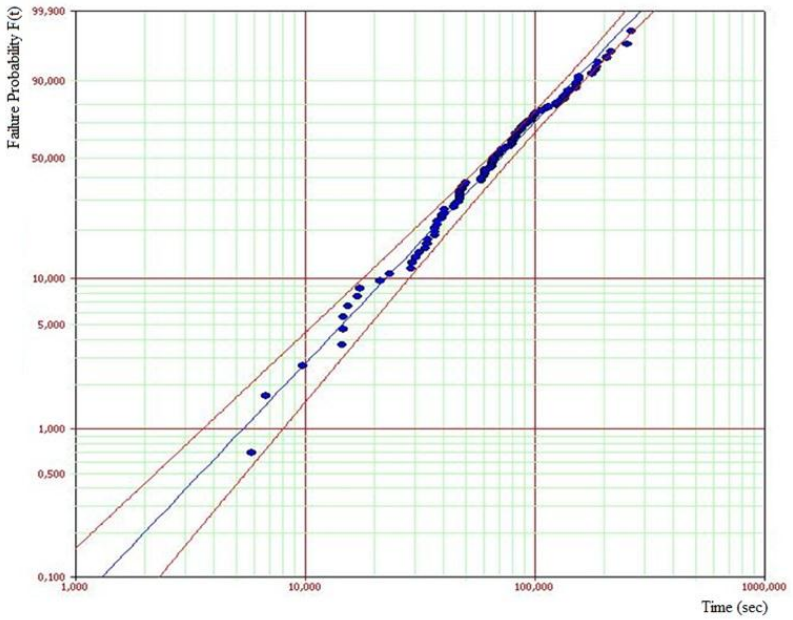

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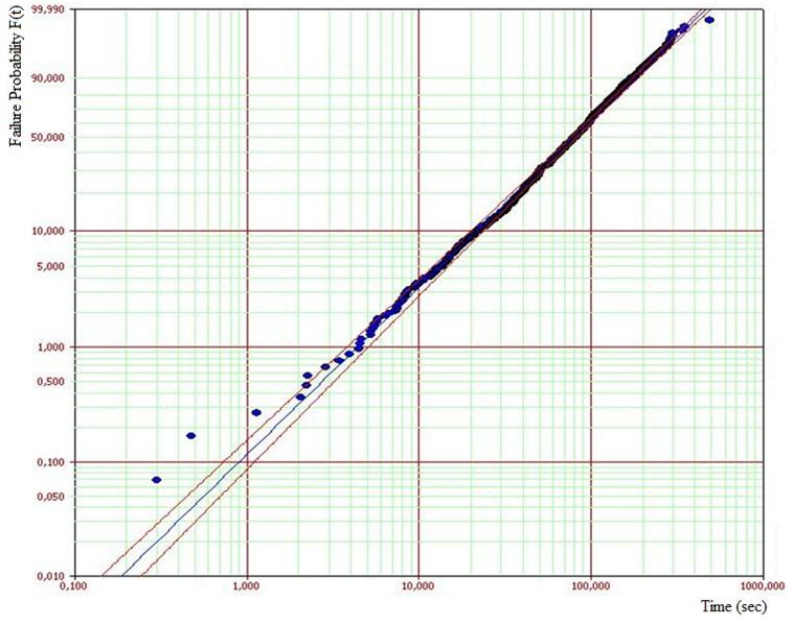

(d)

Figure 1 ï Relation between confidence interval and data sampling. The lines represent the probability line, the upper limit and lower limit of the point.

According to WCM, there are no inefficient people but inefficient process. On this way, increasing human reliability, process' reliability and productivity will increase. In order to make that, only training is not enough, the operator's attitude and a safe and proper work place is much important. These questions are addressed by motivation and stimulus' programs, ergonomics planning, specialized medicine and work safety services and mainly, acknowledgment for the run work. In order to encourage the operator by show poor results, that generate data for MMS, a new policy must be created, a policy to not punish the operator because of "honest mistakes". This data will feed the MMS and enable it to apply the continuous improvement, which is a pillar of WCM (ABNT, 1995).

3. RESULTS AND DISCUSSION

3.1 - Management of Corrective Maintenance

3.1.1 - Fault management

It is the stage in which the maintainer will do the fault management incidents. It will be done through filling a form whose ñinputsò have been defined as support to main needs of the quantitative analysis tools adopted, which will facilitate a following study of obtained data. Table 1 presents a form model to be followed.

Table 1 ï Standard form

	Form Item	Example
1	Reason for call	Machine Locked
1.1	The operating condition at the failure time	Working, waiting, setup
2	What is fail?	PCU
3	The fail was detected by?	Beep, error massage
4	Possible failure modes of component	PCU Heating
5	Performed tests	Measuring current, temperature
6	Need to change? Why?	Yes Component burned.
7	The failure refers only to the component?	Yes.
7.1	If so, which other component?	Vent clogged.
8	Action Taken	Replacing faulty components.

The flowchart of fault management is shown in Figure 2. The stage steps are:
(1)- The occurrence communication is the process start. Generally, the equipment operator is whom make it.
(2)- After communication, the maintainer must drive yourself to the local where is the equipment.
(3) For every occurrence register, must be open an occurrence faults form for each component or peripherals.
(4)- All necessary verifications must be defined by maintainer in according with equipment situation.
(5) The maintainer must inform if performed tests were sufficient to fault identification.
(6)- The maintainer must identify if component fault is linked to some peripherals.
(7) The maintainer should be able to identify if thereôs necessity of change component.
(8) If there isnôt necessity of change component, the maintainer must repair it.
(9) If thereôs necessity of change component, the maintainer must pick up a new component in the stock.
(10) So the maintainer must perform the component change at equipment.
(11) The maintainer should be able to identify if thereôs necessity of change peripheral.
(12) If there isnôt necessity of change peripheral, the maintainer must repair it.
(13) If thereôs necessity of change component, the maintainer must pick up a new peripheral in the stock.
(14) So the maintainer must perform the peripheral change at equipment.
(15) After all interventions the maintainer must perform tests pre established for release the restart of equipment operation.
(16) The maintainer must end the occurrence and register every occurrence form in the system.

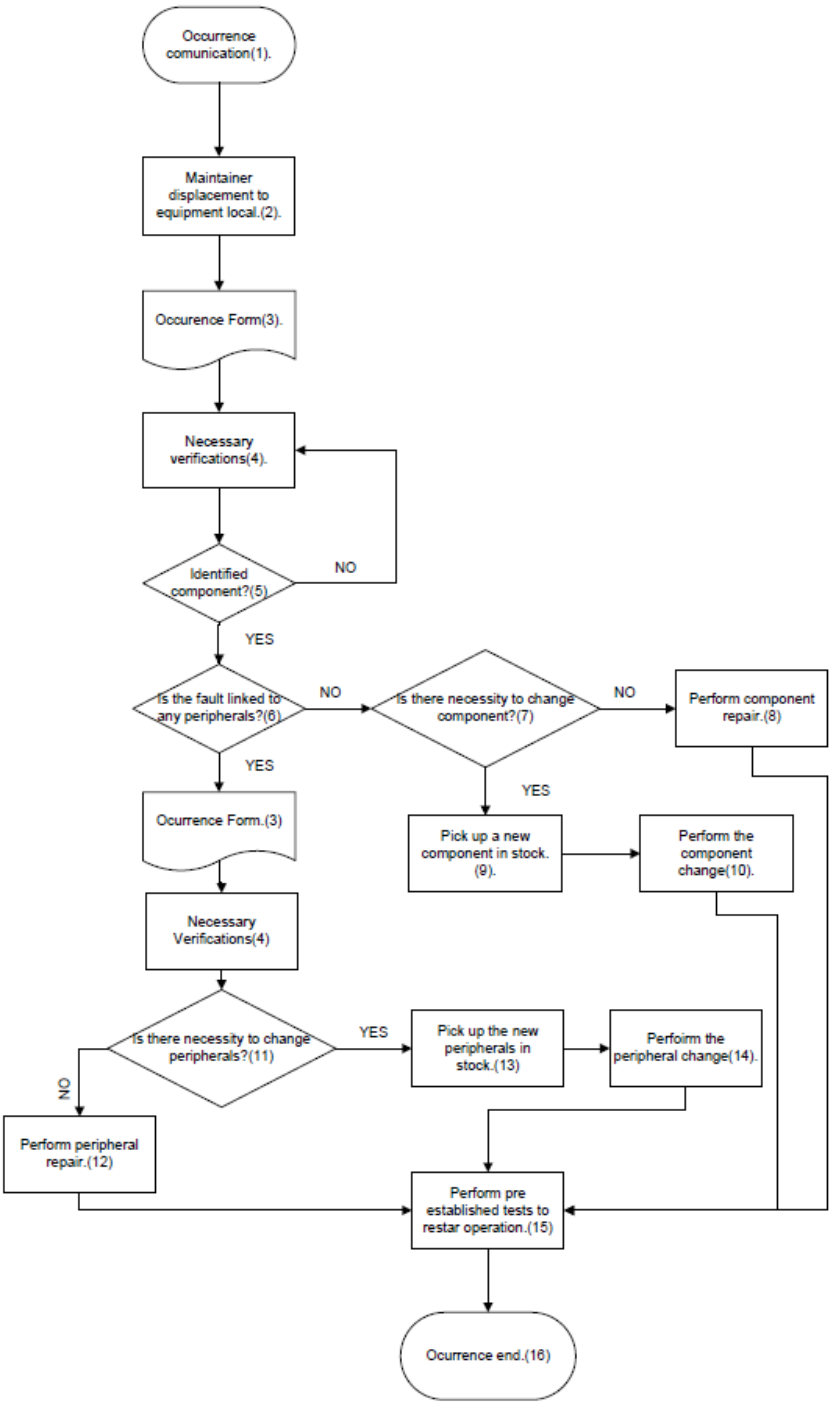

Figure 2 ï Flowchart of fault management

3.1.2 Data Management

It is the stage responsible for treat fault management register in order to obtain all qualitative information related to equipment and its faults, generating a database capable of feed the analyses to be done later. This analysis will be done by a team to be set, in which will be rather involved member of maintenance team, equipment operation team and maintenance planning team. The data treatment will follow fault management methodologies (FMEA, RCA, FTA, RBD, 5W) (Dias, 2000). Figure 3a shows the flowchart that must been follow at this management step. The stage steps are:

(1)- The start of data management occurs when there is some fault register.

(2) The data manager must perform a preliminary analysis of fault register, where he will evaluate the necessity of a meeting with the team to treat the register.

(3) ï In case the responsible considers necessary perform a meeting for treat the register, he should invite members of all interested areas, forming then the team that will be responsible to treat the register.

(3.1) After team members definition, them should define what qualitative analysis tool will be used to treat register.

(3.2) The tasks that will be performed by each member and its respective due dates, must be define in the meeting in way that the register be treated more fast as possible .Meeting must be performed until the register be completely characterized.

(4) The responsible of data management should organizes all data and meeting reports, generated since first meeting until the end of treating process.

(5) All documents must be stored, ending the process of treating register. These documents could be used as lessons learned for next registers.

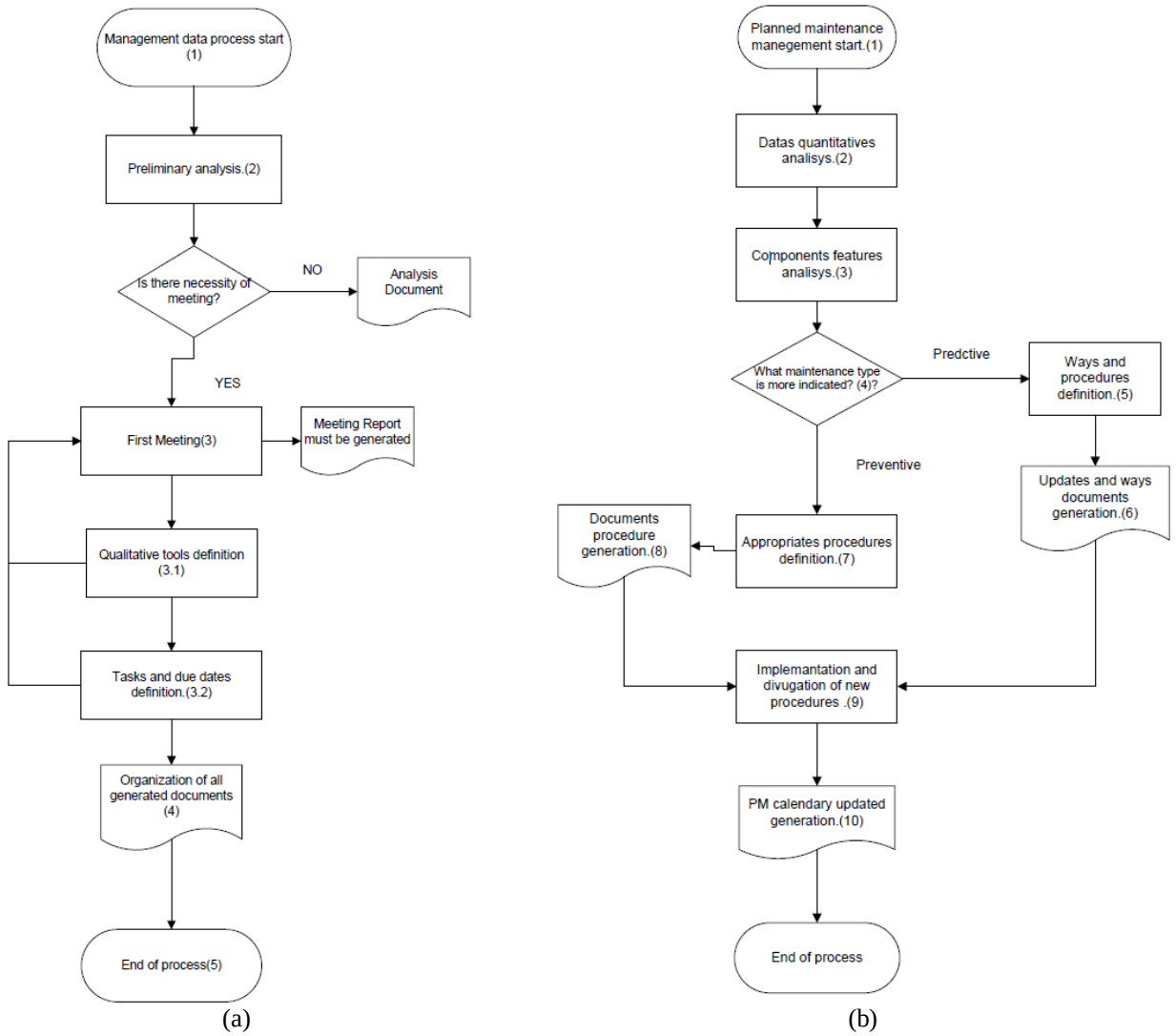

Figure 3 ï (a) Flowchart of data management; (b) Flowchart of planned maintenance management

3.2 - Planned Maintenance Management

Figure 3b shows the flowchart of planned maintenance. The stage steps are:

(1)- The planned maintenance process start is after generation of documents in data management.

(2)- The planned maintenance responsible should use quantitative tools for identify features like MTBF, MTTR, Reliability and others.

(3)- After Component quantitative analysis, should be made one analysis of component criticity for the equipment, considering TTR (Time To Repair), duty cycle and other indicators.

(4)- After all analysis, the planned maintenance management responsible should decide what maintenance type is most indicated for the component, based in maintenance decision matrix.

(5)- In the case of the type of maintenance defined, being the predictive, the planned maintenance management responsible should define what ways for predictive analysis must be adopted.

(6)- The planned maintenance management responsible should generate all documents that were updated or created, storing them in adequated way on system.

(7)- In the case of the type of maintenance defined, being the preventive, the planned maintenance management responsible should define what procedure must be adopted.

(8)- The planned maintenance management responsible should generate all documents that were updated or created, storing them in adequated way on system.

(9)- The planned maintenance management responsible should provide the data implementation and divulgation for all involved.

(10)- The planned maintenance management responsible should generate a PM calendar with all updates, showing where they will actuate.

3.2.1 Management of preventive maintenance

Management of preventive maintenance is characterized by defining the optimum periods for intervention in the component without any intermediate action. These periods will organize the annual calendar of preventive activities which should be prepared between the management and production sectors company. For it, will be used data obtained from Management of Corrective Maintenance and data quantitative analyses (Mirsgawka, 1991), applying the concepts of reliability and following the premises of WCM. Should be prepared ñmachine ledgerò equipment and used quantitative analyses software.

3.2.2 Management of predictive maintenance

It is characterized by defining the optimum periods to make component analyses, ordering to identify the best moments to realize the intervention (Nepomuceno, 1999), structuring an annual calendar of predictive activities. Will be used data obtained on management of corrective maintenance, and the quantitative data analyses.

3.3. Management of spare inventory

It is the planning and determination of replacement part's inventory dedicated to the equipment, included on this, components and necessary tools. A high index of spare inventory will fill a space that could be widely used to other purposes. Remembering that waste space is something that goes directly against WCM premises. Therefore it is important to do an appropriate planning, so that no large inventory will be used, looking for space availability. The spare inventories will be planned according to the life cycle of the tools used by maintainers, by the graph of necessity created by PM's calendar and some components that have features of failure hard to predict and could cause production losses. In order to perform next MMS'step all the previous steps may be considered, such as benchmarking events, suppliers development strategies for quality improvement and high reliability products, among other resources that make feasible the best practices in terms of planning for inventory reposition. In Figure 4 is shown a flowchart presenting inventory management and spare parts. The stage steps are:

(1)-The spare inventory management starts when there are necessities of components or tools replacement.

(2)-The spare inventory management responsible should analysis the real necessity of each applicant.

(3)-In the case of the spare inventory management responsible judge that there isnôt real necessity or sufficient budget, he should inform to applicant.

(4)- In the case of the spare inventory management responsible judge that there is real necessity and sufficient budget, him should generate one purchase order and send to purchase department.

(5)- The spare inventory management responsible should follow the purchase status and inform to applicant the lead time.

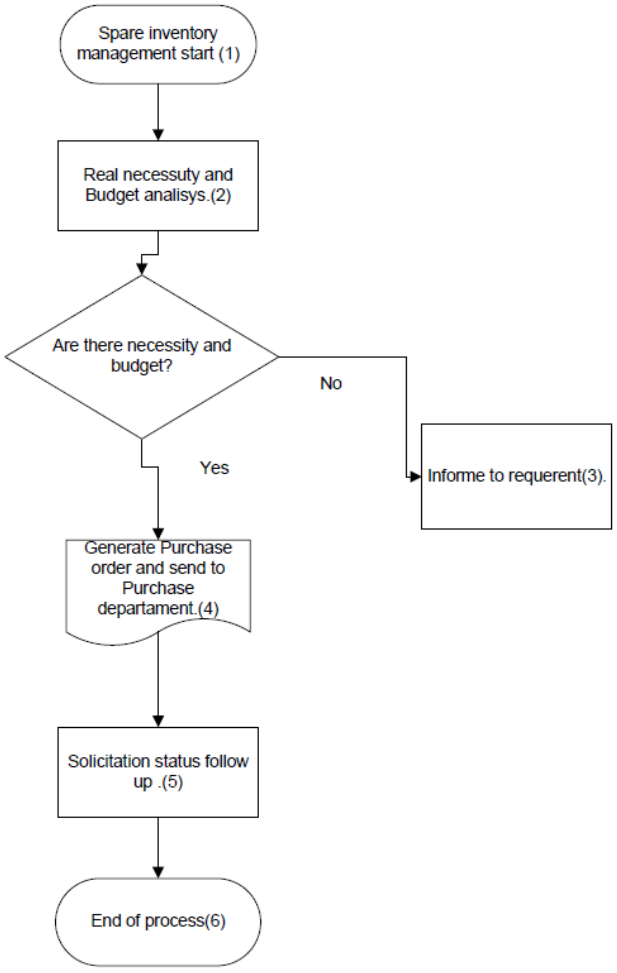

Figure 4. Flowchart of Spare parts inventory management.

3.4 - Human management system (HMS)

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3.4.1. Workplace and safety management

Step on that the ergonomics and specialized questions of work security's and medicines will be accosted. It should be done through ergonomics projects developments directed to adapt the workstation to the ergonomics standards, providing better work conditions to the professional. Projects on work medicine and workplace safety specialized services will be developed in order to provides safety to operator, giving to him great work conditions and assistance in case of accidents, beyond awareness campaigns and disclosure of area's projects. The workplace safety management step will be responsible for the accident risk calculus of each proceeding.
Weeks of release and awareness of workplace management projects will support to disseminate the idea among employees. In these weeks promoted by engineer team in partnership with HR, the projects should be released to target professionalsô, that should receive train and orientation to the ergonomics questions, so they will take awareness through the importance of this area, the same is valid for workplace safety and work medicine.

3.4.2. Motivation management.

This is the step responsible to identify the employee satisfaction and motivation through the partnership from HR and the maintenance department. It will be done through field research, motivational programs, familiar integrate and fraternization events, acknowledgment and encourage programs. The fieldôs researches could be done through sporadically questionnaires to maintainers, bringing daily company subjects, exhibiting training sessions, lectures, etc.

The motivational programs should be developed by HR in partnership with engineer team, based on maintainer's satisfaction and motivation level, and it should be given periodically. These programs should be done from absenteeism and attendance *versus* productivity studies, business turnover, and through quantitative studies done based on visits to the work places.

The acknowledgments and stimulus programs should start from the principle that all employee get its motivation extends when acknowledged and rewarded, working hard and better. Fraternization events and family integrates should be defined and programmed by HR considering commemorative dates and results disclosure.

4. ACKNOWLEDGEMENTS

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