Anatomization of the overall equipment effectiveness (OEE) for various machines in a tool and die shop

Sagarika Raju, Harsha Arun Kamble, Rashmi Srinivasaiah and Devappa Renuka Swamy
Department of Industrial Engineering and Management, JSS Academy of Technical Education, JSS Campus, Bengaluru, India and Visvesvaraya Technological University, Belagavi, India

Received 31 January 2022
Revised 6 March 2022
Accepted 6 March 2022

Abstract

Purpose – The purpose of this research is to discover equipment losses and assess the accomplishment of overall equipment effectiveness (OEE) values.

Design/methodology/approach – Industries specialized in die shops often have issues regarding their efficiencies, conferring to statistics further production line department procedure for various machines frequently suffered restrictions owing to excessive downtime and speed losses in machines thus, reducing their effectiveness and efficiency. OEE is a means of determining how effective a piece of equipment is when in working condition. Calculation of OEE finds the heart of the issue and the root cause for the underlying problem.

Findings – The dimensional outcomes suggest that the average machine effectiveness has not attained the norm of >85%, but there is still room for progression.

Originality/value – One recommended procedure to reduce losses is to keep the actual pace of operation and downtime of equipment constant. Many such suggestions are provided to reduce the losses.

Keywords OEE, Availability, Performance, Quality, Effectiveness, Downtime

Paper type Case study

1. Introduction

Industry, market, product and technology are all crucial parts in the tool and die shops, and they are altering at a tremendous and fundamental tempo. The classical tool and die-making process are governed and driven by elements such as cost pressure, time pressure, quality standards, competitive dynamics and so on (Tang *et al.*, 2004). The ancient tool and die-producing procedures are carried out carefully according to the product drawing of the client that is perhaps the most indispensable reason. Now, the tool and die industries are under enormous pressure to respond quickly to customers' needs to preserve their market positions, particularly in the automotive industry (Tang *et al.*, 2004).

Automobile companies are continuing to lessen lead times in their development to obtain maximum markets. This trend influences the tool and dies complex, notably about the quality of the product characteristics development and serial production, where tool designers follow the crucial pathway of product development and have a great effect on the time of production start (Eversheim *et al.*, 2002). To stay up with changing strategic plans and customer sourcing

Journal of Intelligent Manufacturing and Special Equipment
Vol. 3 No. 1, 2022
pp. 97-105
Emerald Publishing Limited
e-ISSN: 2633-660X
p-ISSN: 2633-6596
DOI 10.1108/JIMSE-01-2022-0004

strategies, tool producers should get a fresh understanding of driving aspects such as new techniques and skills, mass customization of customers' items, greater product complexity, competitive pressures and higher efficiency (Xie *et al.*, 2001). Meanwhile, the rapid development of computer technology, enterprise modeling and system engineering has lately begun to be implemented in the form of new production paradigms which may aid product development in the tool and die sector (Chin and Tang, 2002). In a dynamic environment, equipment effectiveness, new collaborative methodologies and technology are generally required to support the novel communication relationship between the customer and the toolmaker. To maintain a competitive edge in the face of increasing commercial rivalry, industrial leaders must assess the status of all company activities, including production and maintenance (Almeanazel, 2010). As global competition is increasing, CEOs' mindset has changed from improved productivity through economies of scale and internal knowledge to addressing market demands for agility, delivery performance and quality (Baluch *et al.*, 2012). Higher productivity is essential for businesses to succeed. Examining the performance of the company's production plants is one way to improve efficiency (Almeanazel, 2010). The three forms of manufacturing facility issues that cause output to be halted or stopped are human, mechanical and environmental. One technique of resolving production facility concerns and increasing productivity is to require thorough assessment and management of production equipment (Hansen, 2001).

Nakajima (1998) established total productive maintenance (TPM) in the 1980s, which resulted in the invention of a statistic known as overall equipment effectiveness (OEE). It is a gadget that is commonly used in businesses to detect and monitor machine productivity. It is a performance measuring tool made of three parts: performance, availability and quality rate, and it provides an updated status of any product with the least computations (Lesshammar, 1999). Moreover, this technology can foresee prospective losses and provide remedies to prevent them from occurring. This measurement may be used for the equipment, people, or materials, resulting in improved product performance. The following are some of the benefits of OEE:

(1) OEE encourages reducing interruptions and other costs, resulting in better-quality equipment life cycle managing.

(2) Because of increased process visibility and operator empowerment, OEE may boost labor effectiveness while concurrently enhancing productivity.

(3) OEE may boost productivity by detecting bottlenecks.

(4) Product rework is decreased, which may subsidize to higher quality rates.

The majority of today's manufacturers' repair and maintenance issues are caused by a lack of arrangements or approaches that can examine the performance of existing equipment and give resolutions to the root cause of issues (Mainea *et al.*, 2010). As a result, choosing the proper demonstration evaluation technique is critical for businesses to achieve their objectives. OEE is a performance measuring technique commonly utilized by organizations, particularly Japanese enterprises capable of overpowering equipment difficulties (Dal *et al.*, 2000; Jeong and Phillips, 2001). Precision tools or metal forms known as dies are shaped by tool and die manufacturers and are used to cut, shape and mold metal and other constituents (Zandieh *et al.*, 2012). CAD is used by tool and die makers to create products and parts. They input proposals into processor systems, which generate drawings for the tools and dies required. High downtime and equipment losses, according to evidence collected from the manufacturing line department, reliably delay the material production procedure, subsequent in low corporate thruput. This is because of a lack of vigorous handling, which damages the locomotive while also disrupting the business process and product eminence. The OEE strategy is the best way to deal with this issue (Relkar and Nandurkar, 2012). The OEE method may be used to evaluate the degree of efficacy and the quantity of fault that happens throughout the material industrial process. This way has always been broadly used by Japanese firms as well as firms from a variety of other republics (Dal *et al.*, 2000; Mainea *et al.*, 2010).

TPM and OEE are perilous for dropping the six major losses believed to be the root origins of incompetence. Both the availability of equipment and the quality of the product has a role in the link between TPM losses and effectiveness (Lesshammar, 1999). Face losses may occur at any point all over an operation and can be apparent, such as scrap, substitutions and failures, or unseen, such as lethargic running and continual changes to keep manufacturing within tolerance. Each organization should avoid three things when it comes to equipment upkeep.

Nakajima (1988) suggested there are six sorts of equipment losses that affect lower equipment routines. Are apparatus letdown, setup and modification, idle and minor slowdowns, reduced speed, process fault and low yield are the six noteworthy losses. Downtime losses, including setup and adjustment, are classed as downtime fatalities, dropping obtainability; speed losses, including idle and short slowdowns, are defined as speed losses, lowering presentation. Finally, defect loss caused by poor quality is classified as process defect and reduced yield.

1.1 Stoppage losses as a purpose of availability

Shutdowns are defined as the situation when yield is zero and the system generates nothing, or when the machine works and yet produces nothing during the annual inspection, and they are caused by two factors: a breakdown loss, which keeps referring to parts letdown that requires repair or replacement and the losses are caused by two factors: a breakdown loss, which alludes to parts failure that necessitates restoration, and the losses are caused by two factors: a breakdown loss, which demands fixing, and the deficits are triggered (Anantharaman and Nachiappan, 2006). For illustration, the beginning of fabrication or the start of split jobs, product revisions and also the status of the operation. One of the most common sources of this wastage is changes in equipment, dies, jigs and tools, along with setup, setup and adjustment delays (Almeanazel, 2010).

1.2 Losses in speed-related performance

These befall when the yield is less than the alignment speed output and no evaluation is performed to regulate whether the productivity meets the quality standard precondition. Speed loss can be separated into two categories: Minor halts can occur as a consequence of an appliance stopping, jamming or idling. Many individuals prefer to this as the breakdowns since it is a critical module that must be projected (Nakajima, 1998). There is a loss of speed when the speed of the equipment is reduced or the machine does not function at its academic maximum speed. The machine may be utilized at a slow pace to cope with the frequent incidence of quality flaws and minor stoppage issues. It is computed by likening the hypothetical and definite working loads (Almeanazel, 2010; Bamber *et al.*, 2003).

1.3 Quality losses or defects

Whenever the result does not reach the requirement, this is known as a loss in quality. This may necessitate modification for quality concerns that arise all through the normal production cycle. Because the items do not fulfill the requirements, they must be changed to notify the defects (Maram *et al.*, 2012). Rework requires the use of labor, implying that the corporation will incur some costs, and distress is also harmful. The ratio of first-class items to total production is used to calculate the magnitude of these losses. Second, there are yield losses, which result in raw material wastage. Raw material losses (connected to product strategy, manufacturing process and so on) and fine-tuning losses are the two types of yield losses (related to quality snags of items produced at the start of production, swops, etc.) (Almeanazel, 2010).

The goal of this learning is to evaluate the OEE of diverse machines to dodge big losses.

2. Methodology

OEE is a metric tool cast-off in the accomplishment of TPM programs to keep appliances in good working instruction by reducing 6 vital equipment fatalities. OEE is premeditated using three basic ratios: (1) availability ratio, (2) performance ratio and (3) quality ratio. It may be intended by multiplying these three relations. Figure 1 shows a flow illustration of OEE measurement (Na, 98 and the OEE formulation as given below

$$\text{OEE}(\%) = \text{Availability} \times \text{Performance} \times \text{Quality} \times 100 \tag{1}$$

The availability ratio gives how much time is available to run equipment defines this as the ratio of operating time to loading time after modifying for equipment downtime. To calculate this, use equation (2).

$$\text{Availability} = \frac{\text{Operating time}}{\text{Loading time}} \times 100 \tag{2}$$

The third equation designates the capability of the machines to produce things. The operating rapidity rate and the net functioning rate define this ratio. The variance between the ideal speed (specified by the equipment's design) and the actual operating rapidity is stated as the operational speed rate. The net operating rate is the average rate at which a speed is upheld during a certain period (Zandieh *et al.*, 2012). The net operational income proportion assesses whether an operation is steady through periods when the equipment is employed at low speeds. Formula (3) may be used to obtain the formula performance relation.

$$\text{Performance} = \frac{\text{Total produced} \times \text{ideal cycle time}}{\text{Operation time}} \times 100 \tag{3}$$

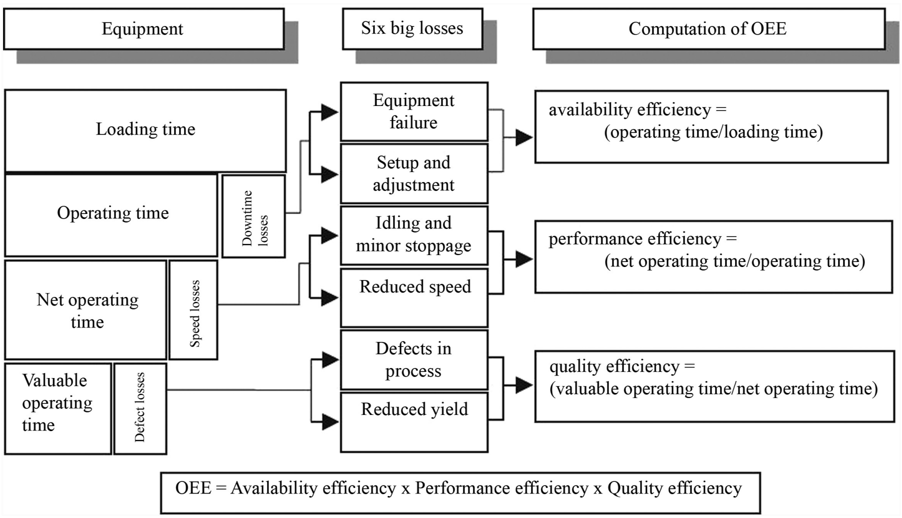

Figure 1.
The OEE and its computation technique

The 4th equation imitates the equipment's ability to produce items that meet necessities. Formula (4) gives the calculation of quality.

$$\text{Quality} = \frac{\text{Net produced} \; - \text{defect amount}}{\text{Net produced}} \times 100 \tag{4}$$

Succeeding the completion of the scheming and analysis, the next step is to make the inference using the criteria of standard initiatives, as specified in below Table 1. Then ideas for enhancement are made.

Seiichi Nakajima led the introduction of TPM, OEE and the Six Big Losses in the early 1970s while at the Japanese Institute of Plant Maintenance. In his 1984 book, Introduction to TPM (translated to English and published in 1988 by Productivity Press), Seiichi Nakajima included the above four "world-class" numbers.

3. Results

3.1 Availability proportion

By comparison of the definite operating time to the loading time, the availability is totaled. The availability rate is made known as given in Table 2.

The calculated rate is revealed to be 87.02%, while the objective is 90%, owing to press machine downtime.

3.2 Performance proportion

Performance rate embodies the machine's speed in transporting the best time against the engine running period. Table 3 demonstrates how to calculate this rate.

OEE factor	World class (%)
OEE	>85.0
Availability	>90.0
Performance rate	>95.0
Quality rate	>99.9

Table 1.
The world-class OEE factor

Press machine	First shift (5 am–1 pm)	Second shift (1 pm–9 pm)	Availability in % Night shift (9 pm–5 am)	Actual in %	Target in %
Machine 1	86.62	87.02	86.27	86.64	90
Machine 2	87	87.45	86.94	87.13	90
Machine 3	86.77	86.95	87.26	86.99	90
Machine 4	87.37	86.95	86.86	87.06	90
Machine 5	87.39	86.54	85.79	86.57	90
Machine 6	87.26	86.65	87.13	87.01	90
Machine 7	87.49	87.67	87.33	87.50	90
Machine 8	87.95	87.33	87.75	87.68	90
Machine 9	87.08	86.83	86.85	86.92	90
Machine 10	87.18	87.27	87.08	87.18	90
Machine 11	86.54	87.19	87.14	86.96	90
Machine 12	86.81	87.2	86.89	86.97	90
Machine 13	86.63	85.55	88.05	86.74	90
Machine 14	86.7	87.31	87.06	87.02	90
Machine 15	87.16	86.57	87.29	87.01	90
AVG IN %				*87.02*	

Table 2.
Availability rate

Press machine	First shift (5 am–1 pm)	Second shift (1 pm–9 pm)	Performance in % Night shift (9 pm–5 am)	Actual in %	Target in %
Machine 1	87.08	86.84	87.7	87.21	95
Machine 2	86.74	87.55	87.04	87.11	95
Machine 3	86.52	87.26	86.99	86.92	95
Machine 4	87.76	87.43	88.04	87.74	95
Machine 5	87.21	86.67	86.93	86.94	95
Machine 6	87.77	87.41	87.62	87.60	95
Machine 7	87.81	87.77	88.11	87.90	95
Machine 8	86.47	87.52	87.28	87.09	95
Machine 9	87.69	87.28	87.32	87.43	95
Machine 10	87.78	87.62	87.67	87.69	95
Machine 11	87.63	87.43	87.42	87.49	95
Machine 12	87.48	87.52	87.04	87.35	95
Machine 13	87.26	87.51	87.79	87.52	95
Machine 14	86.65	87.34	87.19	87.06	95
Machine 15	87.09	86.75	87.44	87.09	95
AVG IN %				*87.34*	

Table 3.
Performance rate

According to Table 3 calculations, press machines 3 and 14 performed fairly poorly. This is related to misfeeds, section jams and product flow pauses, as well as the absence of machine operative training, equipment age and tooling wear.

3.3 Rate of quality

The quality rate is a part of the total number of items that accomplish the quantified standard of all engineering sectors. Table 4 displays its calculation findings.

Based on the conclusions of the quality proportion calculation in Table 4, it can be detected that the worth of excellence was fairly low in all of the machines, but it grew in a few. Defective and good goods both wedged the growth in the value of quality in every equipment.

Press machine	First shift (5 am–1 pm)	Second shift (1 pm–9 pm)	Quality in % Night shift (9 pm–5 am)	Actual in %	Target in %
Machine 1	99.98	99.97	99.98	99.98	99.99
Machine 2	99.96	99.98	99.98	99.97	99.99
Machine 3	99.98	99.98	99.98	99.98	99.99
Machine 4	99.98	99.99	99.98	99.98	99.99
Machine 5	99.98	99.98	99.98	99.98	99.99
Machine 6	99.97	99.97	99.98	99.97	99.99
Machine 7	99.97	99.98	99.98	99.98	99.99
Machine 8	99.98	99.98	99.97	99.98	99.99
Machine 9	99.98	99.98	99.98	99.98	99.99
Machine 10	99.99	99.98	99.98	99.98	99.99
Machine 11	99.98	99.98	99.98	99.98	99.99
Machine 12	99.97	99.98	99.98	99.98	99.99
Machine 13	99.98	99.97	99.97	99.97	99.99
Machine 14	99.98	99.97	99.98	99.98	99.99
Machine 15	99.97	99.98	99.98	99.98	99.99
AVG IN %				*99.98*	

Table 4.
Quality rate

3.4 OEE calculation

After acquiring the 3 rates, the OEE of all machines is calculated. Table 5 displays the OEE totaling.

As per the outcomes of the OEE calculation in Table 5, the average value of effectiveness (OEE) was 75.99%. However, according to Table 5, the OEE number missed the mark of the worldwide threshold of >85% set by the Japan Institute of Plant Maintenance (JIPM). The availability and performance ratio has the lowest prevalence of values among the 3 variables that make the machine's OEE value, with a proportion of just 87.02 and 87.34% (Table 6). Machine breakdowns, machine adjustments/setups, machine stops, machine restricted speeds and equipment breakdown, horrible machine startup parts and bad machine production parts are the major losses in value and volume influencing the small proportion of OEE.

4. Discussion

As per the evaluation of the effectiveness value (OEE) of the press machineries, the factors that have the largest impact on the machine's profitability are delay and speed. This loss comes as an outcome of a machine breakdown, which demands a machine changeover, machine stops and machine reduced speeds.

After determining that speed and downtime are the most significant issues contributing to machine inadequacy, the following step is to pinpoint the source of the issue (Naderinejad and Nilipour Tabatabaei, 2011). Product misfeeds, product flow stoppage, level of machine operator training are amongst its determinants (Relka and Nandurkar, 2012). Failure of equipment, tooling damage, unintended maintenance, process preparation, machine changeovers and material shortage Based on these restrictions, the following stages must be done to evade the incidence of speed and downtime losses:

Press machines	Availability in %	Performance in %	Quality in %	OEE in %
Machine 1	86.64	87.21	99.98	75.54
Machine 2	87.13	87.11	99.97	75.88
Machine 3	86.99	86.92	99.98	75.60
Machine 4	87.06	87.74	99.98	76.38
Machine 5	86.57	86.94	99.98	75.25
Machine 6	87.01	87.60	99.97	76.20
Machine 7	87.50	87.90	99.98	76.89
Machine 8	87.68	87.09	99.98	76.34
Machine 9	86.92	87.43	99.98	75.98
Machine 10	87.18	87.69	99.98	76.43
Machine 11	86.96	87.49	99.98	76.07
Machine 12	86.97	87.35	99.98	75.94
Machine 13	86.74	87.52	99.97	75.90
Machine 14	87.02	87.06	99.98	75.74
Machine 15	87.01	87.09	99.98	75.76
AVG IN %	*87.02*	*87.34*	*99.98*	*75.99*

Table 5. The overall equipment effectiveness rate

	OEE from company (%)	OEE given by world-class (%)
Availability	87.02	>90.0
Performance	87.34	>95.0
Quality	99.98	>99.9

Table 6. A comparison of world-class measuring versus corporate quantity

(1) Conduct risk assessments
(2) Install sensors to identify probable equipment faults early.
(3) Schedule routine machine maintenance
(4) Increase and improve staff communication
(5) Improve manufacturing equipment
(6) Develop a dependable preventive maintenance approach.
(7) Create a repetitive examination program for important equipment.

5. Suggestion

Our calculations suggested that the average standard of machine effectiveness in diverse press machines was 75.99%, and while the value set by JIPM (Nakajima, 1998) has not yet reached >85%, progress is still attainable. Downtime and speed losses are the most serious ramifications to the machines' overall ineffectiveness. Several approaches for reducing losses have been identified and therefore can be employed.

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Corresponding author

Sagarika Raju can be contacted at: sagarikasanika@gmail.com