Optimizing a Production System Using tools of Total Productive Maintenance: Datlabs Pharmaceuticals as a Case Study.

William M. Goriwondo*, Samson Mhlanga, Tapiwa Kazembe
Department of Industrial and Manufacturing Engineering
National University of Science and Technology, P.O. Box AC 939, Ascot, Bulawayo, Zimbabwe
E-mail address: *wgoriwondo@gmail.com, smhlanga126@gmail.com

Abstract

Total Productive Maintenance (TPM) is a World Class Manufacturing principle that has been used by many companies to improve equipment life-cycle costs as well as Overall Equipment Effectiveness (OEE). This paper is a case study of the application of TPM principles at Datlabs Pharmaceutical Company's Belmont Plant in Zimbabwe. An ABC analysis of the equipment was done to establish the critical equipment that required 20 percent attention to yield 80% results. TPM pillars were used to root out major losses in the plant and the results show improvements in machine utilisation and OEE for identified critical equipment.

Keywords
Total Productive Maintenance, Overall Equipment Effectiveness, ABC analysis

1.0 Introduction
In these times of irrepressible competition at a global scale, industry is in constant search for concepts and means that could render firms a consistent enhancement of performance in terms of productivity, quality and delivery reliability. There is inherent intensification of global competition which is throwing challenges to industry in the form of uncertainty and fluctuation in demand [1]. This paper focuses on Total Productive Maintenance as one concept that can be used to attain competitiveness through equipment utilization and people involvement. The project was carried out at Datlabs (Pvt) LTD's pharmaceutical manufacturing plant in Belmont Zimbabwe. The paper highlights the major steps in implementing TPM as applied to Datlabs. At the beginning of the project Overall Equipment Effectiveness (OEE) was at 45%, against a world class standard of 85%.

1.1 Aim
To improve OEE of critical machines and plant performance using TPM.

1.2 Objectives
The objectives of the project were:
- To use Pareto principles to identify the critical equipment in the plant
- To develop a Failure Mode Effect and Critical Analysis (FME&CA) on critical equipment.

1.3 Background
The pharmaceutical factory at Datlabs falls under the technical department and is led by the production manger. The production process is strictly a batch type of manufacturing. The pharmaceutical factory is responsible for the production of all pharmaceutical products and consumer products. The factory is subdivided into two sections namely:-
1) Liquids, Creams and Ointments (LCO) and syrups line
2) Tabletting

1.3.1 Liquids, Creams and Ointments (LCO) and syrup line
The LCO and syrup lines are two similar lines that process different types of products as their names suggest. The facility layout and design of all the lines is largely influenced by the Good Manufacturing Practices guidelines for pharmaceutical premises which demands that different processes be in self contained rooms.

1.3.2 Tabletting line

Tabletting is a multi-staged process with a general process flow as shown in the Figure 1.

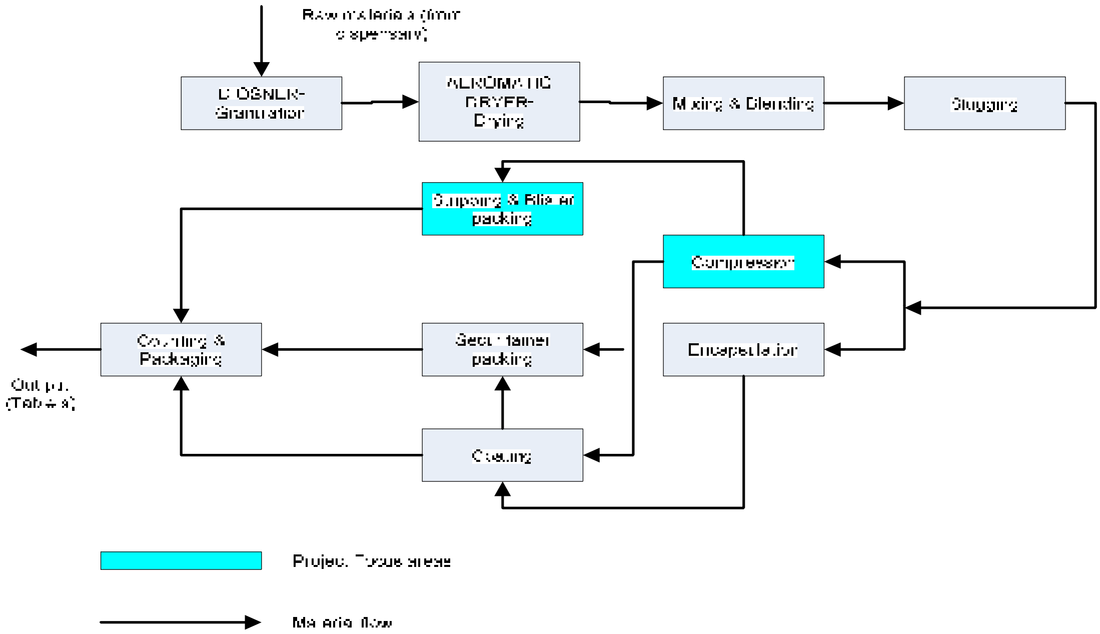

Figure 1: Process flow in the Tabletting line

1.4 Methodology

The study was conducted in the plant starting with a baseline survey to establish the level of TPM or Asset care at the plant. An initial radar chart shown in Figure 2 was drawn up. Using this radar chart, prevailing maintenance problems and key areas of improvement were identified. A Pareto Analysis was conducted and equipment grouped into A, B and C categories. For the A category equipment TPM techniques were applied and results measured.

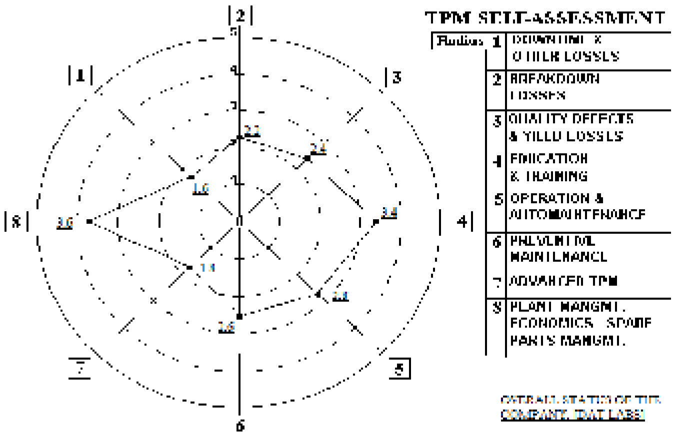

Figure 2: Radar chart results [Datlabs, November 2009]

2.0 TPM

TPM is defined as an integrated life-cycle approach to factory maintenance and support [2]. The principle employed in TPM represent a radical departure from the traditional plant techniques, as employee roles, skill sets, process requirements and rules are totally transformed. However, the goal remains the same and it is to obtain profitability from the plant. This then means that TPM is structured equipment centric Continuous Improvement (CI) process that strives to optimize production effectiveness by identifying and eliminating production losses through active team based participation of all employees.

2.1 Pillars of TPM

The principal activities of TPM are organized as pillars and according to the Nakajima model as shown in Figure 3, [4]. These pillars form the basis of implementation to support other TPM models developed [5].

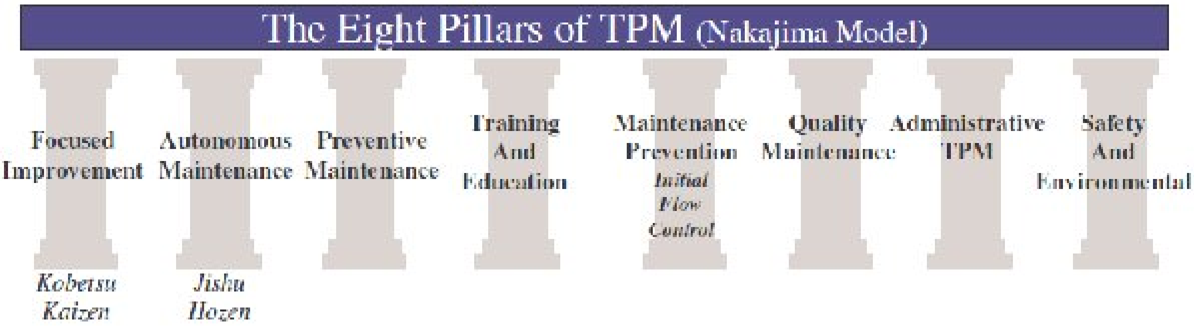

Figure 3: The eight pillars of TPM [3]

2.2 OEE

OEE is greatly affected by losses in the plant. Review of Losses has been summarized in [4] and [6]. The OEE methodology is a proven approach to increase the overall performance of equipment [7]. The formulae used to calculate OEE are summarized in equations (1) to (4).

Overall Equipment Effectiveness = $\times$ $\times$ …….. (1)

where

Availability = $\overline{} \times 100$ …………………………………………………. (2)

Performance = (/)/ ……………………… (3)

Quality rate = / ………………………….. (4)

3.0 Results

3.1 TPM Self Assessment

The current manufacturing system is not economical due to capacity constraints within the system. The tabletting and LCO lines have far much capacity up stream that it can run at optimum capacity and produce material that is enough for the whole week in a day. However the upstream machines are run below capacity leading to low operational efficiencies on their part. A summary of the losses are as follows:

- ***Breakdown losses***- breakdowns on major equipment is rife (King fillers, Shrink wrap, universal strip packer, blister packing machine and conveyors). These result from poor maintenance system and general lack of planning. Most of the maintenance work is done by the maintenance staff in isolation from production operators. This totally defies a Total Productive Maintenance way of conducting work.
- ***Other losses***- the organization subconsciously permits non-value adding activities such waiting for material, instructions, quality results and checks from the Laboratory. This lost time eats in the coffers of available time and thus adversely affects the overall performance of the plant
- ***Setup and adjustment loss*-** the manufacturing process in the tabletting line is highly of the batch type. Though setup and adjustment are almost inevitable, they need to be properly managed. Adjustment loss is largely attributed to the compression machine were weight and hardness variations of tablets is set to required standards.
- **Changeover** of tools and equipment for the Blister packing machine and compression dies are located in a separate room that is always locked. The Production Superintendent is the only person who keeps the keys to the tool room, and an average of 30min to an hour is wasted looking for keys and issuing out the tools.

- ***Quality Rate*** - Defects realized at the end of the production run are rare but when they do occur, they usually result in the whole batch to be discarded. There is no proper recording system for to account for defects and rework but a survey conducted indicates that more than 200 pieces of tablets are reworked per batch.
- ***Start ups-*** Start-up on Monday morning takes between 1-2 hours. Such variances were observed due to operational problems encountered this during start up. For this reason, operators will be idling around and thus a loss in terms of valuable time and money is incurred.
- ***Speed losses-*** most of the equipment is run below the rated capacity. The blister packing machine, which ideally should pack at 80 sachets per min but is currently operating between 45-50 sachets per minute.
- Shift changeovers and tea breaks are extended beyond regulated periods. Close to 15 minutes is lost for every recess, resulting in actual production time being reduced.
- The current mode of operation is corrective maintenance. There is no preventive or planned maintenance system and the level and detail of records is manual and difficult to use when maintenance planning is to be conducted.

3.2 Summary of Annual Losses

Annual losses are summarized in Table 1 while the assumptions used were:

- ✓ The basic labour rate of a qualified artisan or operator is $6/hr
- ✓ The basic labour rate of a semi qualified artisan or operator is $3/hr
- ✓ One qualified artisan and two assistant artisan attend to a breakdown
- ✓ One qualified operator and one assistant operator attend to a particular machine or operation
- ✓ The maintenance department exhausts its monthly spares' budget

Table **1**: Summary of losses in monetary terms **(Datlabs Pvt Ltd 2009)**

Activity	**Amount lost per year (US$)**
Break down loss	291 064.00
Set-up & Adjustment loss	62 092.00
Minor Stoppages & Idling loss	29 007.00
Start Up loss	19 489.00
Other Down time loss	54 356.00
Total Amount Lost	**456 008.00**

3.3 Overall Equipment Effectiveness (OEE)

Table 2 shows the Overall Equipment Effectiveness calculated for the seven months which gives an average of 45%, which is way below the World Class Manufacturing standard of 85%.

Table 2: Average OEE for a period June to December 2009

	June	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Actual OEE	48.7	41.3	43.8	46.2	47.7	47.8	40.5
World Class OEE	85	85	85	85	85	85	85

3.4 Down-time Analysis

The down time analysed over a four months period (September to December 2009) is shown in Figure 4.

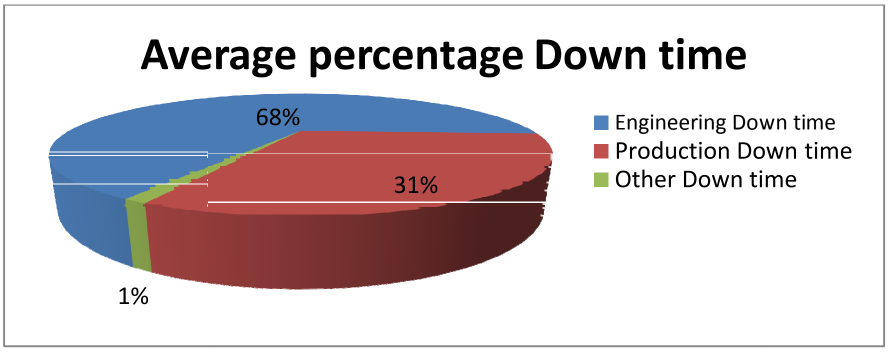

Figure 4: Average percentage down time (September to December 2009)

3.5 Determination of Critical Equipment

Using ABC analysis the critical equipment was determined and a summary of the equipment is shown in Figure 5.

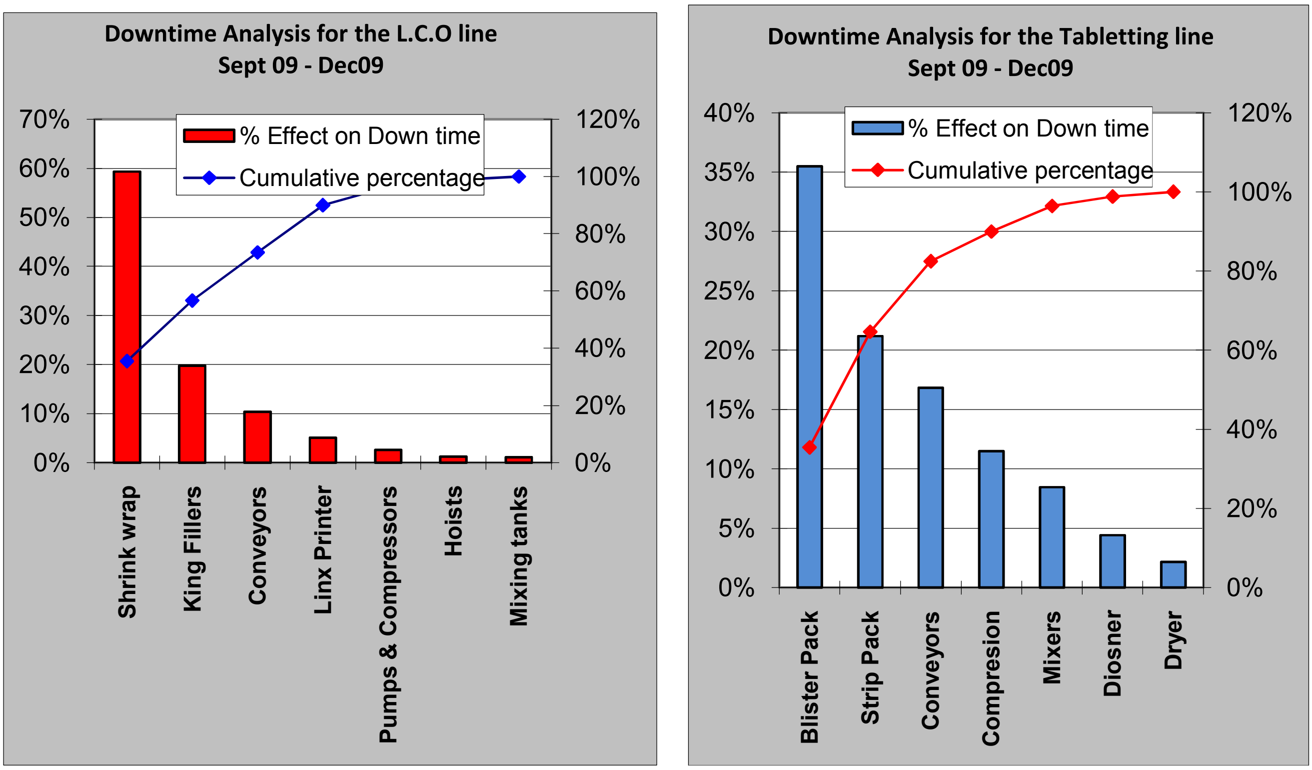

Figure 5: Pareto Chart for down time analysis of the LCO and Tabletting line [Sept 09-Dec09]

The graphs above give a clear indication of the equipment that need to be prioritized in the planning of maintenance. A summary of equipment and operations that need attention are given in the Table 3.

The production downtime trend also shows operations that should be prioritized. Of major importance are equipment setting and adjustments.

3.6 Failure Mode and Effect Analysis (FMEA)

The equipment which was considered vital by the Pareto charts above was subjected to FMEA to identify the causes of the frequent failures. The results of the Failure mode and effect analysis helped in the development of a maintenance plan that improves their uptime, hence an improvement in OEE and overall plant performance. Detail of FMEA that was carried out for the King Fillers can be found in [8].

Table 3: Prioritization of Engineering down time

Zone	Priority	Machine/Equipment	% Effect on Down Time
A	High	Blister Packing machine	80
		Strip Packing machine	
		Shrink Wrappers [SW1 &SW2]	
		King Fillers [KF1 & KF2]	
		Plant Conveyors	
B	Medium	Diosner-Granulator	<20
		Mixers	
		Compression Machine	

		Aeromatic Dryer	
		Linx Printer-Coding Machine	
C	Low	Other mechanical Downtime	<5
		Planned Maintenance	

3.7 Final Radar Chart (after Implementation of TPM)

Figure 6 shows the final radar chart after implementation of TPM.

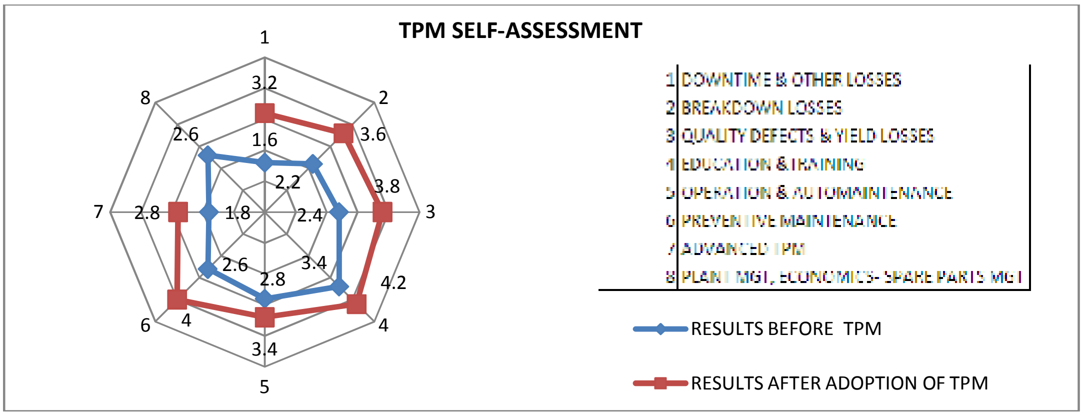

Figure 6: Final Radar Chart

4.0 Conclusion

Use of the TPM methodology and research interventions at Datlabs highlighted a number of areas within the operation which resulted in improvement of OEE. Training and education has led to the improvement through short-course training to the company employees by authors. Further work is envisaged through use of simulation in TPM.

Acknowledgements

The authors are grateful to the Management and Staff of Datlabs (Pvt) LTD for allowing them to conduct this research with their full support. They are also thankful to the National University of Science and Technology for contributing towards transport during the research project.

Reference

1. Upadhye Nitin, Deshmukh S.G and Garg Suresh., 2010, Lean Manufacturing in biscuit manufacturing plant: A case, International Journal of Advanced Operations Management – Vol.2, No. ½ pp 108 – 139.
2. Blanchard, B S, 1997, An Enhanced Approach for Implementation of Total Productive Maintenance in the Manufacturing Environment, Journal of Quality in Maintenance Engineering, Vol 7, No 2, pp69-80
3. Pormoski, T.R., 2004, Total Productive Maintenance: Concepts and Literature Review Cincinnati, OH, The Union Institute and University.
4. Venkatesh, J., 2010, An Introduction to Total Productive Maintenance (TPM), Plant Maintenance Center, www.plant-maintenance.com/articles/tpm_intro.shtml
5. Rashid, Mustafa M. and Ismail Hossam., 2008, Generic approach for the customization of the TPM programme: using the process transformation model and reliability assessment tool, European Journal of Industrial Engineering, Vol.2, No.4 pp 401-427.
6. OEE_Primer, 2010, www.oee.com.oee_six_big_losses.html
7. Badiger, A.S., Gandhinathan, R. and Gaitonde, V.N., 2008, A methodology to enhance equipment performance using the OEE measure., European Journal of Industrial Engineering, Vol.2, No. 3 pp 356-376.
8. Kazembe T, 2010, Optimising a Production System Using tools of Total Productive Maintenance (TPM) (Datlabs as a case study), B. Eng Dissertation, NUST, (unpublished).