DEVELOPMENT OF A TOTAL PRODUCTIVE MAINTENANCE REPORT CARD FOR CRITICAL MACHINES

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ABSTRACT

This project describes a total productive maintenance (TPM) implementation at the Weir Minerals Africa Isando plant where previously a critical machine experienced a breakdown lasting 30 minutes or more every day. A system was created to track the number of breakdowns and availability of critical machines. The proposed solution consists of a report card for each critical machine, which includes a machine diagram, the frequency of breakdowns, a root cause analysis, a list of critical spares and a planned maintenance schedule. The proposed solution is a starting point upon which a comprehensive preventative maintenance program will be developed.

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1 INTRODUCTION

1.1 Background

The ever-increasing competition in today's industry has compelled delivery commitments and operating costs to be an important consideration when securing customers. Costs associated with equipment breakdowns, degraded equipment and unavailability of spares and data, lead to downtime of the plant, production losses and wasteful activities. In order to meet increased market expectations and reduce operating costs, industries have focused efforts on reducing unplanned downtime. The maintenance department is being increasingly viewed as an indispensable function of the production system [1-3].

A Weir Minerals Africa plant in Isando South Africa has initiated a maintenance improvement plan to minimise equipment downtime and increase equipment availability. The plant's current maintenance programme is reactive and plant machinery suffers from a high level of downtime. This paper describes the design and initial results of a maintenance and reliability engineering programme to implement best practices at this plant.

1.2 Literature Review

Total productive maintenance (TPM) originated as a response to the need for the improvement in operational performance. According to Nakajima [4], TPM is a company-wide initiative to achieve zero machine breakdowns and defects. By eliminating these breakdowns and defects, operational efficiency and productivity can improve with a reduction in cost and inventory. TPM is a widely used strategy for enhancing maintenance performance. It has been successfully implemented in organisations for over three decades and is vital tool for any organisation to sustain its competitive advantage [5].

To date, relatively little research has been conducted on the implementation of TPM within the South African context. A search conducted in the South African Journal of Industrial Engineering on the keywords, "*TPM*" and "*total productive maintenance*" revealed no results. A Google Scholar search on the keywords, "*total productive maintenance in South Africa*" revealed only one study on TPM [6]. A further Masters dissertation [7] detailing a TPM case study in South Africa was found.

Van der Wal and Lynn [6] qualitatively observed perceptions of TPM and its implementation at a paper mill in South Africa. The effects which TPM implementation had on employee development, productivity, quality and change in the organisation were examined. TPM was implemented through the establishment of multi-disciplinary teams and continuous improvement projects which allowed employees to assist in the improvement of plant productivity and organisational competitiveness. Results from the study indicated that through the implementation of TPM activities, including visual management, autonomous maintenance and company-wide involvement, improvements in quality, productivity and cost were observed.

A more recent study, conducted by Ncube [7], examined the implementation of TPM on the manufacturing performance of a Mitsubishi Colt production facility. The findings indicated that the successful implementation of TPM needs both production and maintenance departments to be involved. Furthermore, it was observed that training is essential to observe the positive impact that TPM has in the plant.

1.3 Aim of this Study

The lack of research on TPM in the South African manufacturing environment highlights the need for such a study. This case study will raise the profile of TPM in South Africa and illustrate important aspects of the approach such as maximising equipment effectiveness, improving maintainability and ensuring total participation of employees [1].

2 METHODOLOGY

The Weir Group consists of three divisions: Minerals, Oil and Gas, and Power and Industrial. The Minerals division manufactures slurry equipment including pumps, screens and rubber linings for the mining and minerals industry. The Weir Minerals Isando site primarily manufactures slurry pumps and houses a machine shop, rubber plant, foundry and pump test bay facilities. The Maintenance Department at this site carries out all planned and unplanned maintenance on all machines in the plant.

TPM focuses on what are called the six big losses: breakdowns, setups, small stops, reduced speed, start-up rejects and production rejects. The scope of this project was narrowed down to focus only on breakdowns.

The data obtained from the plant's computer maintenance management system (CMMS) was inaccurate and incomplete. This required that data be collected using temporary systems using Microsoft Excel to verify the frequency of breakdowns and the availability of the critical machines. These temporary systems were used to analyse the current state in Section 3.

This quantitative data was augmented using a semi-structured interview with maintenance personnel to obtain in-depth information regarding critical components of the machine as well as critical spares.

The initial first step in the project was to incorporate the CMMS into the day-to-day tasks of the maintenance personnel so that they would receive better guidance and so that the maintenance function could be better measured and managed.

3 CURRENT STATE ANALYSIS

3.1 Identification of Critical Equipment

An equipment impact matrix which positions the various machines according to financial cost of repairing the failure versus impact of failure on operations was created, as shown in Figure 1. Critical machines with a high financial cost of repair and a high impact on operations were considered for further analysis as they have the greatest impact on plant operations.

Financial Cost of Repairing Major Failure				
	Above R150000		•Compressor •Boiler 3T/H •Shot blast rub •Heat treat 1&2 •Auto clave 1&2 •Fastloop •Femco H •Top hat 1&2 •Femco VL 12s •Gen set	•Intermixer •Black mill •Festoon •White mill •Press 6 •Press 14 •Press 15 •Press 16 •Kuraki •Dorries •Scrap crane •Shake out •Furnace trans •WEB136 •WEB 105 •WEB 106 •Cincinnati
	Above R5000		•Chemlock booth •Generators •Hanger shot blast	•Foundary transformer •M/C transformer •Rubber plant transformer •Furnace control system •Fastloop PLCs
	Below R5000	•Tools •Air guns •Grinders		
		Low	Medium	High
		Impact of Major Failure on Operations		

Figure 1: Equipment impact matrix

3.2 Number of Breakdowns and Availability

Details of critical machine breakdowns were obtained from morning maintenance meetings in which the previous and current day's breakdowns were discussed. The data recording began on 8 October 2012 and will continue to be used to develop a database to record the operating history of the equipment until the CMMS is fully functional.

Using this information, the number of breakdowns of critical machines was calculated to determine trends. Data for the month of December were omitted as this is the period during which planned maintenance is carried out. Figure 2 shows the number of breakdowns averaged over the period of October 2012 to January 2013.

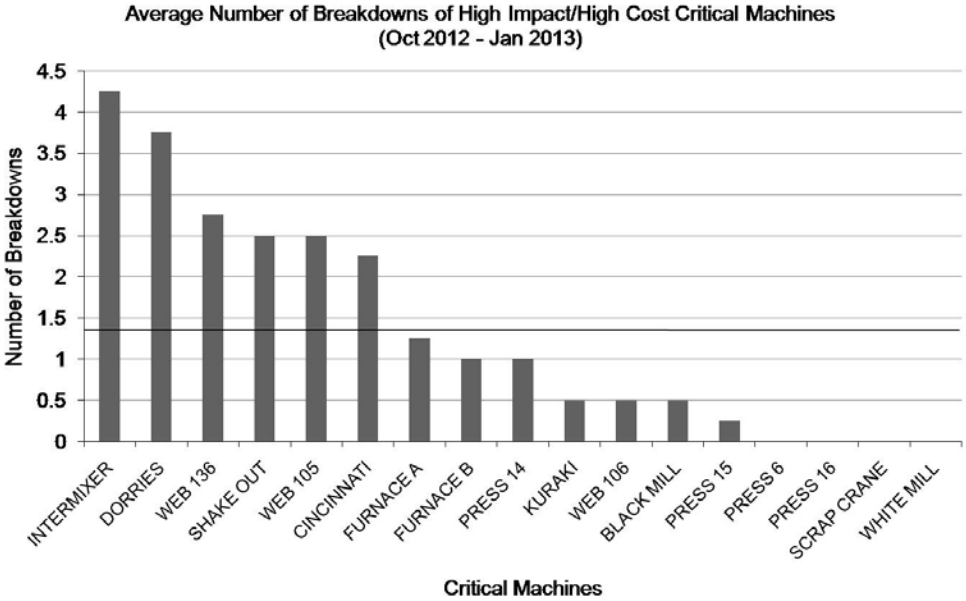

Figure 2: Frequency of critical machine breakdowns from Oct 2012 to Jan 2013

Based on the number of breakdowns, the available hours for all the critical machines were averaged over the months under consideration. The percent availability was averaged over the indicated period and is shown in Figure 3.

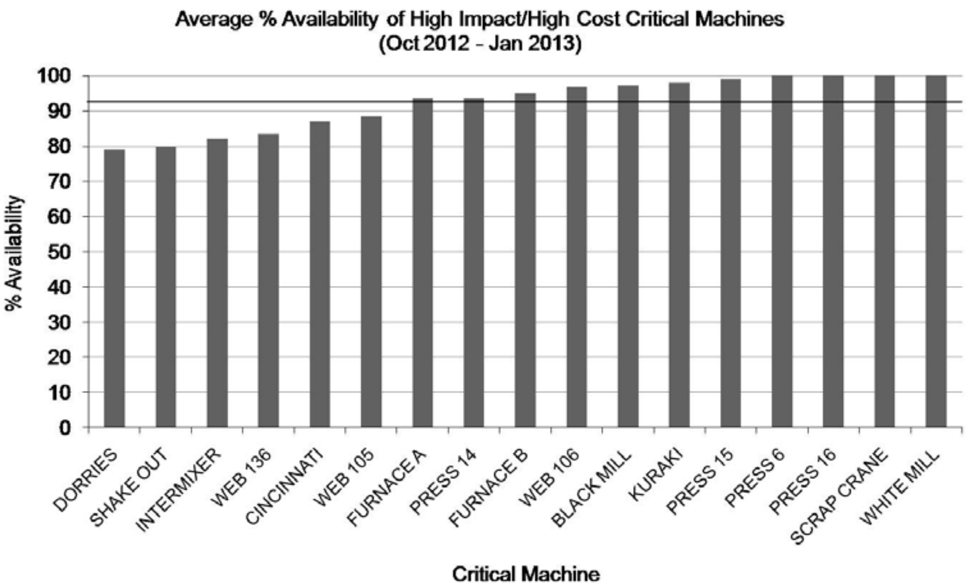

Figure 3: Availability of critical machines for Oct 2012 to Jan 2013

The average machine availability is approximately 92%. This is below the world-class benchmark of 97% [8].The benchmark value of 97% is specific to mechanical availability and where maintenance activities employed are corrective, rather than preventative, in nature. [8].

4 RESULTS AND DISCUSSION

4.1 Proposed Solution

Information used to improve the machine availability was obtained through interviews with maintenance personnel as well those responsible for implementing the plant's CMMS. This proposed solution involves implementing a total productive maintenance plan on the CMMS that includes a report card for each critical machine. The report card details: a picture of the machine, a machine diagram, the frequency of breakdowns, a root cause analysis, the critical spares, and a planned maintenance schedule. These will be discussed in turn.

The machine diagram highlights the strategic functional components which are crucial to the machine's operation. In addition, the sub-components and sub-systems are noted as well as their interaction with one another. Figure 4 shows an example of a machine diagram.

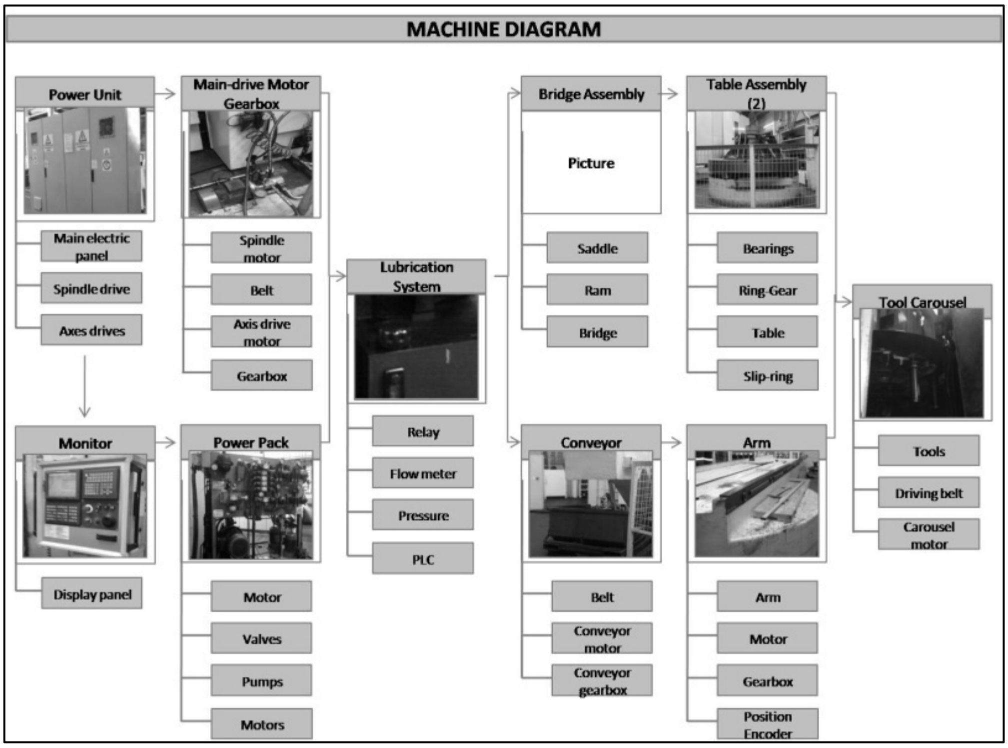

Figure 4: Machine diagram

Using the existing management information system, all the unplanned maintenance carried out from 1 January 2012 to 31 December 2012 was collected and entered into a spreadsheet. This information was then divided based on the critical components identified in the machine diagram. This information was used to draw up the frequency of component failure as shown in Figure 5. This historical data will help identify components which are prone to failure.

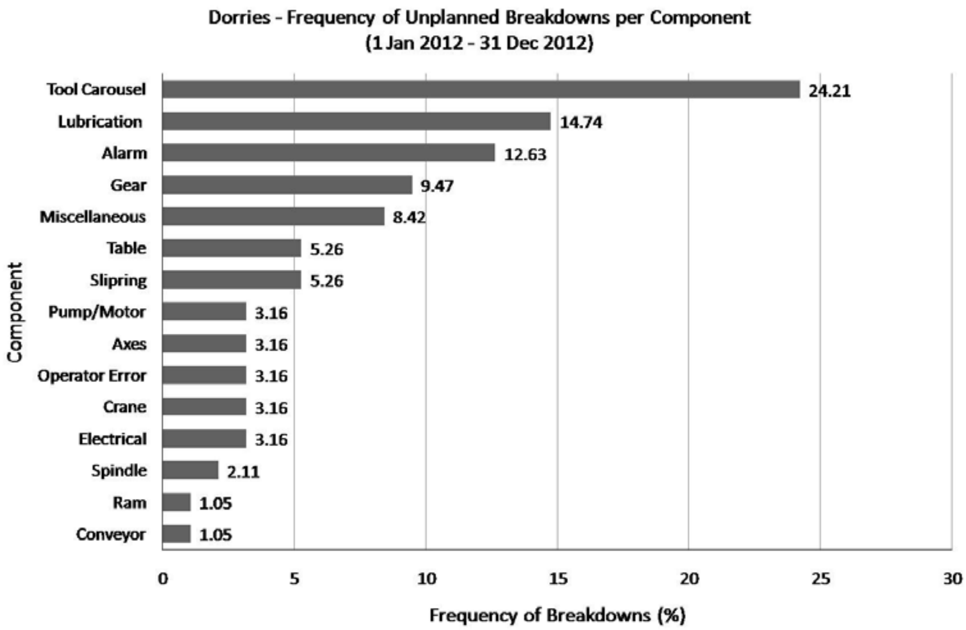

Figure 5: Frequency of component failure per critical machine

A root cause analysis (shown in Figure 6) highlights recurring maintenance issues and determines their root causes. This information is important when developing a preventative maintenance schedule.

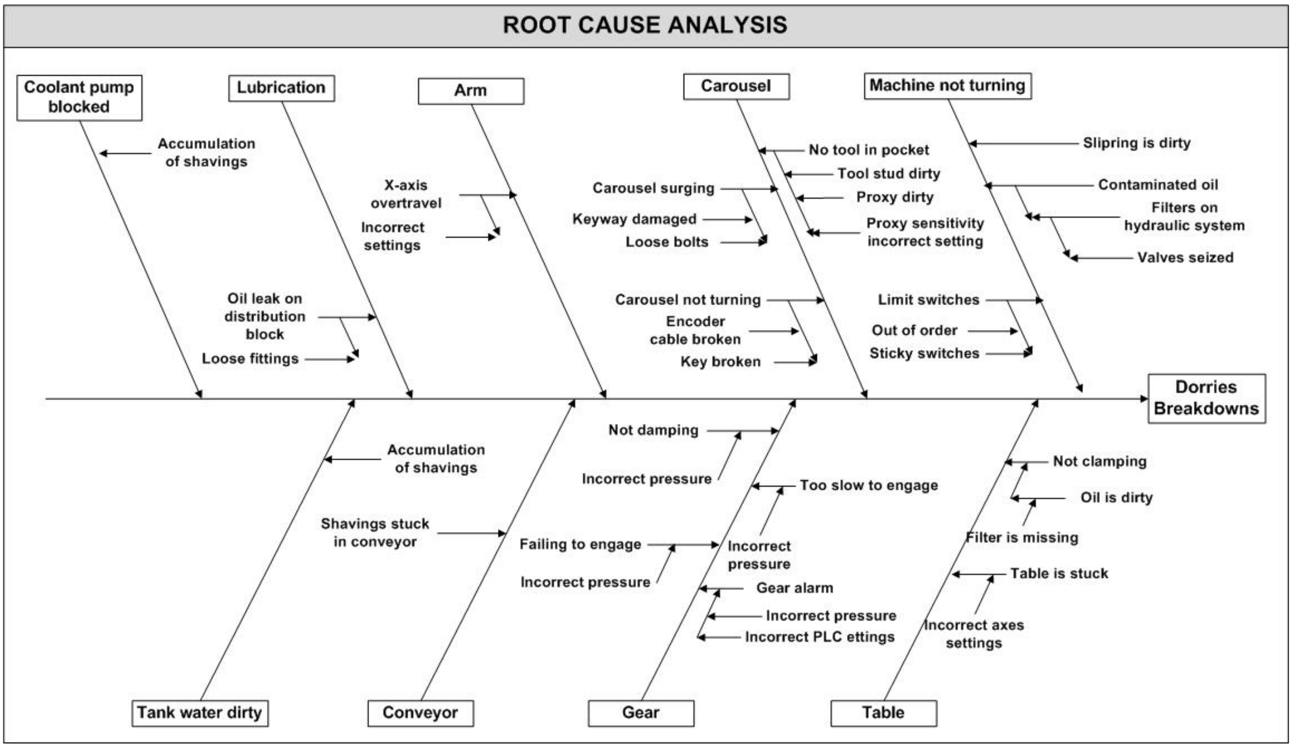

Figure 6: Root cause analysis

A list of critical spares (shown in Figure 7) includes supplier lead time, availability and stock levels for each critical piece of equipment. This information will be updated by maintenance personnel as required.

CRITICAL SPARES				
Spare Part	Availability			
	Supplier Lead Time	Yes (✓)	No (✗)	Stock level
Slip-ring				
Main-thrust bearing				
Main-centre bearing				
Filters				
Strainers				
Drivers/ Controls				
Bolts and nuts				
Screws				

Figure 7: List of critical spares

Lastly, based on the information gathered above, a planned maintenance schedule, including a daily, monthly and annual schedule was developed for the critical machines under consideration.

The final report card format for each critical machine is shown in Figure 8.

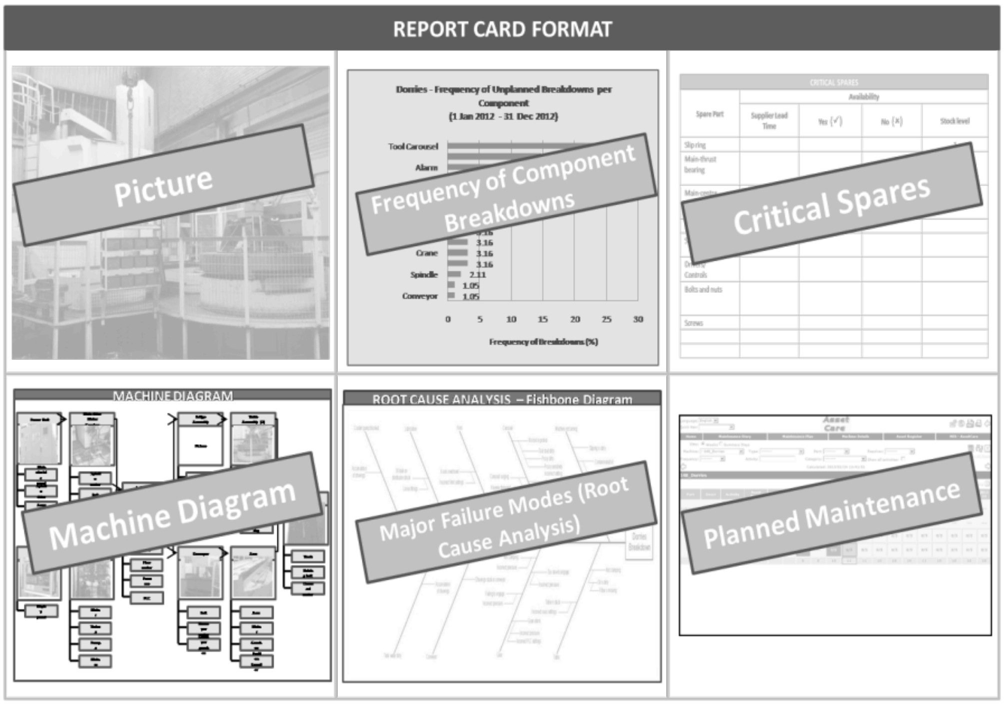

Figure 8: Sample of report card

The proposed solution employs a visual management technique to bring critical equipment issues to the forefront. By using this technique, the information can be easily accessible and visible to employees and managers. The report card aims to encourage employees to expose the problems and issues regarding critical machines so that these may be resolved.

5 CONCLUSIONS AND FUTURE WORK

The use of reactive maintenance at the Weir Minerals Africa Isando plant has resulted in a large portion of the daily workload consisting of managing equipment breakdowns. Due to lack of data regarding frequency of breakdowns and machine availability, a temporary system to collect this data was developed. The machine availability was measured to be approximately 92%. This is below the world-class benchmark of 97%.

The proposed solution to improve the machine availability consisted of a maintenance report card for each critical machine. The report card includes a machine diagram, the frequency of breakdowns, a root cause analysis, a list of critical spares and a planned maintenance schedule. This will be a starting point for a comprehensive preventative maintenance programme for the plant.

The proposed solution has not been fully implemented. Further work is required to implement the maintenance programme, measure the corresponding machine availability using this maintenance programme, and compare this value to the previously measured machine availability of 92%.

6 ACKNOWLEDGEMENTS

This study conducted on TPM has been made possible by accessibility to the maintenance department and maintenance personnel at Weir Minerals Africa, Isando.

7 REFERENCES

[1] **Nakajima, S.** 1989. *TPM Development Program: Implementing Total Productive Maintenance*, Productivity Press.

[2] **Raouf, A.and Ben-Daya, M.** 1995. Total maintenance management: a systematic approach, *Journal of Quality in Maintenance Engineering*, 1(1), pp 6-14.

[3] **Clifton, R.H.**1974. *Principles of Planned Maintenance*, Edward Arnold.

[4] **Nakajima, S.** 1988. *Introduction to TPM*, Productivity Press.

[5] **Ahuja, I.P.S. and Khamba, J.S.** 2008. Total productive maintenance: literature review and directions, *International Journal of Quality and Reliability Management*, 25(7), pp 709-756.

[6] **van der Wal, R.W.E. and Lynn, D.** 2002. Total productive maintenance in a South African pulp and paper company: a case study, *The TQM Magazine*, 14(6), pp 359-366.

[7] **Ncube, M.** 2006. The impact of total productive maintenance (TPM) on manufacturing performance at the Colt section of DaimlerCrysler in the Eastern Cape, Masters Dissertation, *Nelson Mandela Metropolitan University (NMMU) Business School*.

[8] **Poling, A.** 2012. Reliability and Maintenance (RAM): The Path to World-class Performance, *27th Brazilian Congress on Maintenance*, Rio de Janeiro, Brazil.