Performance Improvement Using OEE in Edible oil Industry Focused on Degumming Section

Prabhat Kumar Chaturvedi[*] and Vivek Babele

Mechanical, RGPM, Bhopal.

ABSTRACT

This present paper analyses the present status of edible oil manufacturing in the country. After basic study and OEE calculation, maintenance improvement program is implemented and gaps are identified. Mainly the degumming section are focused as it is one of the important section are identified. The main purpose of this present paper is to provide an overview of the typical processes and interrelations associated with a total integrated process and maintenance activities. OEE (Overall Equipment Effectiveness) are calculated regularly which will prove to be beneficial to those new in the industry. It must be stressed that this present research work attempts to touch in a limited number area of production equipments or departments. Continuous measurement of OEE has proven remarkable improvement.

Introduction

Within the last few years, the emphasis has changed from stand-alone operations toward the integrated manufacturing facility, producing a more complete range of value-added products from the raw seed to the dinner table. During this transition, operations have become more dependent on each other, as the individual functions involved must now consider the impact of their actions on the total process of production. At the same time, the scope of knowledge of each operation must have for other functions which has expanded, and it is important that at least a basic understanding of the ''big picture'' be available to the decision maker.

Prior to the early 1900s, maintenance was considered as a necessary evil. Technology was not in a state of advanced development, there was no alternative for avoiding failure, and the general attitude to maintenance was, "It costs what it costs." With the advent of technological changes and after the Second World War, maintenance came to be considered as an important support function for operations, production, and manufacturing. During 1950-1980, with the advent of techniques like preventive maintenance and condition monitoring, the maintenance cost perception changed to: "It can be planned and controlled."

Degumming

Technically, degumming is referred as an operation of purification of seed oils, which normally contain impurities in the colloidal state or dissolved in them (Bernardini, 1985). Fats and oils contain complex organic phosphorus compounds referred to as phospholipids (phosphatides) or more usually, as gums. Phospholipids should be removed because of their strong emulsifying action and if they are not removed, the oil will went through undue darkening during deodorization at high temperature (Kim et al., 2002). The phospholipids (phosphatides) are removed during processing by a variety of treatments collectively referred to as degumming. The treatment usually involves hydration with water, Orthophosphoric acid and polybasic organic acids either singly or in combination, followed by centrifuging the precipitated material or by its adsorption on bleaching earth or filter.

Mechanical Extraction

As the electrical classification of a mechanical extraction operation is generally the same as that in the preparation area, many processors locate the pressing operation in the same building as the preparation process. In the pressing plant, the seed is subjected to extreme heat and pressure with oil mechanically forced from the oil cell. A typical pressing operation is shown in Figure 4, and involves cooking, pressing, cake cooling and finishing, and oil filtration.
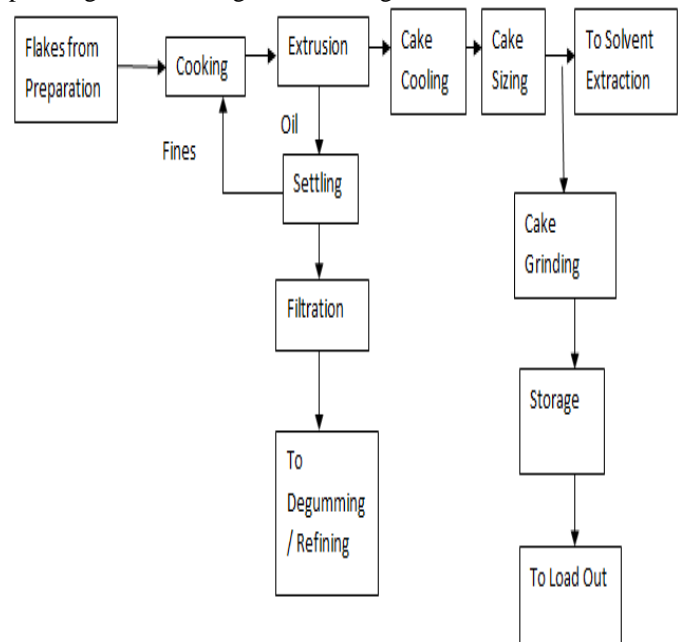

Figure 1. Mechanical extraction/meal finishing.

Tele:
E-mail address: prabhatchaturvedi.sp123@gmail.com

Data Collection

Our real time data consists of equipment maintenance data which were available with the section. The important equipment which play key role in degumming section are kept under the observation during maintenance. Department has also previous maintenance data which helps to implement the new maintenance strategies. Prior to implement the effective maintenance management system the overall equipment effectiveness (OEE) metrics is calculated to find the present status of the equipment. The average OEE is found 27% which is too less that the world class value of 95%.

Overall Equipment Effectiveness (OEE)

TPM is a production-driven improvement methodology that has been designed to optimize equipment reliability and ensure efficient management of plant assets (Robinson and Ginder, 1995). The successful implementation of TPM results in the dramatic reduction of wastage and performance losses associated with production facility. TPM focuses upon cutting down various organizational performance losses as a strategy toward affecting manufacturing performance improvements. The various manufacturing and production losses tackled by TPM include:

Equipment losses (failure/breakdowns losses, start up losses, product changeover/set up losses, tool changeover losses, minor interruption loss, speed loss, defects and rework losses, shut down loss); manpower losses (production stoppage losses, line organization losses, measuring and adjustment loss, management losses, operation motion-related losses); and material losses (yield losses, consumables i.e. die-jig-tool losses, energy losses).

TPM employs overall equipment effectiveness (OEE) as a quantitative metric for measuring the performance of a productive system. OEE is the core metric for measuring the success of TPM implementation program (Jeong and Phillips, 2001). This metric has become widely accepted as a quantitative tool essential for measurement of productivity in manufacturing operations (Samuel et al., 2002). The role of OEE goes far beyond the task of just monitoring and controlling the manufacturing system performance. The OEE measure is central to the formulation and execution of a TPM improvement strategy (Ljungberg, 1998). It provides a systematic method for establishing production targets, and incorporates practical management tools and techniques in order to achieve a balanced view of process availability, performance efficiency and rate of quality (Bulent et al., 2000). OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality products:

$$OEE = Availability\ (A)\ X$$
$$Performance\ Efficiency\ (P)\ X$$
$$Rate\ of\ Quality\ (Q)$$

$$Availability(A) = \frac{LoadingTime - Downtime}{LoadingTime} X\ 100$$

$$PerformanceEfficiency(P)$$
$$= \frac{Processedamount}{operatingtime/theoreticalcycletime} X\ 100$$

$$RateofQuality(Q)$$
$$= \frac{ProcessedAmount - DefectAmount}{Processedamount} X\ 100$$

Present Status of Selected Degumming Section

Currently the selected company is striving to improve their performance at operational and organizational level. However there is no issue of slow demand of product in the market but the most of the edible oil company is failing to cope up the optimum production.

For this company, it is looking for a tool to enhance equipment performance and minimize the hours of breakdown. At the time of start of M.Tech research project the overall equipment average OEE was only 27 % in comparison of 97% world class values. On the basis of frequency and hours of breakdown and more over the criticality of the particular selected equipment of degumming section (Mixer, Heater, Dryer, Separator, Air compressor, Oil Filter etc) is selected. The average breakdown is 870 hours as per the record available from equipment log history book since the plant under consideration. While the present research project, aims to minimize the unplanned breakdown from 17 hours per month to not more than 10 hours per month.

Analysis

Data of equipment breakdown was collected from degumming section of selected Company in the department starting from 2012 until 2016. Figure 2, shows bar graph for degumming section, average equipment downtime since plant commissioning in 2012 until 31st December 2016 is shown.
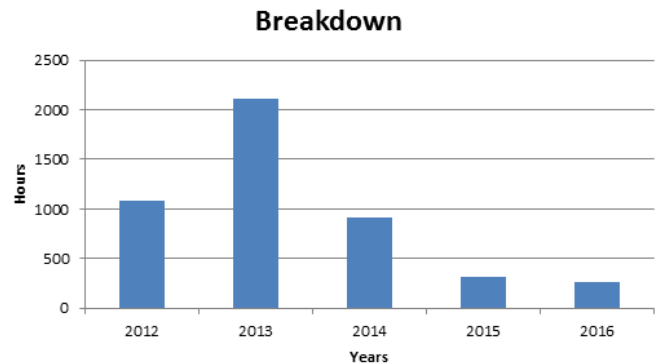
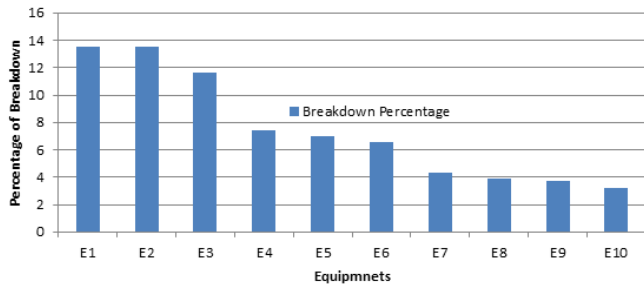**Figure 2. Mechanical equipment downtime from 2012 to 2016**

As shown in the bar graph above, 2013 was the highest recorded downtime for degumming section, total to 2226 hours, followed by 2012, 1089 hours and year 2014, 917 hours downtime. 2016 recorded the lowest downtime for mechanical section since plant re-commissioning, which contributed only about 260.3 hours followed by 2014, 312 hours downtime. In 2012, after all the plant main contractor was ended their service contract, the downtime shoots up double compare to the previous year. It shows that, lack of knowledge in troubleshooting equipment, can lead to higher downtime to plant and equipment.

Downtime seems reduce starting from year 2014 onwards. One of the reasons is because management decided to re-appoint one of the leader during set up of selected plant is under service contract staff. Others, management also add several experience technicians for degumming section to strengthen the section from 10 personnel in mixer section in 2012 to 14 personnel in 2015 including engineer. TPM kick-off at selected plant section start from 2012.

In the selected plant of degumming section, there are about 80 rotating and static equipment such as small conveyor, crusher, mixer, weight drum, bucket elevator, bucket conveyor, fan, vacuum pump, air compressor etc. All of this equipment contributes to machine downtime. A

breakdown Chart will be constructing in order to identify the most critical equipment that contributes to machine downtime mostly. Figure 3, shows downtime Chart for percentage of 37 machines that contribute to downtime from 2012 until 2016. The average most frequent 10 equipments are only shown here for information of breakdown

Figure 3. Chart for mechanical equipment downtime from 2012 to 2016.

From the downtime Chart, it shows the most critical model that contributes to the highest downtime was for DB21 i.e E2, followed by E1 (D12), E3 (D11), E4 (M21), E5 (S102), E6 (C21) and so forth. Mixing section contribute almost 11.4% downtime during 5 years plant operates. In the degumming section all of equipment was selected as a case study although except few of the equipment is not the most critical downtime contribution.

Oee Calculation

The section of edible oil industry selected for OEE application is one of the leading oil making companies in India. The maintenance and performance data are collected from the machine as real time with the help of machine operator. They are key machinery systems and not randomly chosen machines. Data for all machines were analyzed to find out the results.

A truly comprehensive OEE solution will provide machine operators and production managers with continual line notification and control so that actions can be taken to prevent events that can result in downtime, slower cycle speeds, and poor product quality. This system should also provide a way for operators to capture codes or comments about the production process to review and analyze later during root cause analysis meetings. The Production data through degumming section provides all these features to help and implement a Simple OEE solution. Knowledge is imperative for survival in this global economy. Measuring the efficiencies of your machine operators and equipment can yield significant results for a company. Get to know what motivates production and maintenance team and the efficiency metrics of other companies and within the selected industry. Compare the selected industry production data to World Class OEE and see if implementing this Simple OEE tool can achieve and maintain better results with the shop floor machine productivity. This calls it Simple OEE because

of the design of the self contained Production details and data. With no any kind of software to install and the data source formulas programmed into the excel sheet, all it is have to do is select the functionality of the application from drop down menus.

Department have to provide the inputs; select the data sources and the Production sheet that is OEE calculation sheet on excel will take care of the rest.

Real Example of Oee in the Selected Company

Below in Table 1, is an example of real machine production data to help the company and to understand the concept of OEE and the calculation of this available data. This example will show the calculation of Simple OEE and the Simple OEE Metrics of Availability, Performance, and Quality.
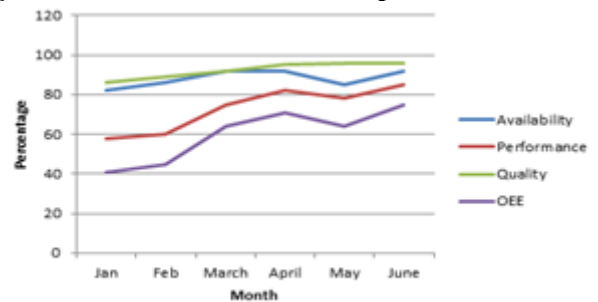
Table 1. Real machine production data.

Machine Data	Values
Run Time	840 minutes
Setup Time	35 minutes
Total Time	960 minutes
Total Count	650
Target Counter	750

The value of overall equipment effectiveness is being calculated after and before the real time
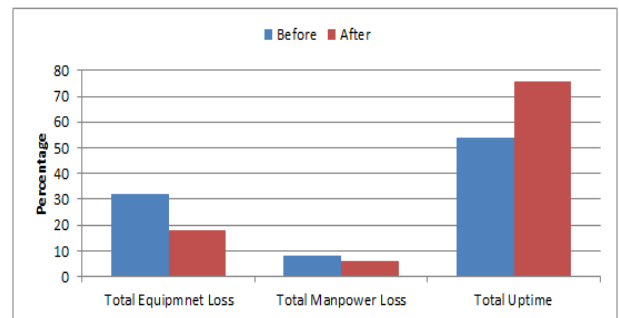
Figure 4. Losses before and after implementation of OEE.

Figure 5. The value of OEE and its factors during case study.

Review of Achievement

The validation for this research project was done by referring to the research project objectives. The objective of this project is to reduce downtime by for degumming section from 138 hours in 2014 -15 to the same value of 138 hours in 2015-16 that is 17.5 hours per month and further only up to 10 hours per month within 6 months period (June 2016 to

Table 2. Summary of the 6 months of 2016 downtime data.

Month	Downtime of the selected equipment	Failure description	Remarks
June	12.5 Hours	Repair turn of tank & Deodorizing section and replacement of loose fastener	Overhaul of the tank and degumming equipment
July	11	Training to the operator	Operator is equipped with all facility
August	8.2	Routine maintenance	Autonomous Maintenance
September	7.15	Change of chain links	New links are used
October	6.2	Overhaul	Proper Lubrication
November	5.2	Routine maintenance	Autonomous Maintenance
December	5.1	Cleaning of tank	Preventive maintenance
Total Breakdown			55.35

Dec 2016) via introducing few maintenance disciplines as a research framework for Total Productive Maintenance (TPM) initiatives. Table 2, shows the summary of the 6 months of 2016 downtime data.

Looking towards the objective stated, target downtime for degumming section is 10 hours for year 2016 -17. Until December, the downtimes recorded only achieve 8.5 hrs. It means that more than there are 60% target downtime left for degumming section. Higher downtime recorded for June 2016 is due to the some portion/part of mixer still not arrives at the plant. After replacing it on Mini Turnaround on July 2016, it shows that is no downtime occurs afterwards. However, the framework proposed is validating to the objective stated. After the entire breakdown minutely checkout is carried out by experts of maintenance as well as production engineer and a remark is putted. Operators play the key role to keep their machine up to date and error free that means zero breakdowns.

Conclusions

This present paper consists of comprehensive analysis of the research contributions made in the area of "maintenance activities and its benefit in an edible oil Plant especially focused on degumming section". It also outlines all the major key findings of degumming and recommendations with a purpose to implement maintenance activities them for the edible oil plant are concerned. OEE is continuously focused for improvement and hence, the present paper represents the salient findings. As the data obtained from real time observation and compared graph of the availability, performance and quality rate along with OEE is showing the remarkable improvement as per the expectation of the author. Under the review of achievement benefit of autonomous maintenance and cost benefit analysis also have remarkable achievement of the company. As the management main focus was the degumming equipment and its reliability along with the availability. This present research is very much capable to note the improvement in very short time of six month.

References

Ahuja, G. and Majumdar, S. K. (1998). An assessment of the performance of Indian state owned enterprises. Journal of Productivity Analysis, 9, 113–132.

Borner G, Hollien J, Schneider M (2003). Latest Development of Cost Savings for Bleaching Process. *Proceedings of the PIPOC 2003 International Palm Oil Congress (Chemistry and Technology).* 136-148

Borner G, Schneider M (1999). Practical Experiences with Countercurrent Bleaching Process. *Proceedings of the 1999 PORIM International Palm Oil Congress (Chemistry and Technology).* 52-59

Campos, L. A., Chiu, M. C., Basso, R. C., Viotto, L. A., Grimaldi, R. and Gonçalves, L. A. G. (2009). Effect of different degummingprocesses on minor compounds in canola crude oil. Luciene Ara Campos UNICAMP – Fats and Oils Laboratory.

D'Souza, J. (1998). Privatization of telecommunication companies: An empirical analysis. Working Paper, Mercer University, Macon, GA.

Eti, M.C., Ogaji, S.O.T., Probert, S.D. (2004), "Implementing total productive maintenance in Nigerian manufacturing industries", Applied Energy, Vol. 79 pp.385-401

Galal, A., Jones, L., Tandon, P. and Vogelsang, I. (1994). Welfare consequences of selling public enterprises. Washington, DC: The World Bank.

Gaskins, D. W. (1970). Optimal pricing by dominant firms. Unpublished Ph.D. thesis, University of Michigan

Kim I C, Kim J H, Lee K H, Tak T M (2002). Phospholipids separation (degumming) from crude vegetable oil by polyimide ultrafiltration membrane. *Journal of Membrane Science* (205): 113-123

Leong W. L (1992). The Refining and Fractionation of Palm Oil. *Palm Oil Mill Engineers-Executives Training Course 14th Semester 1.* PORIM Bangi. 1-6

Lin L, Rhee K C, Koseoglu S S (1997). Bench-scale membrane degumming of crude vegetable oil: Process Optimization. *Journal of Membrane Science* (134): 101-108

Kumar, P. (1985). Growth of industrial corporation in India. New Delhi: Deep & Deep Publications, 27.

LaPorta, R. and Lopez-di-Silanes, F. (1999). Benefits of privatization – Evidence from Mexico. Quarterly Journal of Economics, 114(4), 1193–242.

Liyanage, J.P., Kumar, U., 2003, "Towards a value-based view on operations and maintenance performance management", Journal of Quality in Maintenance Engineering, Vol. 9 No.4, pp.33- 50

Nazim Baluch (2012), Measuring OEE in Malaysian Palm Oil Mills, interdisciplinary journal of contemporary research in business, Vol. 4, No. 2, pp 733-746

Nakajima, S. (1988), Introduction to Total Productive Maintenance (TPM), Productivity Press, Cambridge, MA

Oybek, Z., Štefan, S. and Stanislav, S. (2008). Degumming of rapeseed and sunflower oils. *Acta Chimica Slovac.* 1(1): 321 – 328.

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

Ramamurti, R. (1997). Testing the limits of privatization: Argentine railroads. World Development, 25, 1973–1993.

Sarkaria, M. and Shergill, G. S. (2000). Market structure and financial performance – An Indian evidence with enhanced controls. Indian Economic Journal, 48(2), 98–105.

Sidhu, H. S. and Bhatia, G. (1993). Factors affecting profitability in Indian textile industry. The Indian Economic Journal, 41(2), 137–143.

Sun, Q. and Tong, W. (2002). Malaysia privatization: A comprehensive study. Financial Management, 31(4).

Sun, Q., Tong, W. and Tong, J. (2002). How does government ownership affect firm performance? Evidence from China's privatization experience. Journal of Business Finance & Accounting, 29(1 & 2).

Tsang, H.C.A. (2002), "Strategic dimensions of maintenance management", Journal of Quality in Maintenance Engineering, Vol. 8 No. 1, pp. 7-39

Yang, J., Wang, G. Y., Yang, H., Mainda, B. and Guo, G. Y. (2006). *Food Technology and Biotechnology*. 44: 101-104.