TOYOTA PRODUCTION SYSTEMS:
REDUCING MACHINE SETUP TIME

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Machine setup time

- Time between last quality product of last batch and first quality product of next batch

Time required for manufacturing parts

= machine setup time + number of parts × manufacturing time per unit
Machine setup procedure

• Preparation: Gathering the appropriate tools for next job (all tools must be kept at appropriate places)
• Exchanging: Old parts are exchanged with new parts
• Positioning: After exchanging (mounting) the new tools, repositioning and calibration is done
• Gauging: After calibration, the tools and material are checked against the quality and some trial runs are conducted. (longest stage)
Benefits of reducing setup time

• Small lot production (High flexibility)
• High responsiveness
• Shorter lead time and increased capacity
• Capital equipment purchase avoided or delayed (better utilization of resources)
• Lower manufacturing cost
• Less inventory
• Reduced process variability (standardization)
Issues with machine setup

• Lack of skills

• Setup Variation (leads to deviation)

• No standards available

• Engineering time not studied

• Inadequate tools and manpower
Time waste in changeover

- Searching time
- Logistics waiting time
- Unnecessary movement of operator
- Waiting for decision
- Interruption

Changeover time
Time waste in changeover

• Internal element/setup
  • Tool dismantling
  • Tool mounting
  • Adjustments/calibration etc.

• External element/setup
  • Bringing tools from other places
  • Checking of die mould etc.
  • Checking of availability of material
  • Data entry/documentation
Organizing and Executing SMED workshop

*SMED-single minute exchange of dies*
Machine setup time vs cost

Step 1: Machine Selection
• Selection is made on the basis of some criteria like, longest m/c setup time, frequency of setup, bottleneck machines etc.
• MCDM methods and ABC methods may be used to select the machine

Step 2: Defining target setup time
• 50% reduction in first SMED workshop
• Should reduce in consecutive workshops

Step 3: Selection of team members
• Team leader
• Team moderator (SMED expert)
• Setup operator (will perform the setup operation)
• Protocol writer (will take notes on m/c setup elements)
• Time recorder (records the time required for m/c setup)
• Photographer/videographer
• A team member to draw the path made by setup operator
Step 4: Documenting elements of the m/c setup using existing procedure

• Tools required:
  • notebook of m/c setup elements
  • Monitoring paper (cumulative and individual time of m/c setup elements and microelements)
  • List of path made by setup operator (to identify the unnecessary movement)
  • Photos of m/c setup elements
  • Video film of entire m/c setup process

Step 5: Transformation of m/c setup elements and microelements into a visual form

• Making individual stickers for elements and microelements
• Step 6: Analysis of m/c setup elements and microelements

Phase 0: Analysis of the current situation: The moderator places the stickers (marked with X & E) on a panel. Where,

- X - another microelement follows this one
- E - last microelement

Phase 1: Separation of internal and external microelements: the team must decide

- **Internal microelements** (can be carried out only during m/c shutdown) mark red
- **External microelements** (can be carried out only during m/c operation) mark green

- The internal microelements include, only the removal and setting of dies.
- The external microelements like, dies, tools, and materials must be perfectly prepared beside the machine, and any needed repairs to the dies should have been made in advance.

Phase 2: Transformation of internal microelements into external microelements

- The team moves the yellow stickers either to column 1 (starting activities) or to column 5 (ending activities)

Phase 3: Improvement of internal and external microelements

- The moderator enters all improvements of m/c setup microelements into the lower part of analytical card

Phase 4: Standardization of m/c setup microelements

- Training is organized for setup workers and improved procedure is carried out at least three times during this training.
Transformation of internal microelements into external microelements

Example: The die-casting machine can be preheated using the waste heat of the furnace that belongs to this machine. This means the trial shot to warm up the metal mold in the die-casting machine can be eliminated.

Eliminate the Adjustment Process (takes 50-70% time of internal microelements)

*Finite setting built-in system* vs *infinite setting system*
Eliminate the Adjustment Process

FIGURE 11.5
Examples of quick fasteners (Technique 3): (1) U-shaped washer; (2) pear-shaped bolt hole; (3) nut and bolt with corresponding portions chipped off.
Step 7: Immediate repetition of analysis of elements and microelements

- If target setup time defined in step 2 has not been achieved the team immediately repeats the SMED analysis

Step 8: Repetition of the SMED workshop

- It’s a never ending process
- Repeated periodically
SMED Case study
INJECTION MOULDING MACHINE SETUP
TIME REDUCTION
Step 1: M/c selection: Following criteria have been used for machine selection:

- machine setup times in the last three months,
- number of machine setups in the last three months.

- Using a weighted-scoring method, the manufacturing management decided that a reduction of setup time would be tested on a KM 800 – CNC Injection Molding Machine

Step 2: Defining Target setup time

- Current setup time is 119.97 minutes
- Target setup time is 60 minutes (50% reduction)

Step 3: Selection of team members

- Team leader
- Team moderator (SMED expert)
- Setup operator (will perform the setup operation)
- Protocol writer (will take notes on m/c setup elements)
- Time recorder (records the time required for m/c setup)
- Photographer/videographer
- A team member to draw the path made by setup operator
Step 4: Documenting elements of the m/c setup using existing procedure

- During the actual machine setup, the protocol writer entered the sequence of elements and microelements of machine setup into his notebook.
- He also noted exact setup times, reported by the time recorder operator.
- After recording the machine setup elements, the protocol writer entered the data on the monitoring paper.
- **Drawing of the operator's movements** are prepared.
- It is obvious that the setup operator is disorganized and that he often leaves his workplace and walks around unnecessarily.
Step 4: Documenting elements of the m/c setup using existing procedure

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Machine shutdown</td>
<td>0:00:31</td>
<td>31</td>
<td>10 20 30 40 50 60 70 80 90 100</td>
</tr>
<tr>
<td>2</td>
<td>Setup of the manipulat.</td>
<td>0:01:12</td>
<td>41</td>
<td>10 20 30 40 50 60 70 80 90 100</td>
</tr>
<tr>
<td>3</td>
<td>Walk to the office</td>
<td>0:01:26</td>
<td>14</td>
<td>10 20 30 40 50 60 70 80 90 100</td>
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<tr>
<td>4</td>
<td>Searching for documentation</td>
<td>0:01:35</td>
<td>9</td>
<td>10 20 30 40 50 60 70 80 90 100</td>
</tr>
<tr>
<td>5</td>
<td>Walk to the machine</td>
<td>0:01:50</td>
<td>15</td>
<td>10 20 30 40 50 60 70 80 90 100</td>
</tr>
<tr>
<td>55</td>
<td>Confirmation of first samples</td>
<td>1:59:04</td>
<td>80</td>
<td>10 20 30 40 50 60 70 80 90 100</td>
</tr>
</tbody>
</table>
Paths made by the setup operator - standard machine setup procedure

Recorded: 5.18.2009 from 10:30 till 12:30 = 2 hours

Trodden path: 432 m
- Machine 1: jet-machine
- Machine 2: tempering device
- Machine 3: place of control
Step 5: Transformation of jet m/c setup elements and microelements into a visual form

• The data obtained on the jet-machine setup elements and microelements are copied from the notebook to stickers to be affixed to a panel during the next step.

• The stickers were labeled as
  • X - if there was another microelement after the current one,
  • E - if the current microelement was the last one.
Step 6: ANALYSIS OF JET-MACHINE SETUP ELEMENTS AND MICROELEMENTS

Phase 0: Analysis of the current situation

• At the beginning of the session, the moderator projected the analytical card for entering the current situation onto the panel.

• By affixing stickers to the panel (in agreement with other team members) the current situation of jet machine setup was obtained
<table>
<thead>
<tr>
<th>Machine setup element</th>
<th>EXTERNAL ELEMENTS</th>
<th>INTERNAL ELEMENTS</th>
<th>EXTERNAL ELEMENTS</th>
<th>TOTAL TIME [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element duration [min]</td>
<td>0</td>
<td>19.30</td>
<td>93.97</td>
<td>6.70</td>
</tr>
<tr>
<td>MICROELEMENTS</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Starting</td>
<td>2. Tool</td>
<td>3. Tool</td>
<td></td>
</tr>
<tr>
<td></td>
<td>activities</td>
<td>dismantling</td>
<td>mounting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>procedure</td>
<td>procedure</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Start of the</td>
<td>5. Completion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>machine</td>
<td>activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microelement</td>
<td>Microelement</td>
<td>Microelement</td>
<td>Microelement</td>
</tr>
<tr>
<td></td>
<td>Machine</td>
<td>Machine</td>
<td>Machine</td>
<td>Machine</td>
</tr>
<tr>
<td></td>
<td>shutdown</td>
<td>shutdown</td>
<td>shutdown</td>
<td>shutdown</td>
</tr>
<tr>
<td></td>
<td>31 sec X</td>
<td>31 sec X</td>
<td>31 sec X</td>
<td>31 sec X</td>
</tr>
<tr>
<td></td>
<td>Manipulator setup</td>
<td>Manipulator setup</td>
<td>Manipulator setup</td>
<td>Manipulator setup</td>
</tr>
<tr>
<td></td>
<td>41 sec X</td>
<td>41 sec X</td>
<td>41 sec X</td>
<td>41 sec X</td>
</tr>
<tr>
<td></td>
<td>Walk to the office</td>
<td>Walk to the office</td>
<td>Walk to the office</td>
<td>Walk to the office</td>
</tr>
<tr>
<td></td>
<td>14 sec X</td>
<td>14 sec X</td>
<td>14 sec X</td>
<td>14 sec X</td>
</tr>
<tr>
<td></td>
<td>Lifting the</td>
<td>Lifting the</td>
<td>Lifting the</td>
<td>Lifting the</td>
</tr>
<tr>
<td></td>
<td>previous tool</td>
<td>previous tool</td>
<td>previous tool</td>
<td>previous tool</td>
</tr>
<tr>
<td></td>
<td>from the machine</td>
<td>from the machine</td>
<td>from the machine</td>
<td>from the machine</td>
</tr>
<tr>
<td></td>
<td>89 sec X</td>
<td>89 sec X</td>
<td>89 sec X</td>
<td>89 sec X</td>
</tr>
<tr>
<td></td>
<td>Entering the</td>
<td>Entering the</td>
<td>Entering the</td>
<td>Entering the</td>
</tr>
<tr>
<td></td>
<td>data into the</td>
<td>data into the</td>
<td>data into the</td>
<td>data into the</td>
</tr>
<tr>
<td></td>
<td>documentation</td>
<td>documentation</td>
<td>documentation</td>
<td>documentation</td>
</tr>
<tr>
<td></td>
<td>385 sec X</td>
<td>385 sec X</td>
<td>385 sec X</td>
<td>385 sec X</td>
</tr>
<tr>
<td></td>
<td>Tool heating</td>
<td>Tool heating</td>
<td>Tool heating</td>
<td>Tool heating</td>
</tr>
<tr>
<td></td>
<td>3811 sec X</td>
<td>3811 sec X</td>
<td>3811 sec X</td>
<td>3811 sec X</td>
</tr>
<tr>
<td></td>
<td>Spraying the</td>
<td>Spraying the</td>
<td>Spraying the</td>
<td>Spraying the</td>
</tr>
<tr>
<td></td>
<td>cylinder</td>
<td>cylinder</td>
<td>cylinder</td>
<td>cylinder</td>
</tr>
<tr>
<td></td>
<td>72 sec E</td>
<td>72 sec E</td>
<td>72 sec E</td>
<td>72 sec E</td>
</tr>
</tbody>
</table>
Step 6: ANALYSIS OF JET-MACHINE SETUP ELEMENTS AND MICROELEMENTS

- Phase 1: Separation of internal and external setup microelements
- The moderator presented each microelement of the current machine setup and the team decided whether the microelement was internal or external.
- The moderator marked the stickers of internal microelements with red and those of external microelements with green.
## Analytical Card – Separation of Elements

<table>
<thead>
<tr>
<th>Machine Setup Element</th>
<th>External Elements</th>
<th>Internal Elements</th>
<th>External Elements</th>
<th>Total Time [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element duration [min]</td>
<td>0</td>
<td>19.30</td>
<td>93.97</td>
<td>6.70</td>
</tr>
<tr>
<td><strong>Microelements</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Machine shutdown</td>
<td>Fixing the crane</td>
<td>Test of the jet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31 sec X</td>
<td>clamps 69 sec X</td>
<td>operation 117 sec X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manipulator setup</td>
<td>Insertion of a</td>
<td>Synchronization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>41 sec X</td>
<td>new tool 29 sec X</td>
<td>of jet-machine 166 sec X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Walk to the office</td>
<td>Centering the</td>
<td>Confirmation of</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 sec X</td>
<td>tool position 164 sec X</td>
<td>the first samples 81 sec E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lifting the</td>
<td>Entering the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>previous tool</td>
<td>data into the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>from the machine</td>
<td>documentation 385 sec X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>69 sec E</td>
<td>Tool heating 3811 sec X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spraying the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cylinder 72 sec E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Duration of</strong></td>
<td><strong>Internal</strong></td>
<td><strong>External</strong></td>
<td><strong>Internal</strong></td>
<td><strong>External</strong></td>
</tr>
<tr>
<td>DURATION OF INTERNAL</td>
<td>0.00</td>
<td>12.40</td>
<td>24.67</td>
<td>6.70</td>
</tr>
<tr>
<td>ELEMENTS [min]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DURATION OF EXTERNAL</td>
<td>0.00</td>
<td>6.90</td>
<td>69.30</td>
<td>0.00</td>
</tr>
<tr>
<td>ELEMENTS [min]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Step 6: ANALYSIS OF JET-MACHINE SETUP ELEMENTS AND MICROELEMENTS

• Phase 2: Transformation of internal microelements into external ones

• The moderator moved (in agreement with team members) the green stickers (external microelements) either to column 1 (starting activities) or to column 5 (completion activities).
### Analytical Card - Conversion of Microelements

<table>
<thead>
<tr>
<th>Machine Setup Element</th>
<th>External Elements</th>
<th>Internal Elements</th>
<th>External Elements</th>
<th>Total Time [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element Duration [min]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Shutdown</td>
<td>31 sec X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manipulator Setup</td>
<td>41 sec X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk to the Office</td>
<td>14 sec X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entering the Data</td>
<td>192 sec X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tool Heating</td>
<td>311 sec X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td>43.77</td>
<td>76.20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Start activities**: 73.0 min
- **Tool dismantling procedure**: 12.4 min
- **Tool mounting procedure**: 24.67 min
- **Start of the machine**: 6.7 min
- **Completion activities**: 3.2 min
Step 6: ANALYSIS OF JET-MACHINE SETUP ELEMENTS AND MICROELEMENTS

• Phase 3: Improvements of internal and external microelements

• After the separation of internal and external microelements of machine setup, the team made some suggestions for improvements of internal and external microelements.
## Analytical Card – Improvements

<table>
<thead>
<tr>
<th>Machine setup element</th>
<th>EXTERNAL ELEMENTS</th>
<th>INTERNAL ELEMENTS</th>
<th>EXTERNAL ELEMENTS</th>
<th>TOTAL TIME [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element duration [min]</td>
<td>73.00</td>
<td>12.4</td>
<td>24.87</td>
<td>6.7</td>
</tr>
</tbody>
</table>

### Microelements

- **Machine shutdown**: 51 sec X
- **Fixing the crane clamps**: 59 sec X
- **Test of the jet operation**: 417 sec X

- **Manipulator setup**: 41 sec X
- **Insertion of a new tool**: 29 sec X
- **Synchronization of jet-machine**: 166 sec X

- **Walk to the office**: 14 sec X
- **Centering the tool position**: 164 sec X
- **Potrudite prvih vzorcev**: 411 sec E

- **Entering the data into the documentation**: 3850=192 sec X
- **Lifting the previous tool from the machine**: 69 sec E

- **Spraying the cylinder**: 72 sec E

### Duration of Internal Elements [min]

- 0.00
- 12.4
- 24.67
- 0.70
- 0.00
- 43.77

### Duration of External Elements [min]

- 73.00
- 0.00
- 0.00
- 0.00
- 3.20
- 76.20

### Suggestions for Improvements

1. **Documentation**: Time obtained during walk to the machine - 190 sec
2. **Reduction of walk time by optimization of walking path - 24 sec**
3. **No searching of key – key is always on a fixed position - 50 sec**
4. **Faster water discharge - 12 sec**
5. **Reduction of walk time by optimization of walking path - 25 sec**
6. **Tool preheating before mounting on the machine – executed parallelly - 5 sec**
7. **Container for the granulate should be placed to a fixed position - 39 sec**

### Saving [min]

- 3.66
- 0.60
- 1.90
- -6.16

### NEW TIMES [min]

- 69.34
- 11.80
- 22.77
- 6.70
- 3.20
- 113.01
Step 6: ANALYSIS OF JET-MACHINE SETUP ELEMENTS AND MICROELEMENTS

• **Phase 4:** Standardization of microelements

• The team also carried out a standardization of internal and external microelements and entered the results on the form "Operating instructions for jet-machine setup"
# New operating instructions

<table>
<thead>
<tr>
<th>No.</th>
<th>MICROELEMENTS</th>
<th>Pay attention to:</th>
<th>Figure:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Read operating instructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Check if the new tool is ready</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Setup of new tool handle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Machine shutdown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Program loading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Control of products</td>
<td>Control dept. participates</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Packing of personal tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Packing of vacuum cleaner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Packing of documentation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New path of setup operator
Step 7: REPEATED ANALYSIS OF MICROELEMENTS

• The target setup time defined in step 2 was not achieved, so the team decided to repeat the analysis of machine setup microelements.

• Before the second SMED workshop, the team leader organized a creativity workshop in order to obtain suggestions for improvements, the realization of which would additionally reduce setup time.