

## Predictive Maintenance for intensive energy consuming plants, serviced by under-qualified staff. Case study

Dorina Ionescu<sup>1</sup>

<sup>1</sup> Department of Mechanical Engineering Technology  
Faculty of Engineering and Built Environment, University of Johannesburg  
Doornfontain Campus 2006 Johannesburg (South Africa)  
Phone/Fax number: +0027 559 6509, e-mail: [dorinai@uj.ac.za](mailto:dorinai@uj.ac.za)

### Abstract.

Maintenance has traditionally been viewed as a separate entity outside the manufacturing process. Total Productive Maintenance (TPM) is a maintenance philosophy designed to integrate equipment maintenance into the manufacturing process [1], [2], [3]. TPM is based on proactive and preventative maintenance and places a strong emphasis on empowering operators to help maintain their equipment, thus reducing to a minimum the small stops, product defects, equipment breakdowns and work related accidents. Total Production Maintenance (TPM) is a necessary part of any successful business, where down time for maintenance is an integral part of the manufacturing process [4], [5], [6].

The maintenance process evolved over the years passing through several phases before reaching the highly efficient TPM phase. The TPM program closely resembles the Total Quality Management (TQM) program [2], [4] where several of the tools used in TQM such as employee empowerment, benchmarking, documentation, etc. are used to implement and optimize TPM. However, there are some essential differences making the TPM process human friendly by shifting the means of attaining the final goal from management systematization and software orientation in TQM, to employees participation and hardware orientation in TPM. This process is highly adequate for plant maintenance in developing countries, where work force is generally under qualified.

### Key words

Predictive maintenance, Monitoring and Implementation

### 1. Introduction

One of the socio-economic realities in South Africa is the huge qualification and remuneration gap between the different levels of management and the bulk of the working force. The South African businesses realized that in order to increase the productivity and competitiveness on the international market, steps must be taken to meaningfully involve the work force in all aspects of production. The remuneration should reflect and reward the quality of work and the productivity. To attain this goal, the management must engage in training the existing work force, instilling a sense of responsibility and ownership. The process of TPM requires the change from a reactive/corrective maintenance environment to one that

is based on preventative maintenance [3], [4], [5]. In order to succeed TPM must be a group effort where the entire organization works together to maintain and improve the equipment. The first step in implementing TPM is considering the human capital and forming teams that are empowered to improve the process. Employees empowered to affect the process will typically be in a position to identify and create process improvements that would have normally been overlooked by management. By performing routine maintenance items, the employee assumes an ownership role leading to an on-going production improvement.

### 2. Preventive Maintenance

The notion of **Preventive Maintenance (PM)** was introduced for the first time in 1951 and consisted of daily maintenance activities such as cleaning, inspection, oiling and re-tightening etc. PM was designed to retain the healthy condition of equipment [2]. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance [2]. Preventive maintenance it is further divided into:

**A. periodic maintenance** or **time based maintenance (TBM)** which consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems;

**B. predictive maintenance** is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is **condition based maintenance (CBM)**.

### 3. TPM Implementation in South Africa, case study [7]

The case study refers to a medium size ( $\pm$  430 employees) manufacturing company that can be considered a leader in TPM implementation. Over a

period of approximately two years (from 2006 to 2007) the company produced a comprehensive TPM documentation followed by efficient implementation down to the “grass roots level”, managing about a radical attitude change toward the production process. From the different meetings held between April 2005 and January 2007 a clear picture of the “way forward” emerged, starting with the vision and mission statements encompassing all the essential attributes of the TPM principles.

**A. Vision statement [7]:** “Manufacturing, Maintenance and Engineering united to achieve a fully entrenched TPM system operating within the company, so that it becomes a way of life”.

**B. Mission Statement (abridged [7]):** “To train, educate and uplift selected shop-floor personnel in the TPM operating process, giving them ownership of their machine, so that they will increase the reliability of the machines, the quality of the product and create a safe working environment for all”. The concept of operator’s “ownership” of the machine is extremely important given the recently colonial history of South Africa. The introduction of TPM in any company, would be an efficient tool used to bridge the workers / owners divide.

**C. TPM Pilot Project (abridged):**

- Identify the equipment and operator teams;
- Identify roles (mentors, trainers, etc);
- Training – learning theoretical sessions and practical demonstrations;
- Evaluation and feed-back.

As the **predictive maintenance** is intrinsic part of the larger TPM process, the company approach to TPM implementation is based on four principles:

- Flat organisational structure,
- Full participation,
- Not one-man show but strong mentoring,
- Package developed at the lowest levels possible

The company started its pilot project with the traditional approach to TPM, basing its programme on the classic “**5S**” principles (**housekeeping**) as a foundation and eight supporting activities (sometimes referred to as pillars). For this particular company one of the foundation principles was adopted to be the “Zero Breakdown”, supported by “seven pillars” namely:

1. Machines in reliable conditions;
2. Best maintenance practices;
3. Best operating practices;
4. Condition monitoring;
5. Back-up, plan B;
6. Regular planned reconditioning;
7. Phase out unproductive machines.

The company understood that in a manufacturing environment the operator is the front line tool user and the link between management and tool. A successful cooperation between machine and operator must be based on the several requirements, which once fulfilled, generate a total change in attitude toward work:

Aptitude = Pride

Knowledge = Job satisfaction  
 Intelligence = Self esteem  
 Respect = Responsibility  
 Commitment = Accountability  
 Understanding = Empowerment  
 Bonding = Ownership

Once the basics of TPM implementation were done i.e. designating the operators and the machines, study and examination material was developed to accommodate low qualified operating staff. Figures 1, 2, 3, and 4, show examples of TPM implementation via visual panels.



Fig. 1 – Filter line 1 TPM equipment [7]

Next to each of the designated machines a panel was installed, as shown in figure 1, listing the main possible break-downs and the corrective steps to be taken. This was done with pictures of the machine part that can cause trouble, with a graphic symbol next to it i.e. ear = listen to the noise, eye = watch the temperature, oil level, clock = watch the duration of the operation, spanner = call the maintenance team etc. In this way the language barrier can be avoided or eased, as South Africa has 11 official languages. Each designated operator who obtained the TPM certificate was given intensive personal attention, with the final aim that they will become at their turn mentors for the rest of the operators. Due to labour laws in South Africa a person can do maintenance work on machinery only if she / he have a formal engineering qualification. As the operators are not formally qualified mechanics, the company decided to change the word “maintenance” with “Condition Monitoring”, as the operator permanently monitors the working condition of the machine



Fig. 2 – Filter line 1 TPM panel [7]

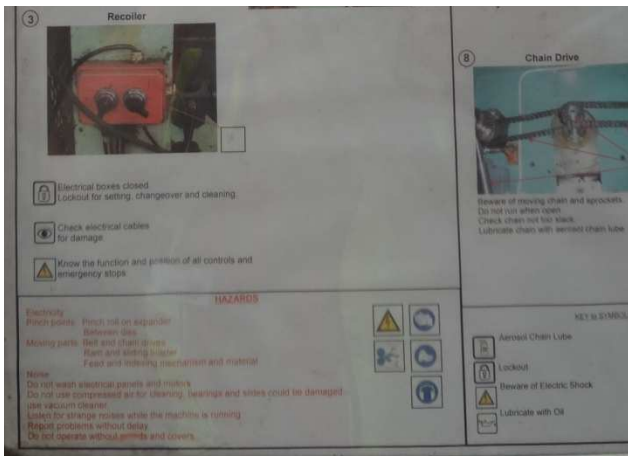


Fig. 3 – Filter line 1 TPM (Detail) [7]



Fig. 6 – Machine 304 – TPM panel [7]

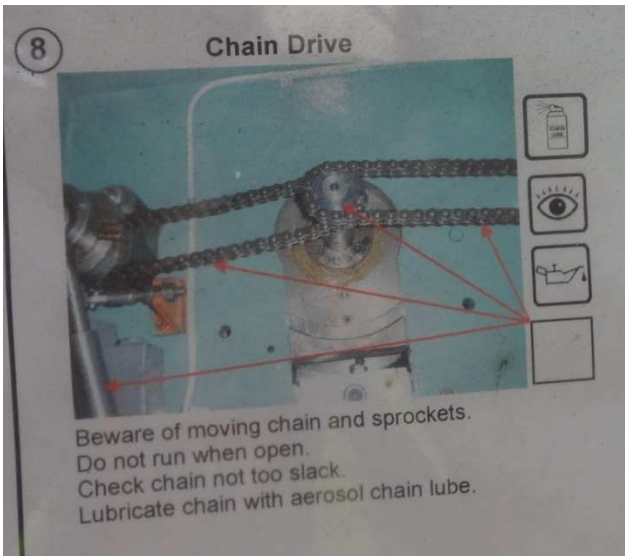


Fig. 4 – Filter line 1 TPM panel – Chain Drive [7]

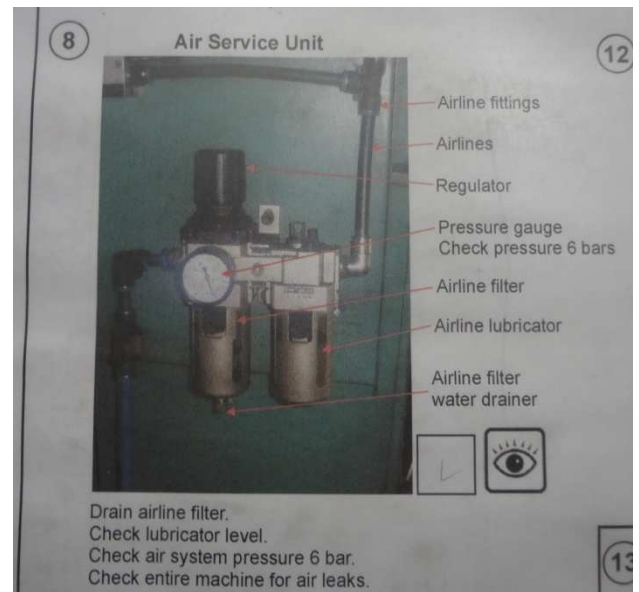


Fig. 7 - Machine 304 – TPM panel (detail) [7]

Figures 5 to 8 show several examples of TPM designated machines and the corresponding visual panels.



Fig. 5 – TPM equipment - Machine 304 [7]



Fig. 8- Machine 304 – TPM panel (detail)[7]



## 4. TPM implementation process in the “case study” company

### A. Example of TPM information flow chart

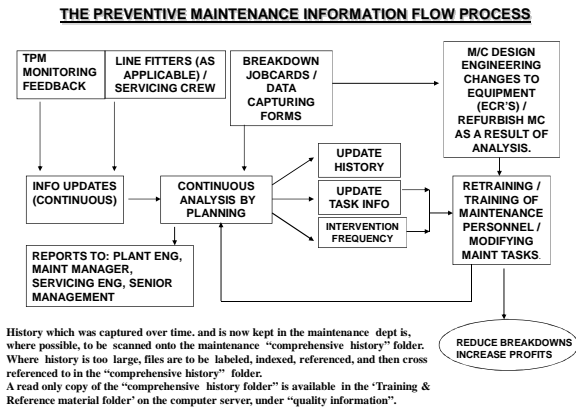


Fig. 9 – TPM Information Flow Process [7]

### B. Example of TPM Planning phase

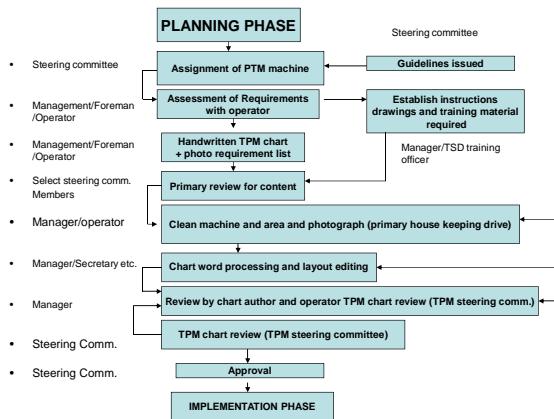


Fig. 10 – TPM Planning Phase [7]

### C. Example of TPM monitoring and controlling list

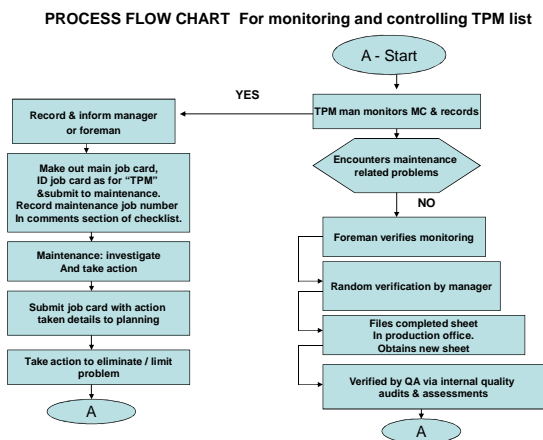


Fig. 11 - TPM monitoring and controlling list [7]

## 5 Conclusions

The case study company successfully implemented a “custom made” TPM programme, resulting in a significant increase of productivity and self-esteem of the staff members. South Africa has a militant working class and “Belonging” is of outmost importance, especially due to the colonial past of our country. The introduction of TPM helped forge a new relationship between management and workers: there is no longer “them and us” but just “us”. The TPM trained machine operators were issued with a badge showing their status and the wearing of the badge is a constant source of pride among staff members.

To alleviate the high level of unemployment in South Africa, many companies have a “Off the street training policy” where a totally unqualified person, literally from the street, is taken in by a company and trained to perform a meaningful task but not always resulting in permanent employment. By contrast the TPM programme practiced by the case study company ensures a permanent employment and real possibility of advancing within the company. Also the introduction of visual panels helps fast integration, overcoming the language barrier.

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