

Overall Equipment Effectiveness (OEE)

Measuring and optimizing Throughput

Changeover.com

We change downtime to uptime

John R Henry

johnhenry@changeover.com 787-550-9650

The goals

- Maximize throughput or output
- Minimize inputs
 - Labor
 - Materials
 - Capital
 - Time
 - Waste
- The ratio of output to inputs is efficiency

Speed

- Packaging line speed is usually expressed in products per minute (ppm)
 - Sometimes in products per hour (pph) – Europe
- Definitions of low/high speed will vary with industry sector and are often a matter of opinion rather than a standard. Typical values are:
 - Low speed – Less than 100 ppm
 - Medium speed – 100-600 ppm
 - High speed – 600+ ppm

Speed \neq throughput

- Speed is usually expressed as the number of products produced when the line is running correctly.
 - Sometimes called instantaneous or snapshot speed
 - It does not account for downtime or rejected product
- Throughput must look at a longer time window. Typically hours, shifts or days.
 - Throughput can sometimes be half, or less, of speed

Measurement

- The first step in optimizing throughput is to understand and measure it
- “If you can’t measure it, you can’t control it”
 - Old accountant’s axiom
- “If you don’t measure it, you won’t control it.”
 - John R Henry

What you measure is what you'll get

- What is measured is critical
 - If the measurement is for speed, throughput can suffer
 - If the measurement is for throughput, large quantities of bad product may be produced.
 - If the measurement is for quality, good product may be produced in low volume
- Performance metrics must be carefully chosen
- Multiple metrics are usually necessary
 - Avoid data overload
- Under OEE all time, 27/7/365 must be accounted for
 - Under Vorne, all time is assigned to a shift and to a job (A/K/A Lot or Batch)
 - All time is recorded must be assigned to running, down (or setup) or standby. No exceptions

Overall Equipment Effectiveness (OEE)

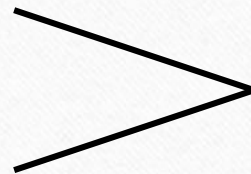
- Overall Equipment Effectiveness combines 3 key metrics of line performance into a single value
 - Availability
 - Performance
 - Quality
- OEE allows comparison of line performance
 - Over time
 - Between shifts
 - Between products
 - Between lines
 - Between plants
 - Between industries

Efficiency vs effectiveness

- Efficiency is the ratio of output to input.
- Effectiveness is getting the right things done.

OEE metric - Availability

- Availability is the ratio of available time to scheduled time
- Scheduled time is all time the line is normally expected to be operating
- Does not include:
 - scheduled breaks
 - 2nd or 3rd shifts in a 1 shift operation
 - NOTE: Some companies may have different definitions and different types of OEE
- Does include:
 - Changeover time
 - Repair time
 - Maintenance time



When done during normal
production hours

Availability example

- A line has 480 minutes/day (1 shift). The line normally stops for two 15 minute and one 30 minute breaks.
- Scheduled time = $480 - (15 + 15 + 30) = 420$ minutes
- The line experiences 45 minutes of downtime
- Available time = $420 - 45 = 375$ minutes

- Availability = $375 / 420 = 89\%$

OEE metric - Performance

- Performance is the ratio of actual line speed to rated or theoretical line speed
- Theoretical speed is determined by:
 - Manufacturer's specifications or nameplate data
 - Actual achievable and sustainable speed
 - Validated speed

Performance example

- Performance example:
 - A line has a rated speed of 300PPM and an availability of 375 minutes
 - Theoretical production is $300 \times 375 = 112,500$ units
 - Actual production is 90,000
 - Performance is $90,000/112,500 = 80\%$

NOTE: Performance does not penalize for rejects

OEE metric - Quality

- Quality is the ratio of good products produced to total products started
- Quality definitions
 - Traditional: Within specifications
 - Better: Absence of variation
 - OEE: Any product that is not rejected (“Bad” product includes rework and false rejects)

Quality example

- Quality example:
 - The line begins 90,000 products during the shift
 - 85,000 good products are produced, 5,000 products are rejected
 - $\text{Quality} = 85,000 / 90,000 = 94\%$

OEE defined

- Overall Equipment Efficiency is the product of Availability x Performance x Quality (%)
- $OEE = A \times P \times Q$

OEE calculation

- OEE from examples:
 - Availability = 89%
 - Performance = 90%
 - Quality = 94%
- $OEE = 89\% \times 90\% \times 94\% = 75\%$

OEE Worksheet

	A	B	C	D	E	F	G
2							
3							
4	Production Data						
5	Shift Length	8	Hours =	480	Minutes		
6	Short Breaks	2	Breaks @	15	Minutes Each =	30	Minutes Total
7	Meal Break	1	Breaks @	30	Minutes Each =	30	Minutes Total
8	Down Time	45	Minutes				
9	Ideal Run Rate	300	PPM (Pieces Per Minute)				
10	Total Pieces	90,000	Pieces				
11	Reject Pieces	5,000	Pieces				
12							
13							
14	Support Variable	Calculation				Result	
15	Planned Production Time	Shift Length - Breaks				420	Minutes
16	Operating Time	Planned Production Time - Down Time				375	Minutes
17	Good Pieces	Total Pieces - Reject Pieces				85,000	Pieces
18							
19							
20	OEE Factor	Calculation				My OEE%	
21	Availability	Operating Time / Planned Production Time				89.29%	
22	Performance	(Total Pieces / Operation Time) / Ideal Run Rate				80.00%	
23	Quality	Good Pieces / Total Pieces				94.44%	
24	Overall OEE	Availability x Performance x Quality				67.46%	
25							
26							
27	OEE Factor	World Class					
28	Availability	90.00%		89.29%			
29	Performance	95.00%		80.00%			
30	Quality	99.90%		94.44%			
31	Overall OEE	85.00%		67.46%			
32							

OEE monitor



An LED display showing OEE monitor data. The display is divided into three columns. The first column shows production statistics: Good (17,667), Reject (178), Rate (3,076), and Cycle (1.17). The second column shows downtime statistics: Run (5:48), Down (0:59), Setup (0:22), and Stdbby. (0:50). The third column shows OEE components: OEE (73%), Avail. (80.1%), Perf. (90.1%), and Quality (99%).

Good	17,667	Run	5:48	OEE	73%
Reject	178	Down	0:59	Avail.	80.1%
Rate	3,076	Setup	0:22	Perf.	90.1%
Cycle	1.17	Stdbby.	0:50	Quality	99%

- Sensors are mounted at infeed and discharge of line
 - Infeed sensor counts products started
 - Discharge sensor counts products completed i.e.; less rejects
 - Internal PLC integrates discharge count with time to compute rate
- LED panel displays production information
- Internal PLC provides additional KPIs that can be viewed or downloaded
 - KPI = Key Production Indicator

Factors affecting availability

- Factors affecting availability are long (>3 minutes) that can be recorded and include:
 - Lack of documentation such as batch records and line clearance
 - Lack of qualified personnel
 - Lack of materials, components & product
 - Lack of **GOOD** materials, components & product
 - Machine breakdowns
 - Plant breakdowns eg; loss of electrical power or other utilities
 - Cleanup & Setup (Changeover less Startup)
 - Product/package design

Setup/changeover time

- Setup (Vorne) or Changeover time is the total elapsed time from the last good product at normal speed and efficiency of the previous production lot to the first good product at normal speed and efficiency of the next production lot
 - Good product to good product
- Typical changeover activities include
 - Waiting
 - Documentation
 - Disassembly
 - Cleaning
 - Quality inspection
 - Etc
- Setup time is a form of downtime and normally counts against availability
 - It is usually a significant availability loss
 - It can usually be reduced significantly

Downtime

- Under OEE the line can be in one of 3 states
- Running – Product is being produced
- Down – No product is being produced. The reason for no product being produced does not matter.
 - Time spent on inspection, rework and similar activities count as downtime
 - Setup/Changeover is a special case of downtime
- Standby – Time when the line is not scheduled to produce, is the only exception to the run/down rule

Standby time

- Standby time is time that the process is not scheduled to be running
 - Breaks
 - Unscheduled shifts
 - Weekends and holidays
- Standby time does not count against OEE
- Standby time represents unused capacity

Factors affecting performance

- Factors affecting performance are short in duration (>3minutes) and generally not recorded
 - Minor adjustment
 - Machine jams including micro-stoppages
 - Defective product, components or materials
 - Marginal product requiring slower machine speed
 - End of production slowdown
 - Startup
 - Operator error
 - Machine wear
 - Contamination & spills
 - Replenishment

Slow cycles and small stops

- “Slow cycle” is a cycle that takes longer than normal to complete. Normally, about 200%.
- “Small stop” is a stoppage that is longer than a slow cycle but not long enough to trigger a downtime event.

Factors affecting quality

- Factors affecting quality result in rejected product and include:
 - Improper changeover (Cleanup & Setup)
 - Improper machine adjustment
 - Operator error
 - Product/package design
 - Machine design
 - Machine wear
 - Inspection system errors (False rejects)

Improving OEE

- Measurement of OEE and other metrics
 - **USE THE DATA to determine improvement opportunities!**
- Lean changeover
- Effective maintenance
 - Predictive/preventive
 - Troubleshooting
 - Repair
- Product & package quality “Absence of variation”
- Personnel training
- Documented standard operating procedures (SOPs) and checklists
- Attention to detail
- **IMPLEMENTATION!!!**

Key success factors

- Attitude
 - Requires management support: If management doesn't think it is important, the plant won't think it is important
 - Support includes money, time, training and other resources
- Involvement
 - OEE improvement requires support from all departments at all levels
 - Must become part of the plant culture
 - WIIFM? Clearly explain the benefits of OEE improvement to the associates, especially on the floor
- Recognition
 - Publish program results and recognize participants

Getting started

- Develop an OEE system
 - Involve the plant, down to the line level
- Implement the system
- Track trends
 - Emphasize what is done right
 - Correct what is done wrong

Do it now!

Resources

- OEE Handbook, worksheet and other resources are available for download at www.oee.com
- Information on Lean Changeover is available at www.changeover.com
- Contact johnhenry@changeover.com for more info

