Operations Management: Using Overall Equipment Effectiveness Metric for Process Improvement and a Case Study

Thomas Seubert
MES Project Manager, Larsen & Toubro Infotech Ltd.
Roseville, MI USA
Thomas.Seubert@lntinfotech.com

Abstract

Recently there has been renewed interest to monitoring manufacturing production efficiencies in real time. This has become interest in understanding more about Overall Equipment effectiveness (OEE) and the trending of Cycle times. This paper explores the recent development of this topic and provides a Case study. These details are referenced in the recently released book, "MES: An Operations Management Approach", available through the International Society of Automation.

Keywords
MES, MOM, Operations, Equipment

1. Introduction

Overall Equipment Effectiveness (OEE) is a metric used by manufacturers to determine to overall health of the manufacturing process. OEE is calculated by:

OEE = (Equipment Availability) * (Production Performance) * (First Time Quality Rate) [i.e. First Time Quality FTQ]

In which:

$$\text{Equipment Availability} = \frac{\text{(Scheduled Production Time)} - \text{(Equipment Down Time)}}{\text{Scheduled Production Time}}$$

$$\text{Production Performance} = \frac{\text{Actual Jobs per Hour}}{\text{Target Jobs per Hour}}$$

(Note: could be Jobs per Shift, or Jobs per Day, etc.)

$$\text{First Pass Quality Rate} = \frac{\text{Actual Good Product}}{\text{Total Product Produced}}$$

(Note: Good Product refers to all product that is not scrapped or does not need to go into repair or rework, in other words, products that are acceptable from performing each operation only once, with no quality dispositions)

In Table 1 is an example:

Table 1: OEE Example

OEE Calculation per Hour									
Shift = 8 hours									
Scheduled JPH	60								
Hour	Downtime	Availability	Scheduled JPH	Actual JPH	Performance	Actual Quality	Quality Rate	OEE	Reasons
1	15	0.750	60	40	0.667	39	0.975	0.488	Equipment Down for Repair
2	0	1.000	60	61	1.017	58	0.951	0.967	
3	0	1.000	45	46	1.022	45	0.978	1.000	15 minute break
4	0	1.000	60	62	1.033	62	1.000	1.033	
5	0	1.000	30	30	1.000	29	0.967	0.967	30 minute lunch
6	0	1.000	60	55	0.917	55	1.000	0.917	
7	0	1.000	45	42	0.933	41	0.976	0.911	15 minute break
8	0	1.000	60	58	0.967	57	0.983	0.950	
Shift Total:	15	0.969	420	394	0.938	386	0.980	0.890	

One of the items that need to be understood is that the actual OEE number is for general information. In most manufacturing plants, there are separate teams that review each of the 3 metrics that make up OEE: the Maintenance team looks that the Equipment Availability, the Production team looks at the Production Performance, and the Quality looks at the First Pass Quality Rate.

Let us take a look at the Equipment Availability metric. Typically, it is the Maintenance team at the plant that responds to negative equipment downtime events. Equipment Availability is not just dependent on if the equipment is down for repair, it also includes any time to prep the equipment between production jobs, which may include specific tooling changes, preventive maintenance task like sensor calibration checks, and others. Any equipment downtime events should be trended and reviewed by the proper plant personnel to see if efficiencies can be determined to improve this area.

Let us now take a look at the Production Performance metric. The production team usually are the ones who review these so that they understand the metrics that are not part of scheduled production. For example, tooling changeover time is not part of production performance, because production cannot be scheduled for that time. This may skew the Production Performance metric. Cycle times are actually not part of OEE but a separate metric. What is typically part of production performance are the following:

- Operator not sure what the process is for that workstation
- Availability of the proper parts for assembly in that workstation
- Equipment health: the equipment may not be faults but may be running slower than it should

Cycle Time

To explain this further, we need to explore a real-world example. Using a five station production line, it is determined that in order to support the production schedule, Production must produce 60 units of a product per hour (also known *as jobs per hour—JPH*), which means a unit is coming off the line, one every minute. This means that the product can only stay in each station for 60 seconds, and this time must include time to complete the work required in each station and any reset or setup time to prep for the next cycle. Given this set of requirements, the following table is created for a specific cycle.

Table 2. Cycle Times Table Example

Station	Work Time	Prep Time	Total Time	Actual Work Time	Actual Prep Time	Actual Totals
1	45	15	60	45	14	**59**
2	40	10	50	40	10	**50**
3	55	0	55	56	0	**56**
4	50	10	60	55	10	**65**
5	45	10	55	45	10	**55**

For each cycle, the actuals are monitored and trended. Cycle times at or under the expectation will show up green. While 5 seconds over cycle, which it would show up red, for Station 4 does not sound like a lot, if this actual cycle time repeats itself, it does represent a production issue, because if it is 5 seconds over cycle for each cycle, after 12 jobs the throughput will drop by 1 job (5 □ 12 = 60). This will cause an inability to support the production schedule. Such an event will require additional research, for the root cause may be equipment related, or operator related. Perhaps a new operator has taken over that station and he/she is taking 5 additional seconds to complete their task as the operator ramps up to speed. Or, the station is overloaded with its work definition in which the Industrial engineering team will need to come int to help to adjust the defined work.

Let us now review the First Pass Quality Rate, or sometime called First Time Quality or FTQ. This is the metric used to show how much end product had to go back for either rework or the end product had to be scrapped due to high rework costs. Each production unit that goes back to rework or is scrapped represents an inefficiency in the manufacturing system and produces extra costs.

Case Study

So to demonstrate this, here is an example of a OEE Improvement case study: We start with a production line where each part that is produced is sold for $1000. The average cost to repair the part is $500. So OEE data is collected and the following trend has been seen:

Table 3: OEE Comparison

If per hour		
	Current Ave	**Goal**
Availability	0.9	0.95
Performance	0.9	0.95
FTQ	0.9	0.95
OEE	0.729	0.857375

So if the plant wants to focus on improving just the Production Performance and FTQ to 0.95 and the production rate is 60 units (or jobs) per hour:

Table 4: OEE Cost analysis

Then			
	JPH	**Revenue**	**Comment**
Performance	increases by 3 jph	Increases by $3000	
FTQ	increases by 3 jph	Increases by $1500	Due to non-repair of 3 jobs
Total		$4,500	

Given this, if the plant is running two 8 hour shifts then the daily revenue will improve by $72k. If there is an investment of $100k to bring the metrics up to 0.95, then the Return on Investment is less than 2 days.

Overall, the OEE and all supporting data needs to be organized in dashboards and reports such a way that the proper personnel can properly respond and evaluate for efficiency improvements.

Acknowledgements

The author would like to acknowledge his co-author of his book, Grant Vokey

References

Seubert, Thomas and Vokey, Grant, *MES: An Operations Management Approach,* International Society of Aotumation Press, Research Triangle Park, North Carolina, USA, 2020

Biography

Thomas Seubert is currently a Manufacturing Execution systems (MES) project manager and business analyst for Larsen & Toubro Infotech Ltd and his main client is American Axle. He has over 25 years' experience in MES starting as a Controls Engineer. He recently co-authored the book, MES: An Operations Management Approach" with Grant Vokey published by the International Society of Automation and has started consulting with different universities on the formation of classes on MES. Thomas has been participating with the IEOM for several conferences since September 2015 where he was one of the Keynote speakers at the conference in Orlando, Florida, USA.