

# Machine efficiency and man power utilization on production lines

SIVA KUMAR A/L SUBRAMANIAM<sup>1</sup>, SITI HUZAIMAH BINTI HUSIN<sup>2</sup>,  
YUSMARNITA BINTI YUSOP<sup>3</sup>, ABDUL HAMID BIN HAMIDON<sup>4</sup>

<sup>1, 2, 3</sup> Faculty of Electronics and Computer Engineering  
Universiti Teknikal Malaysia Melaka

<sup>4</sup> Professor, Faculty of Electronics and Computer Engineering  
Universiti Teknikal Malaysia Melaka  
MALAYSIA

[siva@utem.edu.my](mailto:siva@utem.edu.my)

**Abstract:** - Efficiency of industrial production lines is crucial as it results in an improved production and utilization of available resources. Factors contributing to production line efficiency are manpower utilization and machine efficiency. Measuring the machine efficiency and man power utilization should be on-line, accurate and truthful. The management should be able to look for relevant production data and to accurately interpret these data in order to identify the various faults at production level and to immediately take steps to improve efficiency. However, faults are overwritten and reports are retouched with inaccurate information. An accurate and on line data management system can ensure that these problems are overcome.

**Key-Words:** - Machine efficiency, man power utilization, industrial production line, data management system.

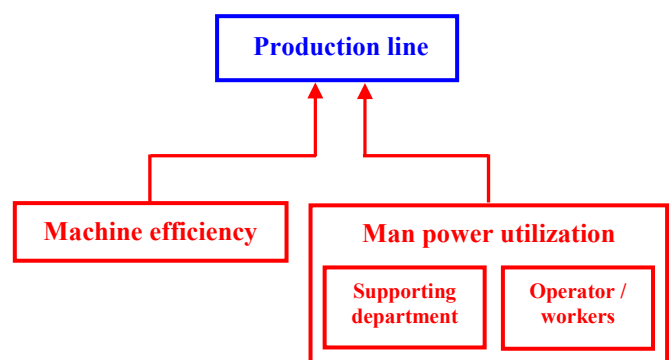
## 1 Production system in industries

A production line is a set of sequential process established on an industrial shop floor. A production process or a manufacturing process is the transformation of raw materials or components into finished products. The stages in a production process involve procurement, fabrication, assembly, testing, packaging and distribution. The production or manufacturing lines in industries can be categorized into three types i.e. automated production lines, semi-automated production lines and manual production lines. The nature of a production line depends on the complexity of the manufacturing parts, the production volume, the sensitivity of the product and cost. Industries' management plan and layout their production lines according to specific production requirements.

Modernization of industries introduced new technologies to ease human on the production lines. Industries have installed machineries to assist workers. This is known as semi-automated process lines. Automated process lines are designed to operate with fewer workers. This can cut cost in the long run. A fully automated process line is designed to fulfill mass production output and is ideally suited to serve large. Machineries for automated production process such as robots are capable of working for long duration at a consistent rate of production

output. Thus, such process lines demand expert and professional people in designing and maintaining the system.

## 2 Production line inefficiency



**Fig. 1 Factors affecting production lines**

Analyses are carried out by the management on production line problems almost daily and counter measures are taken to further strengthen the performance of the production line. Analysis is simplified when data is translated into various categories based on critical factors which affect the production lines. The factors affecting production lines can be categorized into three as shown in fig. 1.

## 2.1 Machine efficiency

Machine efficiency is one of the factors that are frequently overlooked by the management and this can lead towards losses which reduces the yield [1], [2]. Improper maintenance of machines will result in low standards of produced parts and increases the maintenance of machines. Machines are meant to work efficiently, but in some circumstances machines can be less productive due to improper preventive maintenance. Preventive maintenance is a key factor that keeps the machine running efficiently through the production process. The maintenance activity on machines needs extra attention by the management along with the responsible personnel to ensure optimum usage of machineries which will eliminate unwanted wastages due to machine stoppages.

## 2.2 Manpower utilization

Humans play a major role on the industrial shop floor especially when it comes to meeting targets. Humans in the production floor can be divided into two categories which are workers or operators on the production line and the workers in the supporting department.

### 2.2.1 Supporting department

Humans capitalize most of the process on industries from the management to the layman (operators). An industrial environment is one in which there are a large number of people from various departments working together to meet set goals. When it comes to unmet goals, fingers should also be pointed to the supporting department as they also contribute to this matter. The supporting departments play their role in maintaining the consistent pace of work on the industrial shop floor.

There are three basic departments in industries which are the Total Quality Management (TQM), Production Planning and Control (PPC) and Maintenance. The TQM involves all the quality matters of the parts produced. The PPC involves in planning the production process and supplies base on orders. The maintenance department is responsible on all the technical matters on the industrial shop floor. Most of the industries face problem due to unforeseen damages that the company will face if a task is not done on scheduled basis.

### 2.2.2 Operators or workers

Human performance varies from time to time depending on their capability and duration of work. When the performance of a worker drops, the production output also drops. Improper monitoring of workers will result in low standards of production output and will increase the maintenance of machineries. The major factor contributing to this is the attitude of the workers themselves. Most of the workers tend to perform in an average manner and for most of the time they will be less productivity and this will result towards wastage of the planned production time [3].

## 3 Production breakdown

Some industries operate in two 12 hours shifts or operate in three 8 hours shifts a day. The planned shift length can be divided into two, which is the Planned Downtime and Planned Operation Time. Planned downtime is a duration of time where the management has decided to stop the production process due to certain commitments such as preventive maintenances, improvement projects, low in production order and etc. Planned operation time is the proposed time for production process by the management. Generally the planned operation time can be divided into two which is actual operation time and unplanned downtime. Both these factors are the major concern for the management when it comes to measuring machine efficiency and man power utilization. Industries try to maximize the actual operation time and minimize the unplanned downtime to improve their capacity in all means [4]. The production duration can be categorized as shown in fig. 2.

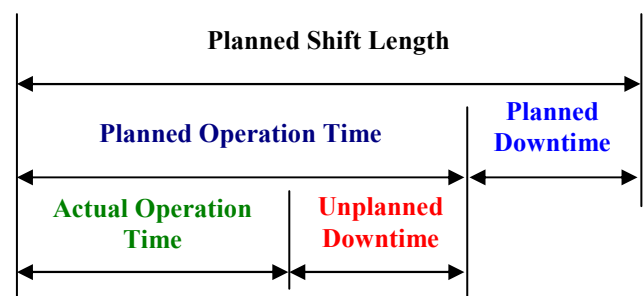


Fig. 2 General breakdown of a production shift

## 4 Measuring machine efficiency

When it comes to manufacturing process, machineries is a very common word in industry especially for higher rate of production output. Since the investment in machineries is high, industries try to maximize their usage in the shortest time possible. Even the management in industries around the world strives towards the optimization of machineries yet this is not to their concern when targets are met. The awareness on true data on machine efficiency is neglected and the results are unwanted purchases of machines. These could be avoided if only the true data is analyzed and counter measures are taken by the responsible personnel.

Overall Equipment Effectiveness (OEE) is a preeminent practice for monitoring and improving efficiency of the manufacturing processes such as machines, cells, assembly lines and etc. OEE is simple and practical yet a powerful calculation tool. It takes the most common sources of manufacturing productivity losses and places them into three understandable categories which are Availability, Performance and Quality [5]. By doing so, it distills complex production data into simple understandable metrics that provide a gauge for measuring true manufacturing efficiency. It also forms the foundation for tools that help to improve productivity [6] – [10].

From fig 2, the Planned Downtime is subtracted from total Planned Shift Length. This includes all events that should be excluded from efficiency analysis because there is no intention of running production (meal breaks, scheduled maintenance and when the management decides to stop production). The remaining time is Planned Operation time as per in the production schedule. All events that stop planned production for a length of time falls under Unplanned Downtime. The possibilities of such events are equipment failures/breakdowns, quality problems, material shortages, and most importantly, changeover time. Changeover time is the time wasted in between shifts i.e. a form of downtime that can be reduced. The remaining time is called Actual Operation Time which is the effective production duration.

### 4.1 Availability

Availability takes into account downtime loss which includes any events that stop production process for an appreciable length of time (usually

several minutes long enough to log as a traceable event). This includes equipment failures, material shortages and changeover time. Change over time is included in OEE analysis, since it is a form of downtime. While it may not be possible to eliminate changeover time, in most cases it can be reduced. The remaining available time is called actual operation time. Availability is the ratio of operation time which is simply planned operation time less downtime to planned operation time and accounts for downtime loss. Availability is calculated as in (1) [2], [4], [7], [11] - [13].

$$\text{Availability} = \frac{\text{Actual Operation Time}}{\text{Planned Operation Time}} \quad (1)$$

### 4.2 Performance

Performance takes into account speed loss which includes any factors that cause the process to operate at less than the maximum possible speed or rated speed when running. This includes machine wear, substandard materials, misfeeds and operator inefficiency. The remaining available time is called actual operation time. So performance is the ratio of actual operation time to planned operating time, and accounts for speed loss. Machine Ideal cycle time is the minimum cycle time that the process can be expected to achieve under optimal conditions for a given part. Therefore when it is multiplied by total pieces the result is actual operation time. Machine Ideal cycle time is sometimes called design cycle time or nameplate capacity. Since rate is the reciprocal of cycle time, Performance is calculated as in (2) [2], [4], [7], [11] - [13].

$$\text{Performance} = \frac{(\text{Machine Ideal Cycle Time} \times \text{Total Pieces Produced})}{\text{Planned Operation Time}} \quad (2)$$

### 4.3 Quality

Quality takes into account quality loss which accounts for produced pieces that do not meet quality standards including pieces that require rework. The remaining time is called actual productive time. The ultimate goal is to maximize actual productive time. Quality is the ratio of actual productive time (time for good pieces produced) to planned operation time (time for total pieces). Quality is calculated as in (3) [2], [4], [7], [11]

$$\text{Quality} = \frac{\text{Good Pieces Produced}}{\text{Total Pieces Produced}} \quad (3)$$

#### 4.4 Overall Equipment Effectiveness

Availability, performance and quality combined into one OEE score and this single number provides a complete measure of machine efficiency. OEE is the ratio of actual production time to planned production time. OEE is calculated as in (4) [2], [4], [7], [12] - [13].

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality} \quad (4)$$

### 5 Measuring man power utilization

Sufficient production data is used in assisting operators especially in informing operator of their performance to date. Apart from that the data will also be able to guide the operator to maintain a consistent pace throughout the day and this will result in a better implementation of work morale among the employees. Once the operators have been tuned to react according to the management's set goals, this will automatically eliminate wasted time and hence produce more units per hour.

Essentially human capitalize nearly all the process on the industrial shop floor from the management to the layman (operators). Visualizing an industrial environment which includes a big number of people from various departments working together in meeting the set goals. When it comes to unmet goals, fingers are not to be pointed to an individual, whereby the supporting department also has their contribution on this matter. Monitoring of supporting departments in industries is another factor which should be taken in account for improving the production performance. By knowing their performance, the departments can be aware of the problems arising and counter measures can be taken to further improve their working quality. The supporting departments play an equal role as the production team in order to maintain the consistence pace of work on the industrial shop floor. There are three basic departments in industries which are the total quality management (TQM), production planning and control (PPC), maintenance and adding to that is others (vendors) also is added to the list as one of the major contribution on production interruption.

The TQM involves all the quality matters of the parts produced. When a machine is not calibrated base on specification or irregular inspection on the parts produced it will result in higher rate of rejection or parts near to perfect. Rejection is a

restricted word in industries because they will lead towards cost factor. Rejection can be categorized into two which is reject rework and this usually falls on parts that can't be repaired to maintain base on the customer's specification. The second reject is reject scrap which is total lost part and these parts are waste materials. Such facts will affect the output when it comes to tight end.

The PPC involves in planning the production process and supplies base on orders. When parts are not ordered base on demand then the production process will be effected when the raw parts are running short. The most crucial task of this department is to plan the production process base on daily targets. Wise production line management is important for this team to sustain.

The maintenance department is responsible for all technical matters on the industrial shop floor. Preventive maintenance is the important task for this department whereby the machine has to be checked on timely basis to ensure optimum performance of the machines. This is to reduce machine parts replacements. Apart from that the most critical matter on industries is safety. When a machine is out of shape, the higher chances for the human who operates it will be injured.

#### 5.1 Operators or workers utilization

Operators or workers utilization falls under man power utilization which includes any factors that cause the production process to operate at less then the maximum possible speed base on the time study or cycle time. The major factor on measuring the performance of human workers is the operator's inefficiency. Base on fig 6 the man power utilization is measured from the duration of actual operation time. For manual process lines, man power utilization is the ratio of actual production output to target production output as in (5).

$$\text{Man Power Utilization} = \frac{\text{Actual Production Output}}{\text{Target Production Output}} \quad (5)$$

For semi automated process lines, man power utilization is slightly different from (5) where by the operators ideal cycle time is the minimum cycle time that the process can be expected to achieve under optimal conditions for a given process. This is due to the combination of humans and machine to perform a specific task on the same work station. Man power utilization should be separated from the machine

performance for easy analysis. Therefore when it is multiplied by total pieces produced the result is actual operation time. Man power utilization for semi automated process lines is calculated as in (6).

$$\text{Man Power Utilization} = \frac{(\text{Operators Ideal Cycle Time} \times \text{Total Pieces Produced})}{\text{Actual Operation Time} - (\text{Machine Ideal Cycle Time} \times \text{Total Pieces Produced})} \quad (6)$$

## 5.2 Performance of supporting department

Supporting departments in industrial are divided into 3 basic departments and the performance should be measured individually before analyses are carried out. Performance of the supporting department is calculated as in (7) where by the down time for a specific department is subtracted from planned operation time and divided by planned operation time. This formula is a common formula for all types of process lines in industries.

$$\text{Performance of Supporting Department} = \frac{(\text{Planned Operation Time} - \text{Down Time})}{\text{Planned Operation Time}} \quad (7)$$

# 6 Sample data

## 6.1 Data on machineries

Data distributed in table 1 shows the performance of a machine. By inserting these data into formulae discussed in the previous section. Detail breakdowns affecting the machine can be visualized. Analyzing the data shown in table 1 clearly indicates that the overall equipment effectiveness of the machine used as the test bed is at 20.75%. From table 1, the machines availability is at 83.96% followed by quality of parts produced is at 57.89 % and the worst is on the machine performance at 42.70 %. Base on the collected data, it is very clear that none of the factors have complied the set targets. This implied that the true performance of the machine is at a very poor condition and if necessary measures are taken by the responsible personnel, then the improvement could be seen by the management. Stage by stage all the figures in this factors can be corrected to improve efficiency of the machine. Once the factor of OEE is broken down into categories, analysis is simplified by tracing the crucial factor affecting the machine.

OEE Factor	Actual OEE	Target OEE
Availability	83.96 %	85.00 %
Performance	42.70 %	90.00 %
Quality	57.89 %	95.00 %
Overall OEE	20.75 %	73.00 %

**Table 1 Data on machine overall efficiency**

## 6.2 Data on man power

Table 2 shows the actual performance of the operator on a certain shift is 22.35%. Based on this, the management could optimize their human capital. From the data collected in table 2, the management can easily trace the major contributor for unmet targets. The management can also differentiate table 1 with table 2 for more details analysis to identify the root cause of the unmet targets.

Factor	Calculated Data	Performance
Man Power Utilization	$(19 \times 3) / 445 - (19 \times 10)$	22.35 %

**Table 2 Data on man power utilization**

## 6.3 Data on the supporting departments

Table 3 shows the individual performance of all the supporting departments involved in the production process on a particular shift. The actual performance of the production planning and control departments and others is at 100%. The actual performance of the maintenance department is at 98.11% and the highest down time contributor is the total quality management department which is at 85.85%. Such valuable information in table 3, will be sufficient for the management to attempt on rational actions to ensure improvements can be seen on the process line.

Department	Calculated Data	Performance
Total Quality Management	$530 - 75 / 530$	85.85 %
Production Planning & Control	$530 - 0 / 530$	100.00 %
Others	$530 - 0 / 530$	100.00 %
Maintenance	$530 - 10 / 530$	98.11 %

**Table 3 Data on the supporting departments**

After analyzing each factors, the process line operator is clearly the major contributor towards the unmet target. The second crucial factor is the machine on the process line which is far below the bench mark set by the management on each factors under OEE which also contributes towards the unmet target. The rejection rate of the parts produced is also high and this indicates that the machine on the work station is not properly calibrated or the standard operating procedure (SOP) is not complied by the operator.

Understanding each of these factors helps the management to improve factors affecting unmet targets. Such data should also assist management in optimizing their usage of man power and machines efficiently. Actions should be taken to remedy the faults of each section in order to meet a better target and yield.

## 7 Conclusion

Relevant and valuable production data helps the management to efficiently monitor the workers. Information on human capital can optimize the true capacity of the workers performance. The awareness of OEE is essential for industries when it comes to decision making. The simple metrics of the OEE brings to light all the valuable information required by the management. The Production data should be very well interpreted and fully utilized in order to optimize available resources within the industrial sector. This will reduce wastage and increase the production yield. By taking these necessary steps industries can improve and maintain more efficient production lines.

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