TOPIC 2 : WORK METHODS

2.1 Elemental breakdowns
2.2 Performance rating
2.3 Personal, fatigue, unavoidable delay allowances
2.4 Workload and line balancing
2.5 Machine and process studies
LEARNING OUTCOME

Upon successful completion of this topic, the student will be able to:-

1. Breakdown the elements
2. Calculate the fatigue factor, rating and the allowances.
3. Construct the workload and line balancing
WORK METHODS

Work Method is the way of job is being performed.

Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.

The scope of work method is not restricted to only manufacturing industries. This techniques can be applied effectively in service sector as well. It can be applied in offices, hospitals, banks and other service organization.
WORK METHODS

The areas to which work method can be applied successfully in manufacturing are:-

1. To improve work method and procedure.
2. To determine the best sequence of doing work.
3. To smoothen material flow with minimum of back tracking and to improve layout.
4. To improve the working conditions and hence to improve labour efficiency.
5. To reduce monotony in the work.
6. To improve plant utilisation and material utilisation.
7. Elimination of waste and unproductive operations.
8. To reduce the manufacturing costs through reducing cycle time of operations.
METHODS STUDY PROCEDURE

1. Select :- Work which can be studied with economic advantage
2. Record :- All facts about the job operation
3. Examine :- The facts critically (purpose, place, sequence, persons) seek alternatives, simplify, eliminate, combine or change
4. Develop :- A record of an improved method under prevailing condition re-examine and select best method
5. Define :- Method, procedure, layout, equipment working conditions, materials, quality instructions.
6. Install :- The improve method, plan arrange and implement
7. Maintain :- Verify at regular intervals that the improved is in use
The objective of work measurement system is to determine the time it should take an average, trained person to a task if he or she were doing under working conditions and working at normal pace.
Normal Time
The time required for an average, trained operator to perform a task under usual working conditions and working at normal pace.

Normal Pace
The pace of an average, trained and conscientious operator working over 8 hour day

Actual Time
The observed time required for an operator to perform a task
2.1 ELEMENTAL BREAKDOWN

Guides for the motion and operation breakdown to the elements

1. Contents of each element should be homogeneous as possible
2. Hand and machine times should be placed in different elements.
3. Each element should be a relatively constant or variable time value
4. Each element should be have a definite start and end point.
2.2 PERFORMANCE RATING

The rating is a systematic attempt to relate the observed performance to the expected performance. This rating is depend on skill qualification, method, condition and pace.

The rating involves consideration of several rules:

1. All raters must practice fairness.
2. All raters must use the basic reference
3. All raters must be consistent and accurate in their judgement
4. Rating must be concrete and based on some observable
5. Management and labor must understand and agree to the basis rating
2.2 PERFORMANCE RATING (cont.)

6. Rating judgement must involve the determination of the effect of the operator’s skill, aptitude and degree of exertion

Rating calculation:

Rating = (time observe/ time expected) X 100%
2.3 PERSONAL, FATIGUE, UNAVOIDABLE DELAY ALLOWANCES

Allowances are the amount of the time added to the *normal time* to provide for personal needs, unavoidable *delays*, and *fatigue*.

![Diagram showing time components]

**OT** - Observed Time  
**PRF** - Performance Rating Factor  
**NT** - Normal Time  
**PA** - Process Allowances  
**RPA** - Rest and Personal Allowances  
**SA** - Special Allowances  
**PoA** - Policy Allowances
2.3 PERSONAL, FATIGUE, UNAVOIDABLE DELAY ALLOWANCES

Allowances are categorised as
1. Relaxation allowance (Fixed allowance)
2. Variable allowance
3. Interference allowance
4. Contingency allowance
5. Policy allowance
1. **RELAXATION ALLOWANCE**
   
a) Fixed Allowance
   
i) **Personal needs allowances:** to attend personal needs, drinking water, smoking, washing hands, etc.

   - 5% for man & 7% for woman

   ii) **Basic Fatigue allowances:** for energy expanded during working

   - 4% of basic time

2. **VARIABLE ALLOWANCE**
   
is working under poor environmental conditions.
   
i) **Standing allowance**

   - 2%

   ii) **Abnormal position allowance**

   - Awkward (bending) 2%
   - Very awkward (lying, stretching) 7%

   iii) **Use of force or muscular energy in lifting, pulling, pushing**
1. Constant allowances:
   (A) Personal allowance ........................................... 5
   (B) Basic fatigue allowance ...................................... 4

2. Variable allowances:
   (A) Standing allowance .......................................... 2
   (B) Abnormal position allowance:
      (i) Awkward (bending) ......................................... 2
      (ii) Very awkward (lying, stretching) ...................... 7
   (C) Use of force or muscular energy in lifting, pulling, pushing
      Weight lifted (pounds):
      20 ................................................................. 3
      40 ................................................................. 9
      60 ................................................................. 17
   (D) Bad light:
      (i) Well below recommended ................................. 2

   (E) Atmospheric conditions (heat and humidity):
      Variable ........................................................... 0–10

   (F) Close attention:
      (i) Fine or exacting .............................................. 2
      (ii) Very fine or very exacting ............................... 5

   (G) Noise level:
      (i) Intermittent—loud .......................................... 2
      (ii) Intermittent—very loud or high-pitched ............ 5

   (H) Mental strain:
      (i) Complex or wide span of attention .................... 4
      (ii) Very complex ............................................... 8

   (I) Tedium:
      (i) Tidious ...................................................... 2
      (ii) Very tedious .............................................. 5
4. CONTINGENCY ALLOWANCE
For small unavoidable delays due to:
- Tool breakage
- Power failures
- Obtaining the necessary tools and gauges

Not exceed 5%

5. POLICY ALLOWANCE
Is to line up standard times with requirements of wage of agreement between employers and unions
Motion Study

The usual procedures in motion study involve the use of:

1. Process Chart
2. Flow Chart/ Work Chart
3. Operation Chart
4. Micromotion chart
Process Chart

Process chart is the series of steps in making an article or the series of events a person goes through in completing a job assignment.

- Operation
- Transportation
- Inspection
- Delay
- Storage
- Combined activity
Process Chart

Process Chart is helpful to :-
1. Visualize the complete sequence of the operation and inspection in the process.
2. Know where the operation selected for detailed study fits into the entire process.
3. In operation process chart, the graphic representation of the points at which materials are introduced into the process and what operations and inspections are carried on them are shown.
Example:

PROCESS CHART

Prepare bottled Coca-Cola to drink

<table>
<thead>
<tr>
<th>ACTION</th>
<th>PRESENT</th>
<th>PROPOSED</th>
<th>OBSERVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sit down</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pour Coca-Cola</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Get a glass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to sink</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Get bottle of Coca-Cola</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close refrigerator door</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open refrigerator door</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to wall cabinet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open bottle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to sofa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit down</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rest on sofa</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rest on sofa:〇△□▼
Stand up:〇△□▼
Walk to refrigerator:〇△□▼30 ft
Open refrigerator door:〇△□▼
Get bottle of Coca-Cola:〇△□▼
Close refrigerator door:〇△□▼
Walk to opener (on wall):〇△□▼5 ft
Open bottle:〇△□▼
Walk to wall cabinet:〇△□▼15 ft
Get a glass:〇△□▼
Walk to sink:〇△□▼12 ft
Pour Coca-Cola into glass:〇△□▼
Set bottle aside in sink:〇△□▼
Walk to sofa:〇△□▼30 ft
Sit down:〇△□▼
Rest on sofa:〇△□▼
Flow Chart

Flow chart is a supporting route of travel that an article or person may take in completing a series of steps in a job assignment. This chart is usually used to supplement the process chart.

The flow chart is useful :-
1. to reduce the distance traveled by men or materials,
2. to avoid waiting time and unnecessary delays,
3. to reduce the cycle time by combining or eliminating operations,
4. to fix up the sequence of operations.
5. to relocate the inspection stages
Operation Chart

Operation chart (two handed process chart) is a detailed analysis of just what an employee does in a specific step or task. Which an activities of the workers hands are recorded in relation to one another. It is normally confined to work carried out at single workplace. This also gives synchronized and graphical representation of the sequence of manual activities of the worker.

The operation chart is useful :-
1. to visualize the complete sequence of activities in a repetitive task
2. to study the work station layout.
Example:
Micromotion (SIMO) Chart

Micromotion (SIMO) chart is a elaborate breakdown of an operation chart into very fine motion pattern, showing what the employee does in a specific step or task. A SIMO chart is a chart based on the film analysis.
MOTION AND TIME STUDY

TOPIC 2

WORK METHODS
Assembly Line Balancing
Outline

• What is Assembly Line Balancing?
• How can Assembly Line Balancing benefit your operations?
• Classic approach to ALB
• Let’s practice!
• ALB in the real world
• Conclusions
What is Assembly Line Balancing (ALB)?

ALB is the procedure to assign tasks to workstations so that:

- *Precedence relationship* is complied with
- No workstation takes more than the *cycle time* to complete
- Operational idle time is minimized
How can Assembly Line Balancing benefit your operations?

A balanced line:
- Promotes one piece flow
- Avoids excessive work load in some stages (overburden)
- Minimizes wastes (over-processing, inventory, waiting, rework, transportation, motion)
- Reduces variation
Unbalanced Line

Work Station 1

Work Station 2

Work Station 3

Work Station 4

10 sec

40 sec!

20 sec

15 sec

Undesirable waiting

Overproduction!
Generates waste
Balanced Line

- Promote one piece flow
- Avoids overburden
- Minimizes wastes
- Reduces variation

Work Station 1 25 sec  Work Station 2 25 sec  Work Station 3 20 sec  Work Station 4 15 sec
Line Balancing prerequisites

Prior to balancing a line we must:

• Determine the required workstation cycle time (or TAKT time), matching the pace of the manufacturing process to customer demand

• Standardize the process
Classic approach to ALB

Also known as SALBP* (Simple Assembly Line Balancing Problem), the classic approach to ALB is an heuristic process to optimize assembly lines simplifying the problem to a basic level of complexity.
Example
The next table shows the tasks performed in a production line. Our goal is to combine them into workstations. The assembly line operates 8 hours per day and the expected customer demand is 1000 units per day. Balance the line and calculate the efficiency and theoretical minimum number of workstations.
## Example

<table>
<thead>
<tr>
<th>Task</th>
<th>Task Time (sec)</th>
<th>Preceding Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>A</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>A</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
<td>B</td>
</tr>
<tr>
<td>E</td>
<td>12</td>
<td>B</td>
</tr>
<tr>
<td>F</td>
<td>13</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>13</td>
<td>C</td>
</tr>
<tr>
<td>H</td>
<td>18</td>
<td>D, E</td>
</tr>
<tr>
<td>I</td>
<td>17</td>
<td>F, G</td>
</tr>
<tr>
<td>J</td>
<td>15</td>
<td>H, I</td>
</tr>
<tr>
<td>K</td>
<td>9</td>
<td>J</td>
</tr>
<tr>
<td><strong>Total Time:</strong></td>
<td><strong>156</strong></td>
<td></td>
</tr>
</tbody>
</table>
SOLUTION

Step 1: Draw a process flow according to the given sequential relationship
Step 2: Determine Takt time or Workstation Cycle Time

Takt Time = Production time per day / Customer demand (or output per day)

Takt Time = 28,800 sec (8 hours) / 1,000 units = 28.8 sec

Step 3: Determine the theoretical number of workstations required

N = Total Task Time / Takt time
N = 156 / 28.8 = 5.42 (~6 workstations)
Step 4: Define your assignment rules. For this example our primary rule will be “number of following tasks” and the secondary rule will be “longest operation time”

Step 5: Assign tasks to workstations following the assignment rules and meeting precedence and cycle time requirements
To form Workstation 1:

Lot 15 > 11

WS 1: A+C = 28sec
Cycle Time met
To form Workstation 2:

- $B + D > TT$
- Lot F & G > E
- WS 2: $B + F = 24$ sec < TT

Arbitrarily choose F
To form Workstation 3 & 4:

WS 2: B + F = 24 sec < TT

WS 3: D < TT

WS 4: G + E = 25 sec < TT
To form Workstation 5, 6 & 7:

WS 1: A+C = 28 sec
WS 2: B+F = 24 sec
WS 3: D = 20 sec
WS 4: E+G = 25 sec
WS 5: H = 18 sec
WS 6: D = 17 sec
WS 7: D = 24 sec

TAKT TIME 28.8 SEC
Following the same criteria we achieve our balancing with 7 workstations

<table>
<thead>
<tr>
<th>Workstation</th>
<th>Task</th>
<th>Task Time</th>
<th>Remaining Unassigned Time</th>
<th>Feasible Remaining Tasks</th>
<th>Task with most followers</th>
<th>Task with LOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>13</td>
<td>15.8</td>
<td>B, C</td>
<td>B, C</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>15</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>11</td>
<td>17.8</td>
<td>E, F, G</td>
<td>E, F, G</td>
<td>F, G</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>13</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>20</td>
<td>8.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>G</td>
<td>13</td>
<td>15.8</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>12</td>
<td>3.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>H</td>
<td>18</td>
<td>10.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I</td>
<td>17</td>
<td>11.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>J</td>
<td>15</td>
<td>13.8</td>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>9</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Step 6: Calculate Efficiency

Efficiency = Total Task Time / (Actual number of workstations * Takt Time)

Efficiency = 156 / (7*28.8) = 77%
ALB in the real world

The simple ALB problem approach is limited by some constraints:

• Balance on existing and operating lines
  ✓ Workstations have spatial constraints
  ✓ Some workstations cannot be eliminated
  ✓ Need to smooth workload among workstations

• Multiple operators per workstation
  ✓ Different paces among operators, different lead times within the same workstation
ALB in the real world (cont.)

- Operator spatial constraints
  - Different workstation imposed working positions
  - More than one task to be performed in what should be the space for one task
- Multiple Products
  - Coping with different products, some operations are needed for some products but not for others
  - Some products can introduce ‘peak times’ in some workstations
- Different task times performed in different shifts
  - Particularly when introducing new employees or workers with some degree of incapacity
Conclusion

Simply Assembly Line Balancing is a valid method to optimize assembly lines. However, many variables found in real operating lines increase the complexity of the problem. More complex algorithms have been developed to solve the difficult task of balancing large scale industrial lines. Some of them are commercially available in software.
MOTION AND TIME STUDY

TOPIC 2 - WORK METHODS

2.5 Machine and Process Study
When you complete this chapter, you should be able to:

Identify or Define:

- ✓ Process flow
- ✓ Man machine chart
Learning Outcome

When you complete this chapter, you should be able to:

Describe or Explain:

- Usage of process flow
- Advantages and disadvantages of process flow
Process Chart

Process chart is the series of steps in making an article or the series of events a person goes through in completing a job assignment.

Process Chart is helpful to:-
1. Visualize the complete sequence of the operation and inspection in the process.
2. Know where the operation selected for detailed study fits into the entire process.
3. In operation process chart, the graphic representation of the points at which materials are introduced into the process and what operations and inspections are carried on them are shown.
Process Chart

- Operation
- Transportation
- Inspection
- Delay
- Storage
Operation

An operation occurs when an object is intentionally changed in one or more of its characteristics (physical or chemical)

Examples of operation are:

- turning, drilling, milling, etc
- a chemical reaction
- welding, brazing and riveting
- lifting, loading, unloading
- getting instructions from supervisor
- Taking dictation
Inspection

An inspection occurs when an object is examined and compared with standard for quality and quantity. The inspection examples are:

- Visual observation for finish
- Count of quantity of incoming material
- Checking the dimension
Transportation

A transport indicates the movement of workers, materials or equipment from one place to another. Examples of transportation are:

- Movement of materials from one workstation to another
- Workers travelling to bring tools
Delay

A delay occurs when the immediate performance of the next planned thing does not take place.
Examples of delay are:
- Work waiting between consecutive operation
- Workers waiting at tool cribs
- Operators waiting for instructions from supervisor
Process Chart

Storage

Storage occurs when the object is kept in an authorised custody and is protected against unauthorised removal.

Examples of delay are:

• Material kept in stores to be distributed to various work
## Process Chart

### PROCESS CHART

<table>
<thead>
<tr>
<th>Task</th>
<th>Instruction</th>
<th>Start</th>
<th>End</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest on sofa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stand up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to refrigerator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open refrigerator door</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Get bottle of Coco-Cola</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close refrigerator door</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to opener (on wall)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open bottle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to wall cabinet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Get a glass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to sink</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pour Coco-Cola into glass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set bottle aside in sink</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to sofa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit down</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rest on sofa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Date:** 01/01/00

**Note:** DRB-HICOM
### Process Chart

**Figure 10.5 (c)**

<table>
<thead>
<tr>
<th>DIST. IN FEET</th>
<th>TIME IN MINS.</th>
<th>CHART SYMBOLS</th>
<th>PROCESS DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>3</td>
<td></td>
<td>From press machine to storage bins at work cell</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td></td>
<td>Storage bins</td>
</tr>
<tr>
<td>4</td>
<td>2.5</td>
<td></td>
<td>Move to machine 1</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Operation at machine 1</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Move to machine 2</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td></td>
<td>Operation at machine 2</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Move to machine 3</td>
</tr>
<tr>
<td>3.5</td>
<td></td>
<td></td>
<td>Operation at machine 3</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Move to machine 4</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Operation at machine 4</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>Move to welding</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Foka-yoke inspection at welding</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Weld</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>Move to painting</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Paint</td>
</tr>
<tr>
<td>97</td>
<td>25</td>
<td></td>
<td>TOTAL</td>
</tr>
</tbody>
</table>

- ○ = operation; ↔ = transportation; ☐ = inspection; ☐ = delay; ▼ = storage

**Date:** 8/1/05

**Chart by:** JH

**Chart No.:** 1

**Department:** Work cell for axle stand

**Sheet No.:** 1 of 1
Operation Chart

OPERATION CHART

<table>
<thead>
<tr>
<th>SYMBOLS</th>
<th>PRESENT</th>
<th>PROPOSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATION</td>
<td>LH 2</td>
<td>RH 3</td>
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PROCESS: Bolt-washer assembly
EQUIPMENT: KJH
OPERATOR: KJH
STUDY NO: 05
DATE: 8/1/05
SHEET NO: 1 of 1
METHOD (PRESENT) PROPOSED
REMARKS:

LEFT-HAND ACTIVITY

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RIGHT-HAND ACTIVITY

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<td>Reach for washer</td>
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<td>Move washer to bolt</td>
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<td>Place washer on bolt</td>
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Figure 10.7