Implementation of OEE – issues and challenges

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Abstract
An operations strategy should be based on a strong systematic and standardized way of working combined with empowered shop floor teams who drive continuous improvement in that standardized work. OEE data on machine performance is a key starting point for teams to understand there equipment losses and to establish improvement programs to eliminate them. We find that the implementation of OEE is typically based on the motivation to use a basic reference measure for analysing and comparing the utilization of resources at the plant. The use of OEE can also be transformed to a system for analysing production data to identify potential areas of improvement, and supporting lean initiatives. Thus, characteristically, OEE typically advances from a base measure for efficiency as the initial purpose, to being a tool to improve effectiveness for analysing data to support CI objectives via the identification and elimination of waste.

Keywords: Multiple-case study, Overall equipment effectiveness, Lean.

1 Introduction

In many industries, the effectiveness of manufacturing equipment is of the utmost importance. Overall Equipment Effectiveness (OEE) is gaining increasing interest as a key measure of considerable relevance for sustainable manufacturing. There is some research literature on OEE but it mostly deals with the technical aspects of OEE as a measure. There are very few case studies reported and when case studies are included, these typically have the role of merely illustrating a particular aspect of the measurement or definition of OEE. We identified a lack of literature concerning the implementation of OEE, i.e. how to introduce it in a plant or company, and how to use it for the continuing operations. This research reports on the results of a multiple case study involving six Australian firms that have implementation experience of OEE.

This paper is structured as follows. First, we review the related literature and define OEE. We then present the research methodology and the case studies one by one, before conducting a cross-case analysis. These results are synthesized into the main findings. We hope that this research contributes to the understanding of how to implement and use OEE in practice.

2 Related Literature

There is a stream of literature dealing with OEE directly, e.g. Leachman (1997), Ljungberg (1998), Jonsson and Lesshammar (1999), Dal et al. (2000), Jeong and Phillips (2001), Da Costa and Da Lima (2002), Bamber et al. (2003), De Ron and Rooda (2005, 2006), Nachiappan and Anantharaman (2006), Muthiah and Huang (2007), Muthiah et al. (2008),

Muchiri and Pintelon (2008), and Braglia et al. (2009). Other literature approach OEE either from maintenance (Nakajima, 1997; Waeyenbergh and Pintelon, 2002; Chan et al., 2005; Pinjala et al., 2006), from performance measurement (Ahmad and Dhafr, 2002; Berrah et al., 2004) or from productivity improvement (Huang et al., 2002, Huang et al., 2003, Kenyon et al., 2005). Most of this literature deals with the technical aspects of OEE as a measure. Some propose alternative measures that assumingly would fit better in a particular circumstance.

OEE measure captures the reduction of scheduled operations with respect to maintenance, production and quality effectiveness, and distinguishes between these three components.

The definition of OEE is illustrated in Figure 1 and detailed below.

$$OEE = AxPxQ. \quad (1)$$

where
A = Availability rate = Operating time (h) / Loading time (h)
P = Performance efficiency = Theoretical cycle time (h) x Actual output (units) / Operating time (h)
Q = Quality rate = [Total production (units) – Defect amount (units)] / Total production (units)

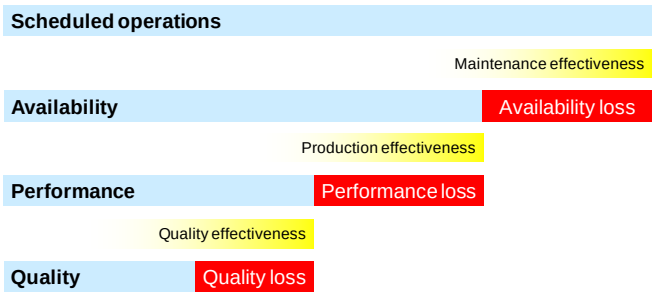

Fig. 1. Illustration of the main components of overall equipment effectiveness (OEE).

Nakajima (1998) identified and classified the main losses related to availability, performance, and quality. He established the “six big losses”: (1) poor productivity and lost yield due to poor quality, (2) setup and adjustment for product mix change, (3) production losses when temporary malfunctions occur, (4) differences in equipment design speed and actual operating speed, (5) defects caused by malfunctioning equipment, and (6) start up and yield losses at the early stage of production.

Based on the review of the related literature, we find that there is a lack of research on managerial issues and challenges related to OEE implementation. Therefore, we set out to study the following research questions:

- What are the issues in implementing OEE?
- What are the challenges in implementing OEE?
- Is there a standard implementation model or are there contingencies; if so, what are the important contingencies?

3 Research Methodology

This research is based on a roundtable seminar and an e-mail questionnaire survey. The roundtable was used to raise interest and to establish a common understanding of OEE and the basic issues concerning implementation. 18 manufacturing firms were present. The follow-up questionnaire was concerned with the specific issues and challenges for each individual company. We received responses from six firms. The results of this study are based on the implementation experience of these six firms. On average, they have four years of experience of using OEE.

4 Case Studies

In this section we present the OEE implementation issues for each respective company. First, we provide an overview of the types of companies as shown in Table 1.

Table 1. Company characteristics.

Characteristic	Case A	Case B	Case C	Case D	Case E	Case F
Size	Large	Small	Large	Medium-sized	Large	Medium-sized
Industry sector	Food mfg	Mfg-building products	Chemical mfg	Steel mfg	Food mfg	Engineered Product mfg
Main process type	Batch / flow shop	Batch / flow shop	Batch / flow shop	Continuous process	Continuous process	Line
Production system (decoupling point)	Make-to-order	Make-to-stock	Make-to-stock	Make-to-stock	Make-to-stock	Make-to-order
Improvement programs	Lean	Lean	Lean, TPM	Lean, Six sigma	Lean, JIT, TPM	Lean, TPM, Six sigma
Years of OEE experience	4	8	1	1	5	3

Notes: TPM=Total Productive Maintenance; JIT=Just in Time

4.1 Case A

The company is a leading brand in the Australian F&B industry and continues to show strong growth in global markets with retail, food service and bulk products making their way into over 50 countries around the world. Its success in export markets has been the ability to build and operate at high capacity utilisation, supply value-added retail-ready products in excess of AUD50 million, despite challenging trading conditions. The company's business is focused on the demand for high quality products from a 'clean, green' industry, underpinned by its ability to quickly respond to the requirements of individual markets, making the business a 'one stop shop' for many customers.

4.2 Case B

This company produces and sells a range of premium building products to the commercial and residential building markets, with operations in the Asia Pacific region, including manufacturing facilities in Australia, China, Malaysia, and Thailand. It prides itself on highly trained and experienced staff which has world class engineering knowledge, research and development, technical and customer service skills. The process in not continuous, machines are stopped and started to load material and remove product. All machines have their OEE measured, but OEE is only measured when product mix demand and labour is available to run a machine. The essence of OEE measurement is when the machine is running, how well is it running. Factors such as market demand and absenteeism are taken out of the calculation. OEE is used as a process efficiency tool rather than an asset utilisation tool. All OEE results are generated from hand written machine reports, which causes inaccuracies if downtime is not recorded accurately. There is a site weighted OEE result which is based on lm produced through each machine. Operators still struggle with the concept of OEE – they are more comfortable in thinking about metres produced not OEE. Steady and continuous improvement of site weighted OEE.

4.3 Case C

This large chemical company operates in multiple business areas including household cleaning, beauty care, and consumer and industrial chemical treatments. OEE is being piloted in Australia with trials on one site and implementation of large data set of run data. Efficiency improvements have been achieved on one extrusion line where material changeover is now done on the fly, rather than waiting for a 10-15 minute shutdown. The company is cautious regarding global standard, and the inconsistency of global comparisons. But they see OEE as a tool for Kaizen and are focussing strongly on continuous internal operational improvements.

4.4 Case D

This company is an integrated, manufacturer and distributor of steel and finished steel products. They are self sufficient in ore and have the ability to be self sufficient in scrap metal, providing significant flexibility to the vertically integrated model that ranges from the mining, collection and supply of steelmaking raw materials through to steel production, manufacturing and distribution in Australia and overseas. The company also makes external sales of ore and scrap metal. The company is thus a uniquely integrated portfolio of complementary businesses. It operates its own distribution operations and supplies the Australian construction, manufacturing, automotive, rail and rural sectors. The company also exports excess slab production to overseas steel manufacturers; however imports have increasingly driven a focus on operational Building organisational capability, particularly in relation to supply chain, operational productivity, and customer and market insight.

4.5 Case E

This company is a leading supplier of quality refined commodity food products. They service the industrial and consumer markets under numerous iconic brands. The product is produced from raw local ingredients and the industry’s value chain is one of the largest in

the world. The company has significant brand presence, and is a large exporter in both packaged and in bulk form. The company is located close to major food manufacturing industries, and to wharf facilities for bulk shipping. As one of Australia's largest and longest suppliers to the food and beverage industry, they have a dedication to excellence (and thus OEE), and this extends to managing the inventory levels and deliveries to major customers.

4.6 Case F

The company is one of Australia's leading manufacturers of Engineered Products. Its manufacturing facility has quality management accreditation to ISO9001 and environmental management systems to ISA14001, and has been manufacturing and supplying to the Australian mining industry since 1960's. It also sells and supports a range of third party Engineered Products-branded industrial power transmission products; heavy-duty and lightweight conveyor belts; hydraulics; rubber track; and automotive and heavy-duty truck belts, hose, tensioners and air springs.

5 Cross-Case Analysis

A comparison between the six companies shows that there are similarities as well as differences between the approaches taken to implementing OEE is shown in Table 2.

Table 2. Company characteristics

Characteristic	Case A	Case B	Case C	Case D	Case E	Case F
Drivers and motives to start using OEE	Intra/inter firm benchmark	*Identifying waste *Measuring improvement	Change from a reactive to proactive data driven culture	*Intra/inter firm benchmark *Identifying waste	*New Operations GM *Part of TPM program	*Intra/inter firm benchmark *Basis for productivity *Communication with crews over all shifts (24/7)
Critical success factors for the implementation phase of OEE	*Visibility of data/target *Management facilitates removal of barriers	Operator *understanding *knowledge	*Operator involvement *Establish link from data to improvements	*Communication of need * Operator education of OEE drivers *Removal of competing systems	*Simple measurement by shop floor *Use of data as part of TPM	*Visibility of data *Up to date data *Operator understanding & control
Difficulties, barriers or pitfalls during implementation phase of OEE	Developing a culture to challenge & present ideas	Shift culture from units produced to waste removal	Long data entry times - Reduced motivation	* Culture of fear of unknown *Mis-understanding of calculations	*Training in CI method *Failure to set target rates	*Criteria not under control * Long data entry times - Reduced motivation *Holidays & shutdowns included

Critical success factors for continued use of OEE	Automation of process once acceptance in place	Management commitment	*Visibility of data/target *Focus on cycle of CI	Management engagement in data discussion	*Ownership by shop floor *Simple data collection *Management link to business objectives	*Data benchmarked *Improvement in margin *Full order book
Main benefits or specific outcomes from using OEE	Enhanced: *morale *asset utilisation *recovery of overheads	Way of monitoring improvements in efficiency	Part of new culture *lean *empowerment *engagement	*Focuses improvements on operations CTQ family	*Throughput increase without large CAPEX *Reduced inventories *Better JIT	*Engaged workers *Best practice comparable data *CTQ increase *Environment
Main future challenges in using OEE	Maintaining links from measures to response	Resetting the rate targets to achieve CI	Application across: *processes *labour constraints	Linkage to the business objectives	Extending application to whole plant	* Maintain through downturn *Data up to date *CI

Notes: GM=General Manager; CI=Continuous Improvements; CTQ=Critical to Quality; CAPEX=Capital Expenditure

6 Discussion and Implications of the Findings

Here we present an initial discussion and possible implications from the case study data set. In terms of drivers and motives to utilise OEE we see that intra/inter firm benchmarking and removal of waste (and identification of losses) were common responses. There was also an explicit linkage to other programs such as TPM, CI and Lean to implying that OEE needs to be considered as part of a program to change the organisations operational culture. With respect to the critical success factors for an implementation phase operator involvement, education and understanding, plus visibility of data/target were consistent responses. The implication of these responses is that although OEE provides a systematic approach to operational measures, the data must still be collected from the right place at the right time and then be displayed in the right format in the right locations before any discussion of CI can take place.

The most common difficulties, barriers or pitfalls during the implementation phase seemed to be resistive cultures, specifically those that did not challenge existing ideas or ways of doing things. The implication of this was a concern that data entry and display was delayed as a result, and this often led to reduced motivation and thus threatened the success of the projects. The critical success factors for the sustainability of OEE in plants focused on two areas; firstly on the simplicity of data capture, storage, display and benchmarking, and secondly on the enabling role that management should play in the system. The implications of these findings suggest that while management may play a key role in the initial manual establishment phases of the system, their role must shift to the enablement of simplicity (perhaps through automation) to ensure the system's continuity.

The main benefits or specific outcomes experienced from using OEE seemed to focus primarily on the tangible aspects of performance metrics such as improvements in CTQ family, and financial dimensions of throughput efficiency, and waste removal. However there was secondary acknowledgement of improvement to the intangible domain of HR empowerment, engagement and morale. The implications of this perspective is that

managerial respondents would seemed to have at least grasped that although they report on the tangible outcomes of OEE, it is the intangible domain that ultimately must be nurtured if the benefits are to be sustained. In terms of the main challenges for plants in using OEE, the focus was not how to propagate the system, but rather how to maintain the shop floor (HR) engagement and commitment to the system while at the same time integrating the increasingly demanding objectives of the business.

In summary there was an almost universal acknowledgement that decisions surrounding strategic business directions were being hampered because of inconsistent operational measurement systems, even though an implicit standard approach was required. There was also acknowledgement that variation in plant performance hampered communication and leads to monetary loss due to less than timely actions being taken. An operations strategy should be based on a strong systematic and standardised way of working combined with empowered shop floor teams who drive continuous improvement in that standardised work. Lean and TPM are key methodologies to improve the capability and empower shop floor teams, and OEE data on machine performance is a key starting point for teams to understand there equipment losses and to establish improvement programs to eliminate them. It was interesting to note that management leadership and commitment that is often cited as critical to program success in the organisational change literature (most often because it is found to be resistive), here was noted in a very positive sense. This would seem to suggest that the managerial role in OEE programs is understood to be one of enablement of systems for training, data collection and analysis and empowerment of an "under utilised human resource" to drive the solution space.

7 Conclusions

We find that the implementation of OEE is typically based on the motivation to use OEE as a basic reference measure for analysing the utilization of the resources at the plant. For firms with multiple plants, a motivation has also been to be able to compare plants based on OEE. However, as time passes the use of OEE is transformed to a system for analysing production data to identify potential areas of improvement, and supporting lean initiatives. Thus, characteristically, OEE typically advances from a base measure for efficiency as the initial purpose, to being a tool to improve effectiveness for analysing data to support CI objectives via the identification and elimination of waste.

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