Rapid Machine Change Over
SMED (Single-Minute Exchange of Dies)

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Lean/Six Sigma 314 Rapid Change Over
What Will Be Learned

- Traditional methods for change over
- Reducing setup time
- Accounting models
- SMED
- Internal operations
- External operations
- The “Water Spider”
I would like to thank Scott Darpel, Cleveland State, for providing a significant contribution to the body of knowledge in this section.

Robert D. Skillman
Definition of Setup Time

• Traditional View: The time required to remove old tooling, equipment from one production run and install the same for the next run
• Costs associated are comprised solely of setup personnel labor
• Is this the only time lost? The only costs?
Definition of Setup Time

- Real Definition: The amount of actual time between the last good part from the previous production run, and the first good part of the next.
- Setup includes any time that production is stopped.

Traditional View of “Setup”

<table>
<thead>
<tr>
<th>Last Good Part</th>
<th>Locate setup items</th>
<th>Remove /Install items</th>
<th>Trial Runs Make Adjustments</th>
<th>First Good Part</th>
</tr>
</thead>
</table>

Actual time Lost Due to Setup
Setup Reduction Motivation

• Setup time is frequently the most significant factor in scheduling
• Excessive setup times lead to large production lot sizes

\[
\text{Lot Size} = \sqrt{\frac{2 \times (\text{SetupCost}) \times (\text{Demand})}{\text{InventoryCarryingCost}}}
\]

• Large lot sizes lead to:
  – Excessive inventory
  – Long lead times
Economic Lot Size Concept

• Large production orders generate large lots; this is ok
• Small production orders that generate large lots; this is not ok
• Large lots are generated to overcome the costs of setups; this is true
• The economic lot size concept ignores that setup time reduction is possible
Economic Lot Size Concept

• If the lot sizes are increased, the ratio of setup time to the number of pieces produced can be improved – True
• Therefore, generating large lots is more economical – True, but with exceptions
• Reducing setup time is far more useful in generating improved economy - True
Traditional Lot Size Definitions

- Small lot – less that 500 pieces
- Medium lot – 501 thru 5,000 pieces
- Large lot – more that 5,000 pieces
Categories of Production

• Processing – assembly, disassembly, alteration of shape of quality
• Inspection – comparison with a standard
• Transportation – change of location
• Storage – a period of time which no work, transportation, or inspection is preformed on the product
Typical Production Process

1. Store raw materials in a warehouse
2. Transport materials to the machines
3. Store them near the machines
4. Process them in the machines
5. Store the finished products near the machines
6. Inspect the finished products
7. Store the finished products for shipment to customers
Setup operations have traditionally demanded a great deal of time, and manufacturing companies have long suffered from the extreme inefficiency this causes.
Setup Reduction Motivation

- Reducing setup times lowers cost/unit
- Increases capacity
- Efforts lead to standardized process, reducing variation in process results

Does time spent during Setup make the company money?? Setup time is WASTE!
The Seven Wastes During Setup

• **Defects** – wasted products created due to unstandardized setup or during trial runs
• **Overproduction** – The large lots forced by long setups create more product than is needed
• **Transportation** – Excessive traveling when items needed for setup are not stored together
• **Waiting** – Operators and downstream processes must wait while the machine is down
• **Inventory** – Maintaining excessive inventories as a means of dealing with limited setups
• **Motion** – Searching for missing items
• **Processing** – Trial runs and adjustments
Setup Waste Number 8
Perhaps the Most Significant One

Not harvesting and implementing the improvement ideas from the ones who do the work (machine operators and setup personnel)
What is Setup Reduction (a.k.a. SMED)?

- SMED is a technique, developed over a period of 19 years by Shigeo Shingo, that systematically eliminates or reduces the time and skill required to ready a piece of equipment, or workstation, for the production of different items.

- SMED proceeds along four conceptual stages, in a team setting, to work towards setups of less than 10 minutes.
Shigeo Shingo
Author of the Book
A Revolution in Manufacturing, the SMED System

Use SMED and be happy, like me
Setup Terms

There are two types of setup activities:

• Internal Setup – Internal setup items are, or should only be done while the machine is stopped.

• External Setup – External setup items can or should be done while the machine is still running.
Steps to Setup Reduction

1. Evaluate current setup activities to identify all activities, and whether they are currently internal or external
2. Separate internal and external activities
3. Determine which internal activities might be converted to external
4. Reduce time it takes to perform all internal activities (Eliminate, Simplify, Automate)
5. Reduce the time it takes to perform external activities
The Four Basic Steps in a Setup

1. Preparation, after installation adjustments, checking materials and tools: 30%
2. Removing and installing actual tools, fixtures and dies: 5%
3. Measurements, settings and calibrations: 15%
4. Trial runs and adjustments: 50%
The Four Steps Defined

- **Preparation, etc**
  - Making sure parts, tools and dies are where they belong; that they are clean, checked for maintenance needs, and put away properly – checking on proper function

- **Removing and Installing**
  - This is what most people consider to be setup; removing the old, installing the new

- **Measurements, calibrations, etc.**
  - Centering, dimensioning, measuring temperatures, etc.

- **Trial Runs and Adjustments**
  - All the time spent running trial pieces and making adjustments until a good piece is produced
Setup Observation

- Form a team
- Train the team in setup reduction concepts
- Observe and video tape a setup
- Record and classify setup steps, including the time it takes to perform them

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Description</th>
<th>Internal Time</th>
<th>External Time</th>
<th>Improvement Ideas</th>
<th>Internal Time</th>
<th>External Time</th>
<th>Comments</th>
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Setup Analysis

• Convert Internal to External
  – Leave preconceived notions of what MUST be done while the machine is stopped at the door
  – Encourage unfettered creativity of ideas

• Eliminate or Reduce Activities
  – 5S Activities
  – Modifying Equipment
  – Adjustment Time
5S and Setup Reduction

- Area sorted and cleaned
- Use of shadow boards for hand tools
- All necessary tools nearby
- Paperwork and checklists in the area
- Next lot nearby
- Incoming and Outgoing areas are clearly defined
- Visual flow of work through the area
- Dedicated tool or tie carts for each machine/station

75% of the reduction is coming from organization and 5S
Modifying Equipment/Workstations

- Eliminate the need for lifting
- Eliminate large material handlers (small lots!)
- Use power-assisted tools
- Pre-heat when heating is necessary
- Replace threaded clamps with pressure clamps
- Replace nuts and bolts with clamps
- Standardize all necessary nuts, bolts, etc.
Eliminating Adjustment Time

- Use locator pins
- Provide instrumentation to eliminate trial and error
- Document “good” positions for future setups
- Mark setup positions (tape, markers, etc.)

50% or more of current setups are spent adjusting the settings
Improvement Ideas

• Classify improvement ideas in three categories:
  • Short Term: Go out and implement immediately
  • Mid-Term: Idea requires some review, fabrication or training – can be implemented within 1-2 weeks
  • Long Term: Idea requires some planning (moving machines, etc), or investment – implement within the next 3 months
Control

- Standardize and train all on improved setup
- Update control plans/work instructions
- Monitor reported setup times
- Transfer knowledge gained to all other similar machines, workstations or operations – True payback comes from institutionalizing the gains
- Revisit setups often, continually improving
Setup Reduction
Team Members

- Machine Operators
- Setup Crew
- Mechanic/Maintenance
- Industrial/Process Engineer
- Quality
- Planning
- Others, as needed

Anyone touched or affected by setup times should be involved!
How to Do It – Preliminary Actions

• Create a team and Charter
• Observe and film a setup
• Add descriptions (audio) to the film
• Generate a Spaghetti Chart (map of travel by the worker, during the setup)
• Have the setup person wear a pedometer to chronicle distances covered
• Create a list of activities and identify them as internal or external and the time they required
Setup Reductions
Come in Two Categories

1. Changes in methods
2. Changes in the tooling and or machine (mechanical)
   - Changes in methods are not expensive and can generate 60 to 70% reductions in setup time
   - Mechanical modifications can be expensive and should be explored once the benefits have been realized from the methods improvements
Moving Internal Activities to External

- Requires someone to conduct external activities while the operator is still running production
- This is best accomplished by a “Water Spider”
- A Water Spider jumps around enabling many machines and operations to be more efficient
Water Spider

• Highly skilled setup person
• Able to setup all the different machines in the department
• Full time position (highly skilled and properly compensated)
• Allows the machines to have maximum possible “up time”
SMED Example: Pit Crews

How does the crew minimize pit time?
Points for Discussion

• How long does it take a NASCAR Pit Crew to change over four tires?
• How long does it take you to get four new tires, at the local tire store?
• What things employed by NASCAR Pit Crews could be used at the local tire store?
• What things could not be used?
Conclusion

- Reducing setup time delivers dollars to the bottom line
- Significant reductions are frequently possible
- Reducing setup time is far more beneficial than increasing lot size, in order to achieve economy