Total Productive Maintenance: A Case Study to Measure & Improve Effectiveness of Performance Measures of Tube Mill Industry

Abhishek Kaswan
BRCM College of Engineering & Technology Bahal, Bhiwani

Abstract— To sustain in this competitive world, manufacturing industries had opted for the several innovative techniques like TPM, TQM, JIT, MRP, Six Sigma, SAP, etc. in order to satisfy the customer as per requirements. All these tools & techniques are used to focus on key areas of product like quality, cost of product, delivery time of the product & bring the cost of operation & maintenance under control in order to increase the profit margin along with the customer satisfaction & business relationship. These tools are popular among manufacturing industries to improve quality & productivity of their products. A detailed case study is done in an auto sector industry named as ANS Steel Tubes Ltd., Faridabad in which TPM is already implemented but the need was just to evaluate and improve the key focus towards it. The objective of this thesis is to focus on TPM functioning in the plant and measure the performance parameters of the plant, ensuring the tangible & intangible benefits to ANS Steel Tubes Ltd. through continuous focus, proper time to TPM. The case study can give insight and help other industries to run the TPM in more efficient way.

Key words: Tube Mill Industry, TPM

I. INTRODUCTION

Total Productive Maintenance is an innovative Japanese concept, the origin of this concept can be viewed back to the early 1950s when preventive maintenance was introduced in Japan

Nippondenso was the first company to introduce plant-wide preventive maintenance in 1960.

This company operator used machines to produce products and the maintenance group maintained their machines

Total Productive Maintenance or TPM can be considered as the medical science of machines.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is the philosophy to increase the productivity and producing the high quality goods by minimizing the waste, thereby reducing the cost. It involves the newly defined programs & concept for maintaining plant and equipment. It aims at continuously improving the availability of equipment and preventing the degradation of equipment, in order to achieve the maximum effectiveness. These objectives require a strong management support along with the continuous use of work teams and small group activities to achieve incremental improvements.

TPM is analyzed into three words:

- TOTAL: This means every individual of the organization from the top level management to the shop floor workmen level.
- PRODUCTIVE: This means no wasted activity or production of goods & services that meet or exceeds the customer's expectation.
- MAINTENANCE: This means keeping the equipment and plant in good working condition i.e. better than the original condition at all times.

TPM is an operations improvement process (machine efficiency and reliability)involving all affected employees with a view to getting as close to zero breakdowns andzero defects as possible. TPM is a production-driven improvement methodology that isdesigned to optimize equipment reliability and ensure the efficient management of plant assets. It provides a comprehensive, life-cycle approach to equipment management that minimizes equipment failures, production defects, and accidents.

considered the science of machinery health.

TPM was introduced to achieve the following objectives:

- Avoid waste in a quickly changing economic environment.
- Produce goods without reducing product quality.
- Reduce costs.
- Produce a low batch quantity at the earliest possible time.
- Send only non-defective parts to the customers.

A. Equipment Efficiency

It employs OEE as a quantitative metric for measuring the performance of a productive system. OEE is a core metric for measuring the success of TPM implementation program. The overall goal of TPM is to raise the overall equipment efficiency. OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality products.

Overall Equipment Efficiency = Availability x Performance Efficiency x Utilized.

Where,

Availability: - Available Time required for producing finished products.

Availability = (Planned hours – Setup Downtime) / (Planned Hours) *100.

Performance Efficiency: - It can be defined as the design cycle time required manufacturing the indent / ordering as per the standard parameters divided by the actually utilized hours in providing the desired output.

Performance = (Target Time)/ (Utilized Time)*100

Utilized = It is the time consumed for production excluding all malfunctioning time out of Available Time.

Utilized = Utilized Time/ Available Time.

<table>
<tr><td colspan="5">Total Time (Hours)</td></tr>
<tr><td rowspan="2">Availability</td><td colspan="3">A - Planned Hours</td><td rowspan="6">No Scheduled Production i.e. No Planning</td></tr>
<tr><td colspan="2">B - Running Hours</td><td rowspan="2">Setup Hours</td></tr>
<tr><td rowspan="2">Performance</td><td colspan="2">C - Target Hours</td></tr>
<tr><td>D - Utilized Hours</td><td rowspan="3">Minor Stoppages & Malfunctioning,</td><td rowspan="3">Lost Effectiveness</td></tr>
<tr><td rowspan="2">Utilized</td><td>E - Utilized Hours</td></tr>
<tr><td>F - Available</td></tr>
</table>

	Hours	Reduced Speed		
O.E.E. = (B/A) X 100		X D/C	X	F/E
Availability %		Performance %		Utilized %

Fig. 1: shows the graphical way to calculate the OEE of the Equipment in a month when there is an order or indent of "X" MT on the Equipment

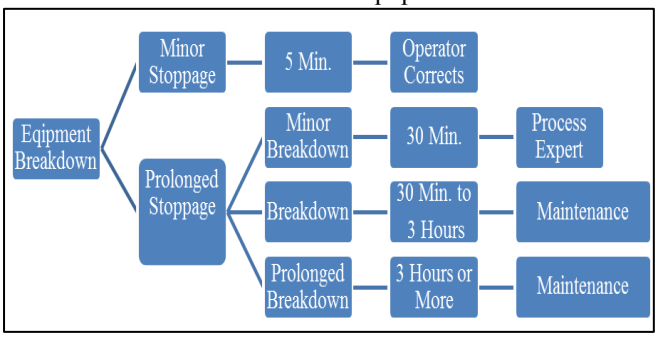

Fig. 2: Equipment breakdown is classified according to the duration of the stop. Refer to the diagram

This complete review study is based on the TPM pillars which are as shown in figure below:

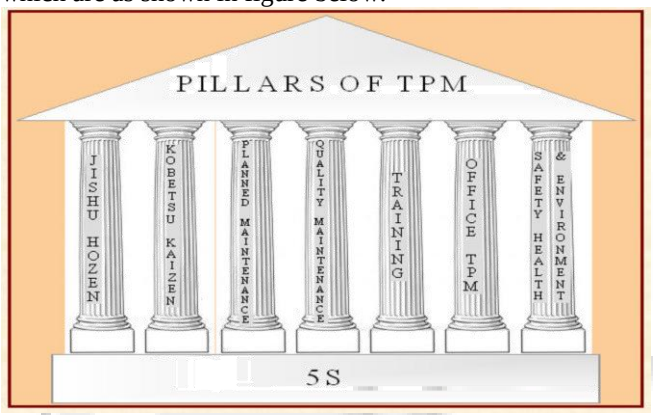

Fig. 3:

Recent competitive trends have prompted top management of manufacturing enterprises to look at the performance of each and every business function, including manufacturing or maintenance, for achieving competitive advantage [1,2].With increased global competition, attention has been shifted from increasing efficiency by means of economies of scale and internal specialization to meeting market conditions in terms of flexibility, delivery performance and quality.[2] Poor organizational competencies in managing the maintenance function effectively can severely affect competitiveness by reducing throughput, increasing inventory, and leading to poor due-date performance[3]. TPM initiatives help in streamlining the manufacturing and other business functions and in garnering sustained profits.[3,4]. It involves everyone in the organization, from top-level management to production mechanics, and production support groups to outside suppliers.[4,5,6].Successful implementation of TPM programs has resulted in the creation of much safer and more environmentally sound workplaces. Another strategic outcome of TPM implementations is the reduced occurrence of unexpected machine breakdowns that disrupt production and lead to losses, which can exceed millions of dollars annually.[7] TPM employs OEE as the core quantitative metric for measuring the performance of a productive system.[8,9]Greater job satisfaction translates into higher productivity and quality and ultimately contributes to lower manufacturing costs, since TPM envisions organizations to consider the human aspect of TPM in combination with technical and financial impacts[10].Intense competition has been witnessed in terms of low costs, improved quality and diverse products with superior performance[11].

An insight into the contemporary manufacturing scenario has revealed that maintenance and human factors have remained neglected areas for a long time in Indian manufacturing Organizations[12]. The paper reports a case study for improving OEE with the help of TPM and 5s technique using a systematic approach .The result obtained from the TPM approach showed that the OEE was improved from 43% to 72% which indicate the desired level.[13]. In this paper the author implemented a TPM strategy in the machine shop having a CNC turning of different capacity and eliminates the losses; improve the utilization of CNC Machine. OEE is used to measure success of TPM implementation. [14].In this paper the author present the literature review of TPM and is used to solve the manufacturing problem, this paper also explain the overview of TPM pillar.[15]. In this the author study and overview of TPM implementation in Indian spinning Industries and uses a JH-check sheet, PM-Check Sheet, OPL in order to improve the OEE and proper implementation of TPM.[16]. In this a researcher uses a TPM technique which aimed at maximizing the effectiveness of facility and also carried out a successful implementation of work literature reviews was done and carried a study at printing press machine and packaging based on real time data and analysis was done to obtain achievable results and calculate OEE and solve problem to increases OEE.[17,18].In this a team is formed to find out the benefits of formation of a team from different dept. To eliminate any boundaries between a dept. and make maintenance process more effectively and also adopt the autonomous maintenance and also suggest implementing TPM to improve their maintenance procedure and productivity after calculation of the OEE.[19]. The automotive industry is considered as a key sector for the economic development of any country. The global automobile industry is slowly and gradually shifting towards Asian countries, mainly because of saturation in the West [20, 21].

II. A CASE STUDY

A case study has been conducted in one of the leading manufacturing of the Tubes in the Tube Mill industry. The company is an integrated plant with a facility to carbon steel, aluminized and SS409/SS436 tubes in various shapes and sizes. It is the large scale industry which has set up modern production facilities to meet the customer requirements for quality. The ERW steel tubes from 12mm to 85mm in 0.7mm to 4mm thickness in various shapes like round, rectangular, square, oval and flat for automobile parts application and also for furniture accessories.

The study conducted along the 6months& still going on, the company produces different size of Tubes and uses different size of rolls (Tools for forming tube) as per requirement. Finally, the aim of this case study is to measure the overall equipment efficiency of the company and find

out the bottleneck which causes stoppage of production. There are some of the standard from the industry:

- Three shift each shift eight hours and timing per shift is shift A 6:00-2:00, shift B 2:00-10:00, shift C 20:00-6:00.
- Two Equipments are there in the plant named as below:
  - Equipment 1: Tube Mill No. 01/ R-1 (TM - 01)
  - Equipment 2: Tube Mill No. 02/ R-4 (TM - 02)
- The target for production of Tubes for month is as per the indent received from marketing.
- The product time process, the production line can operate at speed as per Process Control Parameters of Company, this speed is theoretical speed which is being used to evaluate the Target time while calculating the efficiency (i.e. as per the product mix received in the indent).

A. Problem Identification

Major industry losses were identify which are shut down, production setup adjustment, equipment failure, process failure, normal production loss, abnormal production loss, quality defect. Following are some of the areas under which the losses occur during the production process:

1) Electrical related.
2) Mechanical related.
3) Operation/Production related.
4) Tooling's related.
5) Setup related
6) Other malfunctioning.

The study is done at ANS Steel Tubes Ltd. for the period of eight months. During this period first three months were spent in collecting the data & observing the areas of improvement from the fourth month the implementation of the improvement plans was started & the results observed after the implementations were quite positive.

The data collected & calculation is done as follows for the complete duration.

Calendar Hours = (No. of days in month) X 24
Planned hours = Calendar hours – Shift Off hours
Available operating time =Planned time – Setup time
Available % = (Available Hours/ Planned Hours)*100
Utilized Hours = Available Hours –Malfunctioning Downtime
Utilized % = (Utilized Hours/ Available Hours)*100
Efficiency % = (Target time/Utilized Hours)*100
Overall Equipment Efficiency (O.E.E) = Available % * Utilized % * Efficiency %
Production per planned hour = Production/ Planned Hours
Production per available hour = Production/ Available Hours
Production per utilized hour = Production/ Utilized Hours
Yield = Prime Production/(Prime Production + Scrap)
Consumables Cost Monitoring is done as per Finance data.

B. For November 2015

TM-1			
Production (MT)	138.215		
Calendar Hour	720		
Planned Hour	272.66	Planned %	37.87%
Available Hour	243.41	Available %	89.27%
Running Hour	126.30	Running %	51.89%
Utilized Hours	126.30	Utilized %	51.89%

Break Down			
Category	Time (Hr.)	Breakdown %	
Electrical	8.52	3.50%	
Mechanical	26.41	10.85%	
Production	29.42	12.09%	
Tooling	19.35	7.95%	
Others	31.82	13.07%	
Power	1.59	0.65%	
Total	117.11	48.11%	
Available %	89.27%		
Utilized %	51.89%		
Target Time (Hours)	110		
Efficiency %	87.09%		
Overall Equipment Efficiency (O.E.E)	40.34%		
Prod/planned hr.	0.51		
Prod/available hr.	0.57		
Prod/utilized hr.	1.09		

Table 1: Equipment no. 01

TM-2			
Production (MT)	1472.545		
Calendar Hour	720		
Planned Hour	499.83	Planned %	69.42 %
Available Hour	436.08	Available %	87.25 %
Running Hour	304.99	Running %	69.94 %
Utilized Hours	304.99	Utilized %	69.94 %
Break Down			
Category	Time (Hr.)	Breakdown %	
Electrical	31.44	7.21%	
Mechanical	19.99	4.58%	
Production	21.93	5.03%	
Tooling	18.17	4.17%	
Others	37.37	8.57%	
Power	2.19	0.50%	
Total	131.09	30.06%	
Available %	87.25%		
Utilized %	69.94%		
Target Time (Hours)	250.52		
Efficiency %	82.14%		
Overall Equipment Efficiency (O.E.E)	50.12%		
Prod/planned hr.	2.95		
Prod/available hr.	3.38		
Prod/utilized hr.	4.83		

Table 2: Equipment no. 02

Plant Yield (as per Finance data) = 90 %
Consumables per MT = Rs. 813
Similarly the data is collected with the technique of focusing & monitoring the proper aspects which shows the tangible & intangible results shown in the graphs below:
Following intangible results are observed after the study:

- Increase in team spirit and group behavior in operators and staff.
- Development of clean, dry, bright, visual and lively work places.
- Multi-skill abilities done by operators.
- Increase in the ownership of equipment and workplace by the operator.
- Increase in confidence of their ability to perform complex jobs/problems by operators and staff.
- Appreciation from customers and other visitors during plant visits.
- Following tangible results are observed after the study:
- OEE improvement 14.11% for Equipment – 01 & 11.06% for Equipment – 02

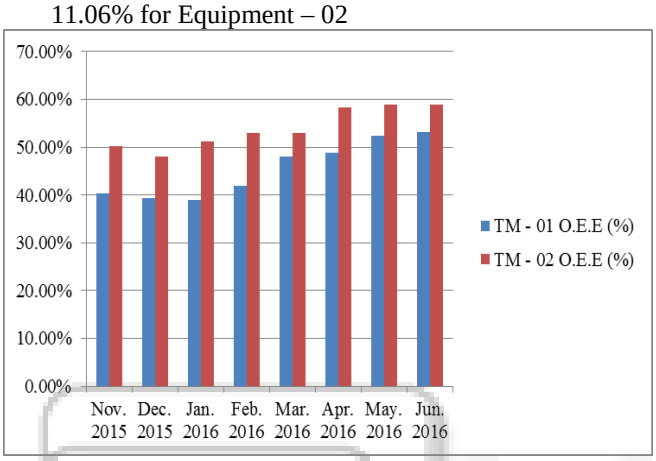

Fig. 4:

- Time efficiency 33.31% for Equipment – 01 & 19.08% for Equipment – 02

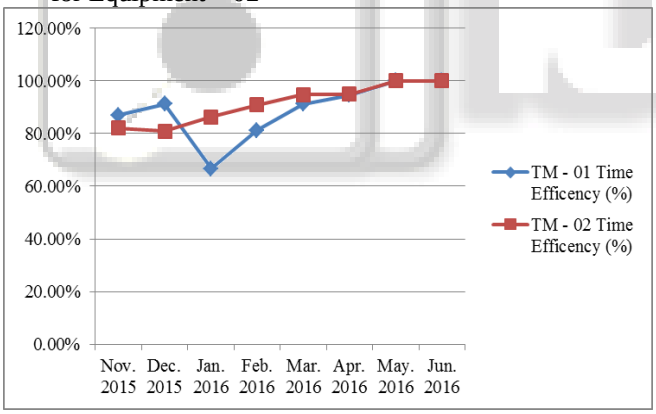

Fig. 5:

- Reduction in consumables cost Rs. 211 / MT

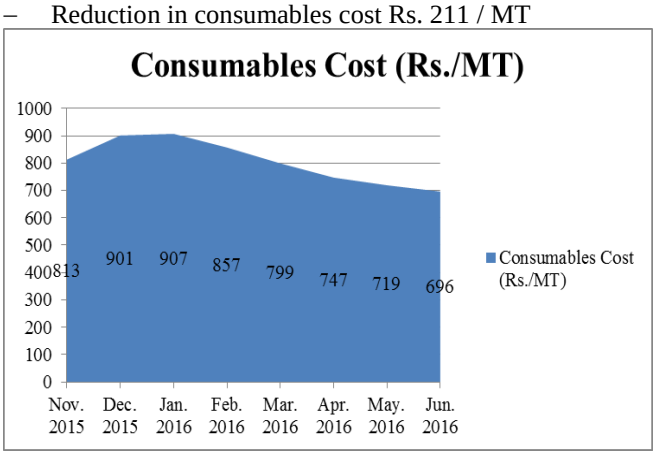

Fig. 6:

- Production per utilized hours 0.55 MT for Equipment – 01 & 0.74 MT for Equipment – 02

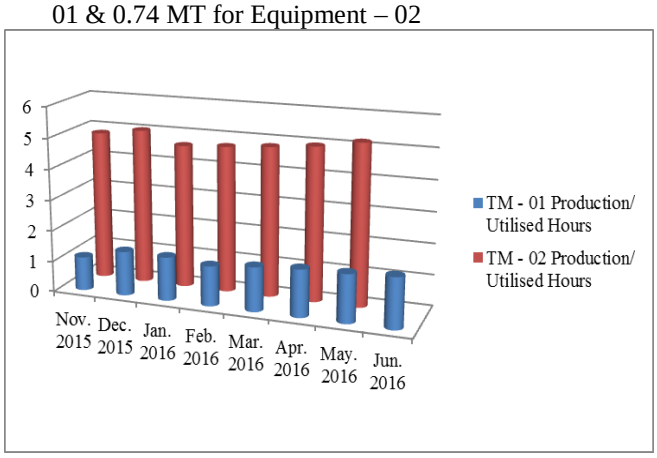

Fig. 7:

- Yield improvement 3.50%

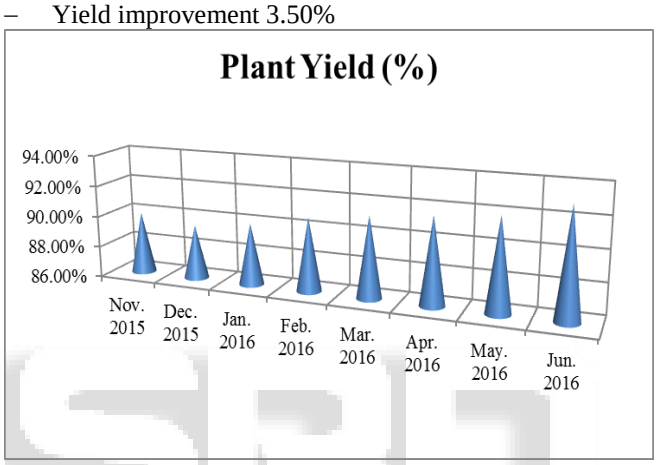

Fig. 8:

III. Scope of Work

There exists a big scope to extend our research work in the field of TPM and some other programs of Lean Manufacturing. The immediate focus can be on the following two areas:

- The study of the impact of Total Quality Control, Six Sigma and JIT along with TPM on the full utilization of company's chief resources, equipment and capital assets is also needed to establish their best suitability and inter-relation between these programs
- TPM has been proven to be a program that works. It can be adapted to work not only in industrial plants, but in construction, building maintenance, transportation, and in a variety of other situations. The suitability of TPM in these areas can also be the part of future research.
- Many companies implemented the TPM in its area but there is further scope of monitoring the TPM program regularly & properly to view its tangible & in tangible results.

References

[1] Pintelon, L., Pinjala, S.K. and Vereecke, A. (2006), "Evaluating the effectiveness of maintenance strategies", Journal of Quality in Maintenance Engineering, Vol. 12 No. 1, pp. 7-20.[1].

[2] Ben-Daya, M. and Duffuaa, S.O. (1995), "Maintenance and quality: the missing link", Journal of Quality in Maintenance Engineering, Vol. 1 No. 1, pp. 20-6.[2].
[3] Ahuja, I.P.S. and Khamba, J.S. (2007), "An evaluation of TPM implementation initiatives in an Indian manufacturing enterprise", Journal of Quality in Maintenance Engineering, Vol. 13 No. 4, pp. 338-52.[3].
[4] Ahuja, I.P.S. and Khamba, J.S. (2008a), "Total productive maintenance – literature review and directions", International Journal of Quality & Reliability Management, Vol. 25 No. 7, pp. 709-56.[4].
[5] Ahuja, I.P.S. and Khamba, J.S. (2008b), "An evaluation of TPM initiatives in Indian industry for enhanced manufacturing performance", International Journal of Quality & Reliability Management, Vol. 25 No. 2, pp. 147-72.[5].
[6] Ahuja, I.P.S. and Khamba, J.S. (2008d), "An assessment of maintenance management initiatives in Indian manufacturing industry", International Journal of Technology, Policy and Management, Vol. 8 No. 3, pp. 250-78.[6].
[7] Gosavi, A. (2006), "A risk-sensitive approach to total productive maintenance", Automatica, Vol. 42 No. 8, pp. 1321-30.[7].
[8] Shirose, K. (1989), Equipment Effectiveness, Chronic Losses and Other TPM Improvement Concepts in TPM Development Program: Implementing Total Productive Maintenance, Productivity Press, Portland, OR.[8].
[9] Jeong, K.Y. and Phillips, D.T. (2001), "Operational efficiency and effectiveness measurement", International Journal of Operations & Production Management, Vol. 21 No. 11, pp. 1404-16.[9].
[10] Hamrick, J. (1994), "Eastward with TPM and CMMS", Industrial Engineering, Vol. 26 No. 10, pp. 17-18.[10].
[11] Chandra, P. and Sastry, T. (1998), "Competitiveness of Indian manufacturing: finding of the 1997 Manufacturing Futures Survey", Vikalpa, Vol. 23 No. 3, pp. 15-25. [11].
[12] Ahuja, I.P.S. and Khamba, J.S. (2008c), "Justification of total productive maintenance initiatives in Indian manufacturing industry for achieving core competitiveness", Journal of Manufacturing Technology Management, Vol. 19 No. 5, pp. 645-69.[12].
[13] Ranteshwar Singh, Ashish M Gohil, Sanjay Desai "Total Productive Maintenance Implementation in a machine shop: A Case Study", ELSEVIER (2013).[13].
[14] Jignasha P Acharya, Maharshi J Bhatt "A Brief Literature Review on Total Productive Maintenance", IJAERD, vol.1, issue 5, may 2014.[14].
[15] Nistesh Mundhada, Aditya WAnkhede, Bhavesh Bohra "Detail Investigation, Analysis and Implementation for improving Quality/productivity in Rolling mill", IJEIT, Vol.2, Issue9, March 2013.[15].
[16] Melesse Workneh Wakjira, Ajit Pal Singh "Total Productive Maintenance: A Case Study in Manufacturing Industry" , Global Journal of researches in engineering Industrial engineering , Volume 12 , Issue 1 Version 1.0 February 2012, ISSN: 2249-4596 Print ISSN:0975-5861.[16].
[17] G Ananth, DR. B K Vinayagam "Implementation and fall of TPM in Micro Manufacturing Industries Using SWOT Analysis-A review", IJEIT, Vol.1, Issue 4, April 2012.[17].
[18] IPS Ahuja "Total Productive Maintenance literature review and direction" Emerald (2008).[18].
[19] Martand Telsang; "Industrial Engineering And Production Management"; Reference Book; S. Chand Publication; First Edition 1998.[19].
[20] Minister for Industries, "Auto Industry Development Programme."[Online]. Available:http://www.pama.org.pk/images/stories/pdf/AIDP/AIDP.pdf.[20].
[21] Hongyi Sun Richard Yam Ng Wai- Keung Thev implementation and evaluation of Totalv Productive Maintenance (TPM)—an action case study in Hong Kong manufacturing company. International Journal Advance in manufacturing Technology (2003)Vol22: pp224-228[21].
[22] Chan, F.T.S.; Lau, H.C.W.; Ip, R.W.L.; Chan, H.K.; and Kong, S. (2005).Implementation of total productive maintenance: A case study. International Journal of Production Economics, 95(1), 71-94.[22].

