Chapter 11

Standard Operations

Definition

- Group of standards that completely defines all aspects of a task, operation, or process
- Defines best practice
- Must be adapted to reflect, for example, changes in product demand, current worker skill and proficiency levels, current equipment, as well as how work is actually performed
- Should change as things change on the shop floor
- Work procedures, sequence of tasks, and times prescribed for the shop floor to produce a unit of output
Shop-Floor Involvement

- Industrial engineers are the key people that initially develop the standard operations.
- Industrial engineers should recruit the help of shop-floor supervisors and workers.
- Goal: For the supervisors and workers to perform their own measurement and standards development.
- Supervisors and workers must be trained in the methods and procedures of operations analysis, time/motion study, and related tools.
- The standards should be applied to planning, scheduling, and control.

Benefits

- When performed on the shop-floor, corrections to the standards may be made immediately when a change occurs.
- Allows planners to make master schedules that are feasible and reflect shop-floor status.
- Allows for identification of safety hazards and procedures that lead to or permit defects and then to modify them.
- Allows inexperienced workers to quickly become familiar with a task.
- Allows workers and supervisors to check standards vs. current work.
Procedure

1. Determine the required cycle time
2. Determine the standard task time by measuring each task many times. All manual and machine times must be included in the task time. A judgment about the worker’s speed is determined.
3. Determine the completion time per unit
4. Understand the production capacity
5. Develop standard operations routines
6. Fill out the standard operations routine sheets
7. Determine the process routing sequence
8. Develop standard operations sheets

Cycle Time

- Reason for cycle time - The quantity to be produced should be based upon a production output goal
- The output goal should be best stated in terms of frequency that an item must be produced in the allotted time (also referred to as takt time)

\[
CT = \frac{\text{Daily Time Available}}{\text{Required Daily Quantity}} = \frac{T}{Q}
\]

Required Cycle Time = \frac{(480 \text{ min/day} - 30 \text{ min (lunch)} - 15 \text{ min (break)})}{210 \text{ units/day}}

= \frac{420 \text{ min/day}}{210 \text{ units/day}} = 2 \text{ min/unit}

- Do not account for waste in the process (this will allow us to address problems in the system)
**Standard Task Time**

- **Task** - Elemental unit of work; a simple step or motion
- **Operation** - Group of tasks performed together, such as those performed at a workstation
- **Standard task time** - Expected time for an average worker to perform a task at a satisfactory level. Used to determine production capacity and work schedules.
- **Machine time** - Automatic run time of the machine
- **Manual or handling time** - Time in which the worker is working on the machine or handling parts

*Note: There may be a learning curve for a newly created task or a new person performing a standardized task.*

**Standard Task Time (cont.)**


= 105 sec. * 0.95 * 1.1 = 109.725 approximately 110 sec.

- **Performance rating** - is 100% if the worker is of average skill and may be raised or lowered if the worker’s skill is lower or higher, respectively
- **Allowance factor** - takes into account unavoidable delays that are a normal part of the operation. Do not account for delays that may be eliminated or use this as a fudge factor.

- **What would happen if the performance rating of a new person was 105%? Would he be able to meet the takt time of 120 sec.?**
**Completion Time per Unit (CTU)**

- **Definition:** The average time required to process one unit.

- Determined for every task and operation (for value-added and non-value added activities)

- May or may not be the same as the standard task time

- If a task is observed and found to have times of 5, 5, 4, 3, and 4 seconds for four units, the average is needed for the completion time per unit = 4.2 sec. (shown on next page).

- The completion time per unit is the sum of the completion time per unit for all the tasks.

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### Completion Time per Unit (cont.)

**Part:** Liner  
**Station:** Machining 1  
**Operation:** Stamp holes into liner and then cover the holes with foam tabs.

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Procedure</th>
<th>Act</th>
<th>CTU</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Walk to skid</td>
<td>Walk to skid.</td>
<td>2, 2, 2, 2, 2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Unload finished material</td>
<td>Unload finished material from machine.</td>
<td>4, 4, 4, 5, 4</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Get material</td>
<td>Raise one piece of raw sheet material. Pull off of skid.</td>
<td>5, 5, 4, 3, 4</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Start machine</td>
<td>Load raw sheet into the machine. Start machining.</td>
<td>10, 10, 11, 18, 14</td>
<td>12.6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Machining</td>
<td>Machining cycle time on body.</td>
<td>83, 77, 159, 153, 116</td>
<td>117.6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Remove finished part</td>
<td>Walk around skid of finished products. Assist in moving finished part to skid.</td>
<td>14, 6, 19, 29, 16</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Attach foam</td>
<td>Place foam tabs over holes.</td>
<td>60, 69, 64, 59, 64</td>
<td>63.2</td>
<td></td>
</tr>
</tbody>
</table>

**CTU Total:** 220.6
Production Capacity

- Production capacity is the number of units that can be produced in the available production time.
- Use completion time per unit to estimate the production capacity.
- Requires information about the lot size and setup time.

\[ N \text{ = production capacity} = \frac{\text{total operation time}}{\text{completion time per unit} + \text{setup time per unit}} = \frac{T}{C + m} \]

\[ m \text{ = setup time per unit} = \frac{\text{total time required per setup}}{\text{batch size}} \]

Production Capacity (cont.)

- Example:

For the previous figure, a new pallet of sheet metal is required after 50 liners are stamped. The setup operation is described as follows:
- Restock the skid of material by taking the cardboard, protecting the sheet metal from the pallet, off of the pallet and throwing it in the recycle bin. Get on the forklift, stage the empty skid across the aisle. Identify skid of sheet metal and move it from the rack to the machine. Sit material next to the machine and start operations. This operation takes 9 minutes and 2 seconds.

\[ m = \frac{542 \text{ sec.}}{50 \text{ units}} = 10.84 \text{ sec./unit} \]

\[ N = \frac{420 \text{ min./day}}{(220.6 + 10.84)/60 \text{ min./unit}} = \frac{420 \text{ min./day}}{3.857 \text{ min./unit}} = 108.88 \text{ units/day} \]
Objective: To determine the sequence in which the tasks will be performed, which is called the standard operations routine.

Three types:

1. For a single repeated operation - an operation is performed repeatedly product after product.

2. For multiple repeated operations - several operations at different machines are performed repeatedly.

3. For multiple non-repeated operations - many different operations are performed that are not necessarily repeated during the day, but are repeated from day-to-day.

What would happen if the foam tabs were applied to the finished liner while the next liner was being machined? What is the cycle time?
Answer: Cycle time will be met easily.

For multiple, repeated operations:
1. Determine the required cycle time and draw it on the SOR sheet.
2. Determine the approximate number of workers and the range of operations that each worker will be able to perform within the required cycle time.
3. Draw on the SOR sheet the CTU for the first operation.
4. If an automated machine is turned on, draw a dashed line continuing from the line drawn in step 3.
5. Draw a wavy line continuing from the line drawn in step 3 to display the time required to walk to the next machine.
6. Repeat steps 3, 4, and 5 for each operation.
7. Draw a wavy line back to task #1 if the worker has to walk to the task.

Note: If the worker arrives at task #1 before the required cycle time, then the routing sequence is verified.
Note: This sheet must be drawn twice to make sure that machines are not operating when the worker arrives at the machine. If so, this will lengthen the CTU.
Notice that the machine is still working when the operator arrives to place a new piece of sheet metal in the machine.

What should we do now?

What is the actual cycle time now?

Is there room for improvement? Where?
What should you do if the actual cycle time is longer than the required cycle time? Can you meet demand?

Gear and Sprocket Machining Example Problem

Regular Work Day: 420 minutes  Required Daily Output: 1800 units
1) Machine layout Diagram:

2) Processing Sequence: A, B, C, D, E, F, G
3) Times

<table>
<thead>
<tr>
<th>Process Steps</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Task Times</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Automatic Run Times</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

* All times are in seconds
4) Tool Changes and Times
   a) Tools on machine A are changed in 120 seconds every 600 parts.
   b) Tools on machine B are changed in 45 seconds every 1000 parts.
   c) Tools on machine E are changed in 75 seconds every 400 parts.
   d) Solution in washer changed in 150 seconds every 500 units (machine F).
   e) Tools on shaver changed in 60 seconds every 100 parts (machine G).

5) Miscellaneous
   a) Two seconds walking time between machines.
   b) Two seconds task time for picking up raw materials and two seconds task time for putting down finished product.

Assignment:
1. Determine maximum output that can be achieved.
2. Estimate the number of operators needed at Takt Time.
# Ch11 Standard Operations

## Process ID: Gear/ Sprocket

### Operator: 1

<table>
<thead>
<tr>
<th>Seq. No.</th>
<th>Task Description</th>
<th>Time</th>
<th>Time Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fin. Prod. into Container</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pick Up Raw Mat</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manual Chucker</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

**Total:** 7 6 Manual Machine Move

**Utilization = 13/14 = 92.9%**

## Process ID: Gear/ Sprocket

### Operator: 2

<table>
<thead>
<tr>
<th>Seq. No.</th>
<th>Task Description</th>
<th>Time</th>
<th>Time Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manual Broach</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manual B.C. Hob</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

**Total:** 9 4 Manual Machine Move

**Utilization = 13/14 = 92.9%**
### Standard Operations

**PROCESS ID:** Gear/Sprocket  | **STANDARD WORK** | **DATE:** 12/8/95  
**OPERATOR:** 3  |  | **TAKT TIME:** 14 sec.  

<table>
<thead>
<tr>
<th>SEQ. NO.</th>
<th>TASK DESCRIPTION</th>
<th>TIME</th>
<th>TIME SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MAN</td>
<td>MACH</td>
</tr>
<tr>
<td>1</td>
<td>Manual L.B. Hob</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Manual Trim</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

**TOTAL 9 4**  

**UTILIZATION = 13/14 = 92.9%**  

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**PROCESS ID:** Gear/Sprocket  | **STANDARD WORK** | **DATE:** 12/8/95  
**OPERATOR:** 4  |  | **TAKT TIME:** 14 sec.  

<table>
<thead>
<tr>
<th>SEQ. NO.</th>
<th>TASK DESCRIPTION</th>
<th>TIME</th>
<th>TIME SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MAN</td>
<td>MACH</td>
</tr>
<tr>
<td>1</td>
<td>Manual Washer</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Manual Shaver</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

**TOTAL 7 4**  

**UTILIZATION = 12/14 = 85.7%**
Machining Cell Capacity Analysis
(Example)

Part Number: 69242
Part Name: Master Cylinder
Regular Work Day: 460 Minutes
Required Daily Output: 1200 Units

1) Machine Layout Diagram

2) Processing Sequence and Times

<table>
<thead>
<tr>
<th>Type of Processing</th>
<th>Mounting Surface Cut (A)</th>
<th>O.D. Cut (B)</th>
<th>Drill Hole (C)</th>
<th>Thread (D)</th>
<th>Check Thread Diameter (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Task Time (sec.)</td>
<td>2&quot;</td>
<td>4&quot;</td>
<td>5&quot;</td>
<td>4&quot;</td>
<td>3&quot;</td>
</tr>
<tr>
<td>Automatic Run Time (sec.)</td>
<td>14&quot;</td>
<td>15&quot;</td>
<td>13&quot;</td>
<td>12&quot;</td>
<td></td>
</tr>
</tbody>
</table>

3) Tool Changes and Times
   a) Tools on machine A are changed in 60 seconds once every 100 parts.
   b) Tools on machine B are changed in 50 seconds once every 200 parts.
   c) Tools on machine C are changed in 100 seconds once every 300 parts.
   d) Tools on machine D are changed in 30 seconds once every 400 parts.

4) Miscellaneous
   a) 2 seconds walking time between machine.
   b) 2 seconds manual task time each for picking up raw material and putting down finished product.

Assignment:
   1. Determine maximum output that can be achieved.
   2. Estimate the number of operators needed at takt time.
### TABLE OF PRODUCTION CAPACITY BY PROCESS

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>PART NAME</th>
<th>LINE NAME</th>
<th>CURRENT OUTPUT</th>
<th>PERSON/DAY WORKERS NEEDED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Master Cylinder</td>
<td>Master Cylinder Processing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE OF STANDARD WORK

<table>
<thead>
<tr>
<th>SEQ. NO.</th>
<th>TASK DESCRIPTION</th>
<th>TIME SCALE</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAN/MACH/MOVE</td>
<td></td>
</tr>
</tbody>
</table>

### STANDARD WORK

**PROCESS ID:** unknown

**OPERATOR:** unknown

**STANDARD WORK**

**DATE:** unknown

**TAKT TIME:**

<table>
<thead>
<tr>
<th>SEQ. NO.</th>
<th>TASK DESCRIPTION</th>
<th>TIME SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**REMARKS:**

- A
- B
- C
- D
- E

**TIME INDICATED:**

- Base Time
- Auto Run
- Time to Complete
- Time to Change
- Required Output
- Takt Time
- Operators Needed

**NOTE:** REVISE TIMES EVERY TIME KAIZEN HAS SHORTENED THEM AND WRITE THE REASON FOR THE NEW TIMES IN THE “REMARKS” COLUMN.
<table>
<thead>
<tr>
<th>SEQ. NO.</th>
<th>TASK DESCRIPTION</th>
<th>TIME</th>
<th>TIME SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MAN</td>
<td>3 6 9 12 15 18 21 24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MACH</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MOVE</td>
<td></td>
</tr>
</tbody>
</table>

**PROCESS ID:**

**STANDARD WORK:**

**DATE:**

**TAKT TIME:**

**MANUAL:**

**MACHINE:**

**MOVE:**
Operations Routine and Process Routing Sequence

- Process routing sequence – The order in which operations must be performed to make a part or product.
- Note: The standard operating routine may be different from the process routing sequence.
- Example: The worker’s sequence may be the opposite direction of the flow of the product.

Standard Quantity of WIP

- Standard quantity of WIP:
  - The minimum work-in-process inventory for the process to function.
  - The minimum amount of material necessary to achieve smooth flow of work.
- If the SOR sequence is the same as the process routing sequence
  ⇒ The standard quantity may be the same as or less than the number of operations.
- If the SOR sequence is the opposite of the process routing sequence
  ⇒ One piece of WIP must be used between each operation.
Standard Quantity of WIP

- WIP must be kept where workers exchange parts.
- WIP buffers variation.
- Buffers should be tactically positioned at bottleneck operations.
- Should consider the quantity necessary to check product quality at necessary positions of the process.
- May also need to consider quantity to be held until the temperature of a unit from the preceding machine cools to a required level (e.g., such as drying time).

Standard Operations Sheet

- Contains:
  - Completion time per unit
  - Required cycle time
  - Standard operations routine sheet
  - Standard WIP
  - Actual cycle time
  - Layout (with positions of quality checks)

- Purpose:
  - Teaches worker about each operation
  - Insures standards are met
  - Tool to evaluate performance and improvement
Rules

- SOS sheets must always be dated to identify when they were revised last
- SOS sheets should be revised regularly
- Standard operations:
  - “Are always imperfect”
  - Should never be considered fixed
  - Must be adapted to reflect changing demand, worker skills, etc.

Conditions for Successful Standard Operations

1. Focus on the worker not the machines
2. Job security because workers will only be transferred, not fired
3. Repetitive work
4. Level production
5. Multi-skilled operators
6. Team effort (union contracts must be re-negotiated)