

Welcome to the class....

Maintenance Management (FRSI 2153)

Lecture: 5 - 6 ELIMINATE WASTE & OVERALL EQUIPMENT EFFICIENCY (OEE)

Lecturer:

Assoc. Prof. Dr. Astuty Amrin (astuty@utm.my)

Dr. Roslina Mohammad (mroslina.kl@utm.my)

Lecture 5

ELIMINATE WASTE



What Exactly is Waste?

- The simplest way to describe waste is as **“Something that adds NO Value.”** Our customers would not be happy to pay for any action that we take that does not add value to what they actually want and nor should we be.
- These wastes are included within the **cost of our products**, either inflating the price we pay or reducing the profit of the company.

Why Remove Waste?

- Waste increase products and services **PRICE** due to unnecessary costs.
- Removing all elements of waste from processes reduce cost and increase profit.
- Waste has a major impact on customer's satisfaction with ones products and services. Customers want on time delivery, perfect quality and at the right price.

Major Losses in Production Line and Organization

- Failure losses – Breakdown losses
- Setup / adjustment losses
- Cutting blade loss
- Start up loss
- Minor stoppage / Idling loss.
- Speed loss - operating at low speed
- Defect / rework loss
- Management loss
- Operating motion loss
- Line organization loss
- Logistic loss
- Measurement and adjustment loss
- Energy loss
- Die, jig and tool breakage loss
- Yield loss
- Scheduled downtime loss

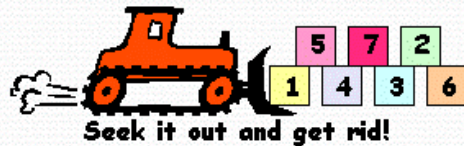
7 Wastes of Lean Manufacturing

- The seven wastes (*Muda*) of Lean Manufacturing are what a company should aim to remove from its processes by removing the causes of *Mura* (unevenness) and *Muri* (overburden) as well as tackling *Muda* directly.
- The Seven Wastes of Lean Manufacturing are;
 - a. Transport**
 - b. Inventory**
 - c. Motion**
 - d. Waiting**
 - e. Over-Processing**
 - f. Overproduction**
 - g. Defects**

7 Wastes of Lean Manufacturing

The 7 Wastes

MUDA is the Japanese word for WASTE.



Over Processing



Processing beyond the standard required by the customer.

Rework

Non right first time. Repetition or correction of a process.

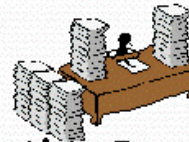


Transportation



Unnecessary movement of people or parts between processes.

Overproduction



To produce sooner, faster or in greater quantities than customer demand.

Inventory



Raw material, work in progress or finished goods which is not having value added to it.

Waiting



People or parts that wait for a work cycle to be completed.

Motion



Unnecessary movement of people, parts or machines within a process.

Copyright TE 2010

LECTURE 6

Measuring Overall Equipment Effectiveness (OEE)



Introduction to OEE

- **Overall Equipment Effectiveness (OEE)** is a quantitative way of measuring how well a standalone or a flow-line production system operates in making good product relative to what the system could make if it operated perfectly, 100% of the scheduled time *based on specific products and processes*.
- OEE is a **Key Benchmarking metric** used to define the Throughput Gap between Current State and ‘World Class’ for your system.
 - “World Class” is considered to be 85%.
 - Good companies run in the 95+% range.
 - Many manufacturers run in the 35% to 45% range.

Introduction

- The OEE Industry Standard gives a guideline in order to find ALL potential losses in effectiveness.
 - An average machine in an average factory runs about 35 to 45% OEE.
 - So it is losing 55 to 65% capacity while
 - not running,
 - running at reduced speed or
 - producing parts out of spec.
-
- How come then, that the average reported numbers are way over 80%?
 - To really reveal the hidden machines in your factory, ALL Losses need to be defined and visualized.



Why use OEE?

- Reduce Unplanned Downtime
- Reduce Setup and Changeover Times
- Better Management of Resource Allocation, Planning and Scheduling
- Operator Productivity Increases
- Efficiency with Automated Data Collection
- Better Root Cause Analysis
- Improve Quality, Minimize Rejects
- Identify Bottlenecks and Constraints
- Improve On-Time Delivery
- Manage Operations Pre-emptively & Proactively
- Measurably Improve Profitability
- OEE is the visual metric of Total Productive Manufacturing



What are the benefits of OEE?

FOCUS

→ Highlight priorities for change.

SIMPLICITY

→ Even complex processes can be measured.

FEEDBACK

→ Before and after change.

BENCHMARKING

→ Objective comparisons.

TARGET SETTING

→ Setting achievable goals.

OEE Formula

- **OVERALL EQUIPMENT EFFECTIVENESS % =**
AVAILABILITY x PERFORMANCE x QUALITY
- Shows group or plant output as a percentage of maximum capacity.

World Class = 85% (= 95% x 95% x 95%)

OEE Formula

Availability %

Percentage of scheduled time that the operation is actually operating.

$$\text{Availability \%} = \text{Run Time} / \text{Scheduled Time}$$

Performance %

Speed at which the Work Center runs as a percentage of its designed speed or ideal cycle time or most often considered the “Standard”.

$$\text{Performance \%} = (\text{Parts Made} \times \text{Standard}) / \text{Run Time}$$

Quality %

Good Units produced as a percentage of the Total Units Started.

$$\text{Quality \%} = \text{Good Units} / \text{Units Started}$$

What does that mean?

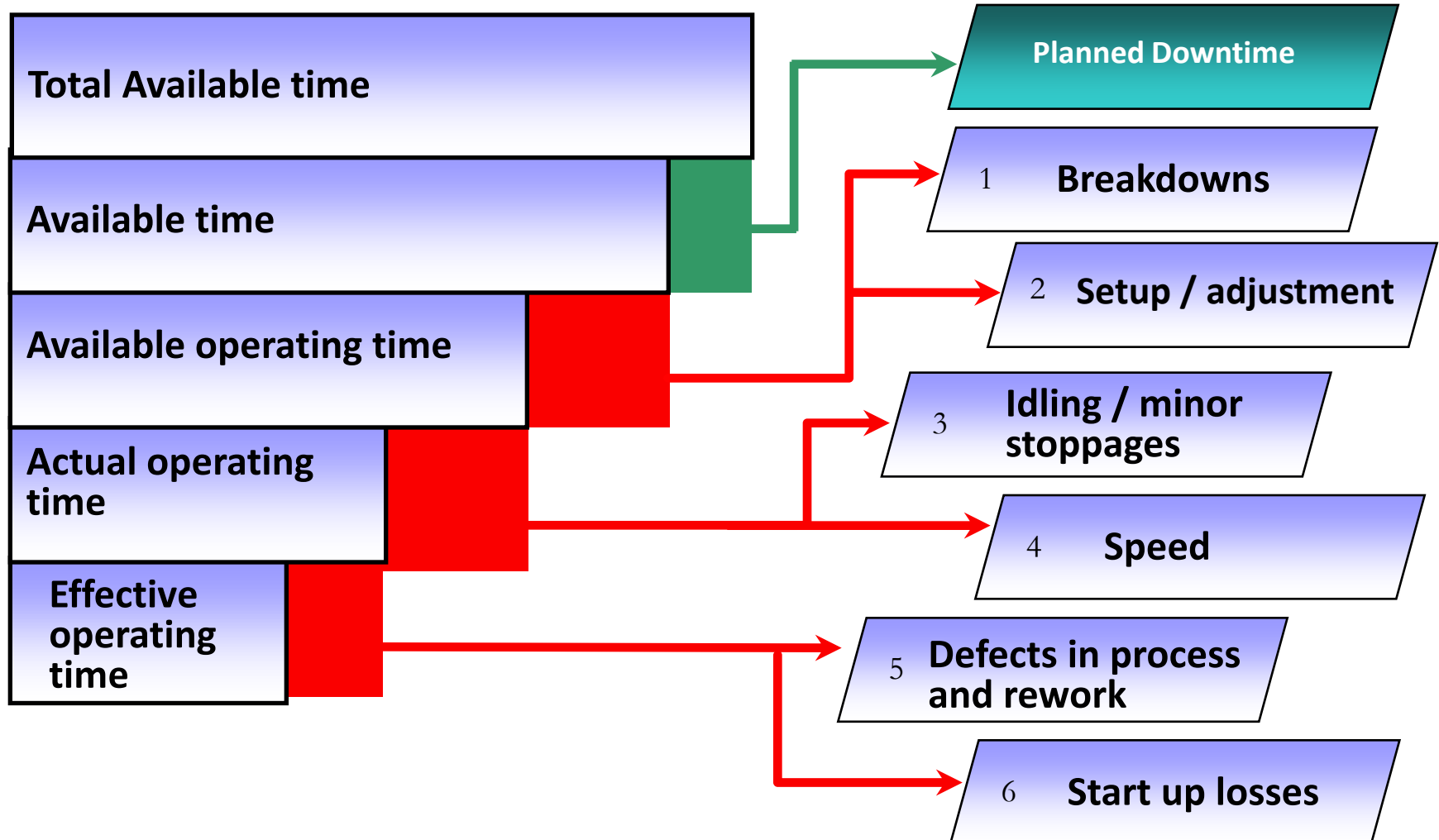
- OEE is a Key Performance Indicator (KPI) that can measure the impact of change on a process caused by eliminating process, or equipment losses
- OEE is used to measure the performance of equipment and the process - not the operator.
- Make visible specific machine status for everyone.



OEE and the Six Big Losses

Equipment

Six Big Losses



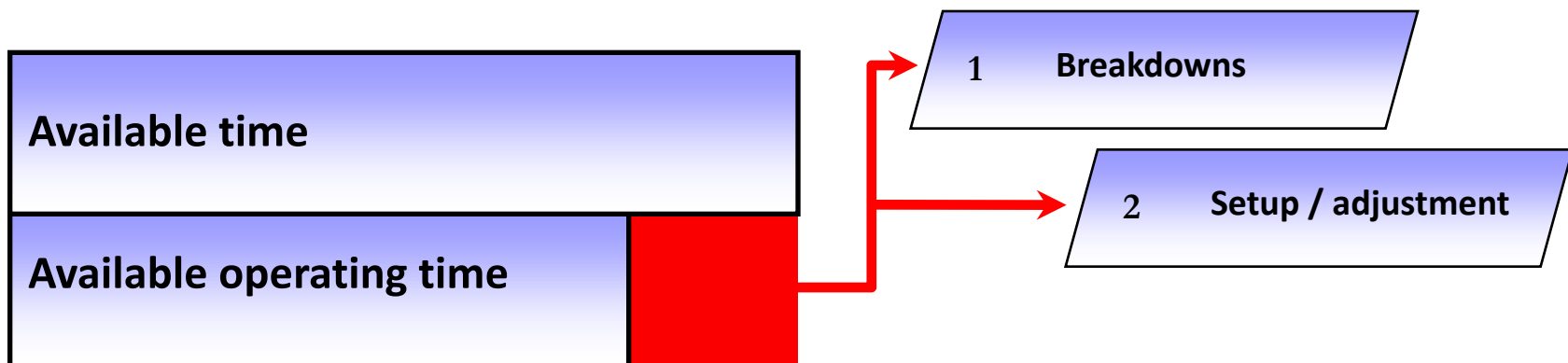
Availability

$$\text{AVAILABILITY} = \frac{\text{AVAILABLE TIME} - \text{UNPLANNED DOWNTIME}}{\text{AVAILABLE TIME}} \times 100\%$$

Where;

Available Time = Total Available Time – Planned Downtime*

**Note :- Planned Downtime could be PM, no scheduled work, breaks, etc.*



Planned vs. Unplanned Downtime

Planned

- Excess capacity.
- Planned breaks.
- Planned Maintenance.
- Communications briefs / team meetings.

Unplanned (Losses)

- Breakdowns.
- Set Ups and Adjustments.
- Late deliveries (material).
- Operator availability.

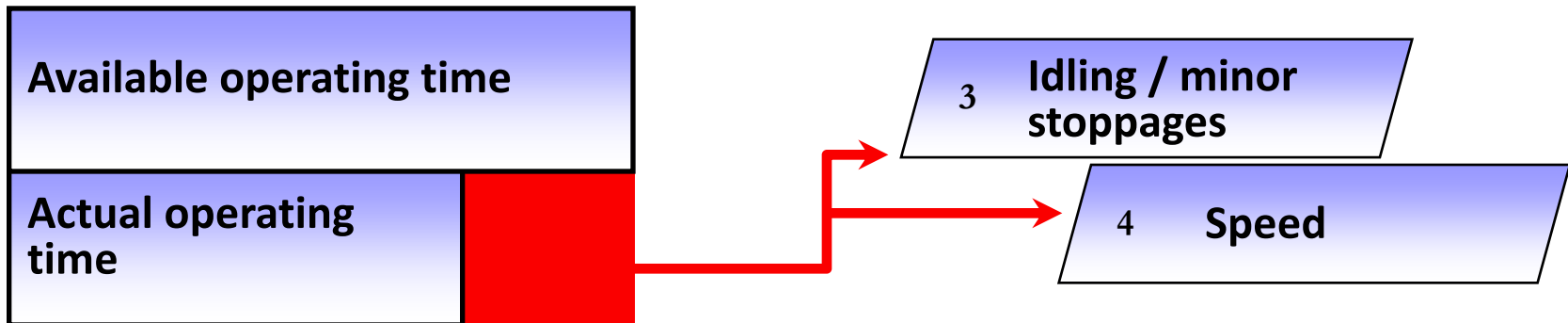
Note :

Planned time such as breaks, meetings and maintenance can be considered as losses (useful for encouraging ideas on how to minimise their disruption) as long as a consistent approach is taken.

Productivity

$$\text{PRODUCTIVITY} = \frac{\text{IDEAL CYCLE TIME} \times \text{ACTUAL OUTPUT}^*}{\text{AVAILABLE OPERATING TIME}} \times 100\%$$

**Note :- Actual Output is the Quantity of good & bad parts*



Operating Speed vs. Productivity

Operating Speed Rate

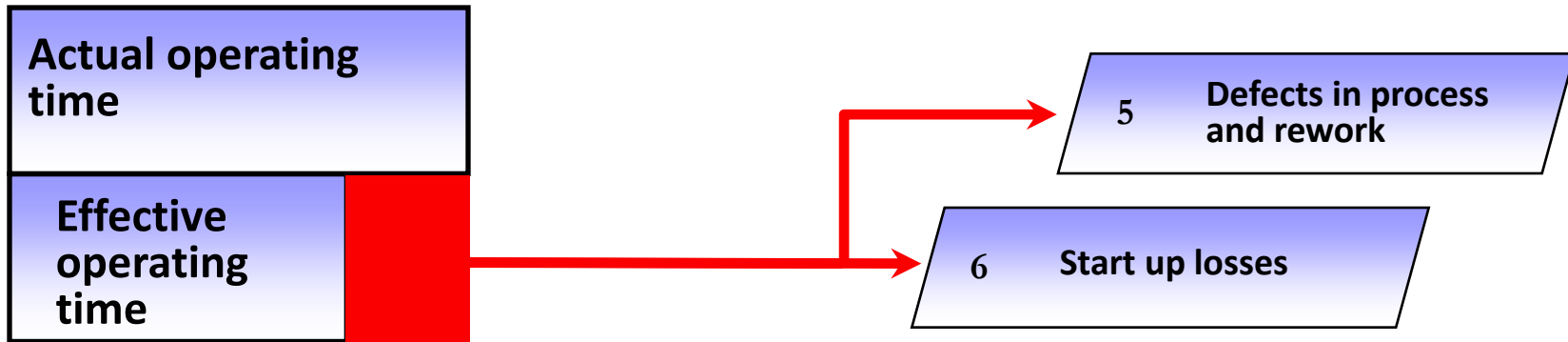
→ The % of actual cycle time against ideal cycle time.

Productivity

→ The Operating Speed Rate factored with interruptions to constant processing, i.e. idling and minor stoppages.

Quality

$$\text{QUALITY} = \frac{\text{PARTS MADE} - \text{DEFECT QUANTITY}}{\text{PARTS MADE}} \times 100\%$$



Processed vs. Defect Quantity

Parts Made

→ The total quantity of parts produced in the available time

Defect Quantity

→ The quantity of parts that did not meet the required standard (including rework) in the available time

Data Collection for OEE

- OEE is a measure of the equipment or process, not the operators productivity.
- Keep it simple.
- Ensure the process of measuring and applying OEE involves the people who use the equipment.
- Make data collection second nature not a hindrance.
- Understand the process.
- Obtain the data on fixed frequency.
- Snap shot v continuous.
- Units of time (1 min, 10 mins, 30 mins, etc.).
- Automatic or manual data collection.
- Ownership.
- Partnership – those completing sheets and those collecting/collating.
- Regular communication of results.
- Response to trends, peaks and troughs.

Data Collection

Example: Three Hourly Data Sheet

Machine No.		No. operators		A B C D		Day / Night		Date /					
Hour of the Day	Tape No.	Machine Downtime										Total Downtime every 3 hrs	
		Programme change inc. test piece	Tooling problem - please specify cause	Machine problem - please specify cause	Cartridge Change	Calibration	Meetings (inc. team brief)	Clean up & SAP up	Post / fixture problem	Slaving Up	Other - please specify cause		Specified causes of machine downtime
7-8													
8-9													
9-10													
10-11													
11-12													
12-1													
1-2													
2-3													
3-4													
4-5													
5-6													
6-7													
TOTAL													
Hand Over Notes:													

Data Analysis

AVAILABILITY

Gross Time

	(in minutes)
--	--------------

A

Planned Down Time

	(in minutes)
--	--------------

B

Net Available Time

	(in minutes)
--	--------------

$C = A - B$

Non planned stoppages

	(in minutes)
--	--------------

D

Operating Time

	(in minutes)
--	--------------

$E = C - D$

AVAILABILITY

--

$F = E / C$

PRODUCTIVITY

Output

--

G

Standard Cycle time

	(mins/ unit)
--	--------------

H

PRODUCTIVITY

--

$I = (H \times G) / E$

QUALITY

Defect Quantity

--

J

QUALITY

--

$K = (G - J) / G$

Example 1

A medium volume manufacturing facility with a capacity of producing 2 parts/minute actually produced 800 parts in a planned running 2 shifts of 8 hours each. It had breaks and scheduled maintenance for 40 minutes and also faced 40 minutes breakdowns and 1 hour 20 minutes for changeover and adjustment. Number of rejects and re-works were 10 and 6 parts respectively. Calculate its overall effectiveness.

Planned production time = 2 (shifts) x 8 hrs. = 960 minutes

Available time = 960-40 (scheduled maintenance) = 920 min.

Unplanned-time = 40 (Breakdowns) + 80 (Changeover & adjustment) = 120 min.

$$\text{Availability \%} = \frac{\text{Available time} - \text{Down time}}{\text{Available time}} \times 100 = \frac{920 - 120 \text{ min.}}{920} \times 100 = \mathbf{87\%}$$

Example 1 - continue

$$\begin{aligned}\text{Performance \%} &= \frac{\text{Quantity produced}}{\text{Time run} \times \text{Capacity/given time}} \times 100 = \frac{800}{(920-120) \times 2} \times 100 \\ &= 50\%\end{aligned}$$

$$\begin{aligned}\text{Quality \%} &= \frac{\text{Amount produced} - \text{Amount defects} - \text{Amount rework}}{\text{Amount produced}} \times 100 \\ &= \frac{800 - 10 - 6}{800} \times 100 = 98\%\end{aligned}$$

$$\text{Overall effectiveness (OEE)} = 0.87 \times 0.5 \times 0.98 \times 100 = 42.6 \%$$

Example 2

A chemical plant was expected to run for 120 hours/week continuously with production capacity of 2400 metric tones /hour. At the end the week it produced 220,000 tones together with a waste of 3000 tones. It had 120 minutes breakdowns and 460 minutes changeover and adjustment. Calculate plant overall effectiveness.

Planned production time = 120 hrs/week = 7200 min.

For continuous production, breaks and scheduled maintenance = 0 min.

Therefore, loading time = 7200 - 0 = 7200 min.

Down-time = 120 (Breakdowns) + 460 (Changeover & adjustment) = 580 min.

$$\text{Availability \%} = \frac{\text{Loading time} - \text{Down time}}{\text{Loading time}} \times 100 = \frac{7200 - 580}{7200} \times 100 = \mathbf{92\%}$$

Example 2 - continue

$$\text{Performance \%} = \frac{\text{Quantity produced}}{\text{Time run} \times \text{Capacity}} \times 100 = \frac{220,000}{(6620) \times (2400/60)} \times 100$$
$$= 83\%$$

$$\text{Quality \%} = \frac{\text{Amount produced} - \text{Amount waste}}{\text{Amount produced}} \times 100$$
$$= \frac{220,000 - 3000}{220,000} \times 100 = 98.6\%$$

$$\text{Overall effectiveness} = 0.92 \times 0.83 \times 0.986 \times 100 = 75.3 \%$$

Example 3

A semi-automated assembly machine, assembles and welds automotive components for a single shift of 7.5 hours, 5 days a week; planned throughput = 150 units/hour; actual output = 2875 units/week.

The following **losses** are encountered during assembly:

1. Incorrect assembly causes the machine to stop and needs re-set on average 5 times/hr. where 1 unit and 2 minutes are lost. (This leads to performance loss due to minor stoppage and also quality loss)
2. Worn out electrodes are to be replaced once per week, it takes 1 hour when 30 units are scrapped => availability and quality losses

Example 3 - continue

3. Burst out cooling hose causes a machine breakdown once in a month and replacement takes 5 hours => availability loss
4. Misaligned fixture causes a loss of 220 units/ week => quality loss
5. For different size parts, fixtures to be removed and replaced and electrode position to be adjusted 3 times/week which takes 2.25 hours where 24 units are scrapped each time => availability and quality losses
6. Actuating cylinder sometimes sticks for 15 minutes/ day causing production delay which takes double cycle time => performance loss
7. Application of rust protective spray by operator stopping the machine at the start and end of the day takes 5 minutes each time => minor stoppages thereby performance loss
8. Limit switches corrode once in every 6 weeks stopping the machine and replacement takes 6 hours => availability loss.

Example 3 - continue

Calculation of all the losses:

$$\begin{aligned}\text{Availability losses} &= 1 \times 60 \text{ mins (No.2)} + \\ &\quad 5 \times 60/4 \text{ mins (Av No.3)} + \\ &\quad 2.25 \times 3 \times 60 \text{ mins (No.5)} + \\ &\quad 6 \times 60/6 \text{ mins (Av No.8)} \\ &= 600 \text{ minutes/week}\end{aligned}$$

$$\begin{aligned}\text{Performance losses} &= 2 \text{ mins} \times 5 \times 7.5 \times 5 (\text{No.1}) + \\ &\quad 15 \text{ mins} \times 5 (\text{No.6}) + 5 \text{ mins} \times 2 \times 5 (\text{No.7}) \\ &= 500 \text{ minutes / week.}\end{aligned}$$

$$\begin{aligned}\text{Quality losses} &= 1 \text{ unit} \times 5 \times 7.5 \times 5 (\text{No.1}) + \\ &\quad 30 \text{ units (No.2)} + 220 \text{ units (No.4)} + \\ &\quad 24 \text{ units} \times 3 (\text{No.5}) \\ &= 510 \text{ units/week}\end{aligned}$$

Example 3 - continue

Loading time = $7.5 \times 5 \times 60 = 2250$ minutes/week

$$\text{Availability \%} = \frac{2250 - 600}{2250} \times 100 = \mathbf{73\%}$$

$$\text{Performance \%} = \frac{1650 - 500}{1650} \times 100 = \mathbf{70\%}$$

OR

$$\text{Performance \%} = \frac{2875}{21650 / (60 \times 150)} \times 100 = \mathbf{70\%}$$

$$\text{Quality \%} = \frac{2875 - 510}{2875} \times 100 = \mathbf{82\%}$$

$$\text{Overall Machine Effectiveness (OME)} = 0.73 \times 0.70 \times 0.82 \times 100 = \mathbf{42\%}$$

Solution

# of breakdown	Frequency
0	$4/20 = 0.2$
1	$8/20 = 0.4$
2	$6/20 = 0.3$
3	$2/20 = 0.1$

Step 1

$$\begin{aligned}\text{Expected \# of breakdowns} &= \sum(\text{\# of breakdown}) \times (\text{frequency}) \\ &= (0)(0.2) + (1)(0.4) + (2)(0.3) + (3)(0.1) \\ &= 1.3 \text{ breakdown per month}\end{aligned}$$

Solution

Step 2

$$\begin{aligned}\text{Expected breakdown cost} &= (\text{expected \# of breakdown}) \times \\ &\quad (\text{cost per breakdown}) \\ &= (1.3) \times (300) \\ &= \text{RM390 per month}\end{aligned}$$