



Continuous Improvement Toolkit

SMED

Managing Risk

PDPC
FMEA RAID Logs
Fault Tree Analysis
Risk Assessment*
Traffic Light Assessment

Deciding & Selecting

Pros and Cons
Break-even Analysis
Force Field Analysis
Decision Tree
QFD
Kano Analysis
Critical-to Tree
Cause & Effect Matrix
Confidence Intervals
Probability Distributions
Graphical Analysis
Run Charts
Control Charts
Sampling
Brainstorming
Nominal Group Technique
Affinity Diagram
Lateral Thinking
Visioning
Creating Ideas**

Planning & Project Management*

Importance-Urgency Mapping
Cost -Benefit Analysis
Voting
TPN Analysis
Prioritization Matrix
Paired Comparison
Pareto Analysis
Design of Experiments
Regression
Multi-Vari Charts
Relations Mapping*
TRIZ***
SCAMPER***
Mind Mapping*
Attribute Analysis
Flowcharting
Service Blueprints
Designing & Analyzing Processes

Understanding Cause & Effect

RACI Matrix
Stakeholders Analysis
PEST
PERT/CPM
Activity Diagram
Roadmaps
Project Charter
Gantt Chart
PDCA
Control Planning
Gap Analysis
Hoshin Kanri
Kaizen
How-How Diagram
Standard work
Simulation
TPM
Mistake Proofing
Pull Systems
JIT
Ergonomics
Work Balancing
Automation
Bottleneck Analysis
Visual Management
Flow
Value Analysis
5S
Wastes Analysis
Time Value Map
Process Redesign
IDEF0
Value Stream Mapping
SIPOC
Flow Process Chart
Process Mapping

Identifying & Implementing Solutions***

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Understanding Performance

Lean Measures
OEE
MSA
Cost of Quality
Reliability Analysis
Benchmarking
Focus groups
Photography
Measles Charts
Data Collection
Critical Incident Technique
Observations

Descriptive Statistics
ANOVA
Hypothesis Testing
Scatter Plot
Correlation
5 Whys
Chi-Square Test
Fishbone Diagram
Analogy
Mind Mapping*

Confidence Intervals
ANOVA
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Analogy
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Familiar Terms?

SMED:

- Have you participated in a SMED activity before?

Lean:

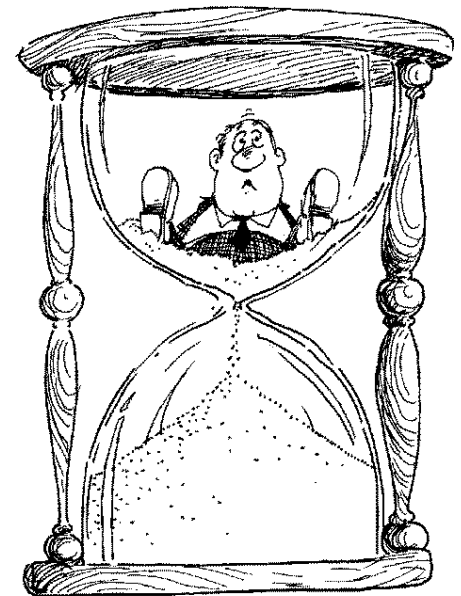
- Do you know what is Lean?

Changeover:

- Are you involved in changeovers?

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- ❑ Stands for: “*Single Minute Exchange of Dies*”.
- ❑ Activities designed to reduce and simplify changeovers.
- ❑ SMED is one of the many Lean methods for reducing waste in manufacturing processes.
- ❑ SMED is a philosophy where the target is to reduce changeover time to few minutes.



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“Single Minute” means:

Necessary changeover time is counted on a single digit.

Why “Exchange of Dies”?

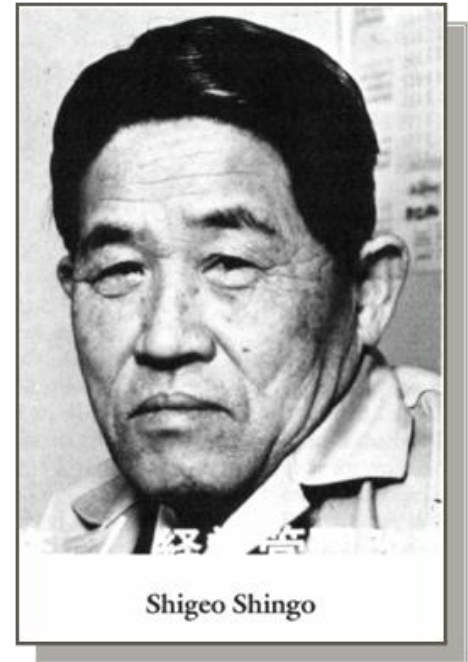
Toyota found that the most difficult tools to change were the dies on the large transfer-stamping machines that produce car vehicle bodies.



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History of SMED:

- ❑ Shigeo Shingo was the originator of SMED system at Toyota in the 1970s.
- ❑ Toyota reworked factory fixtures and vehicle components to maximize their common parts and standardize assembly tools and steps, and utilize common tooling.
- ❑ These standardized steps reduced change-over time from 3 hours to 3 minutes.



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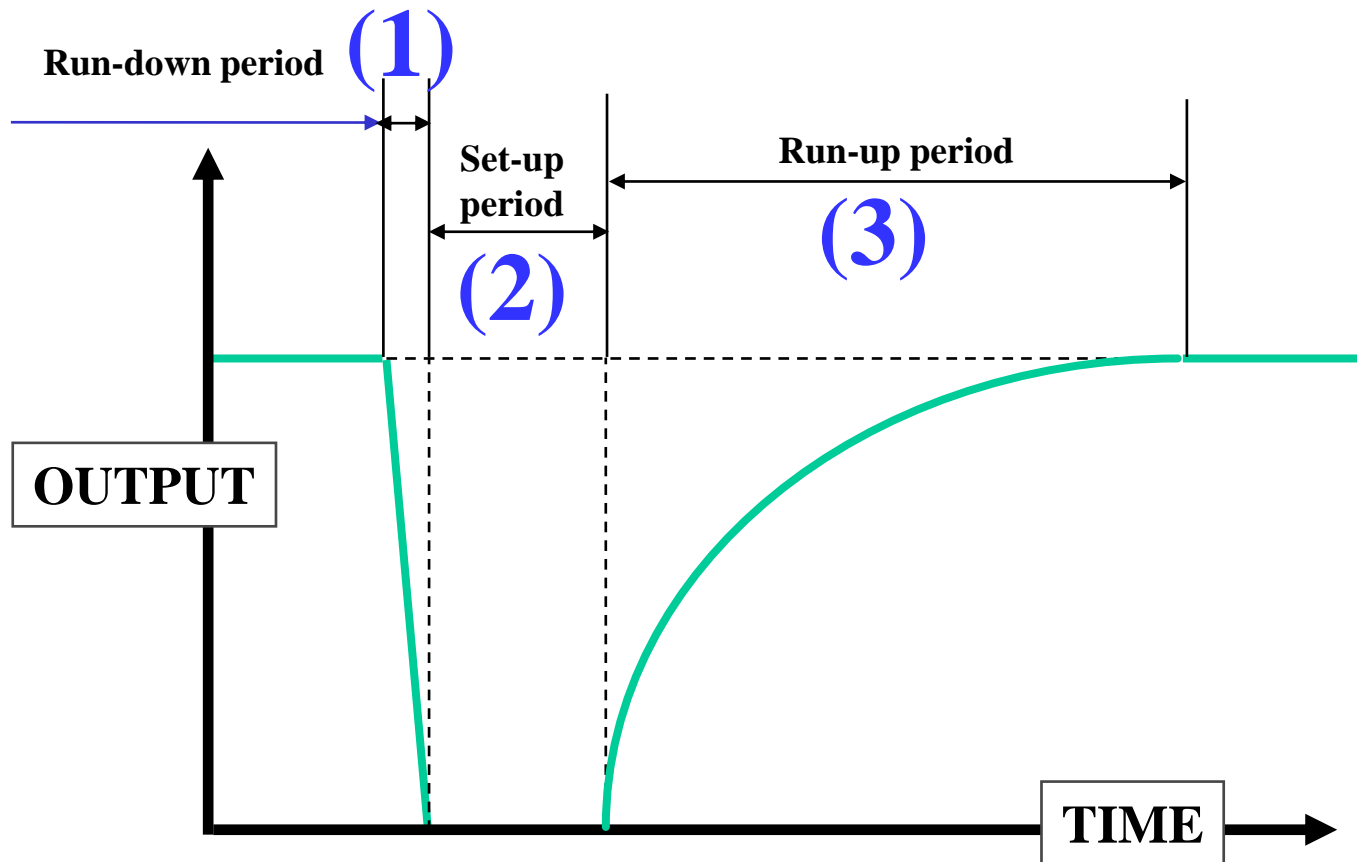
Changeover:

- The time between the last good piece of one run at production speed, and the first good piece of the next run at production speed.

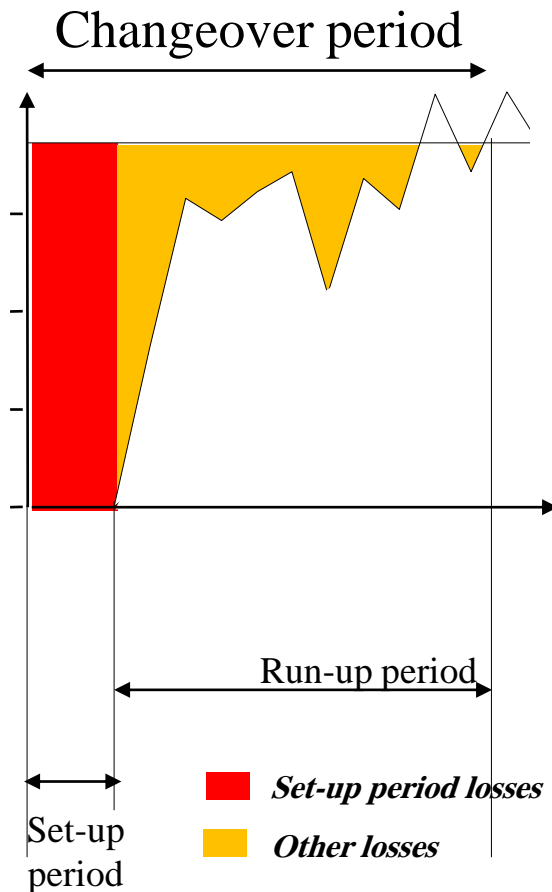


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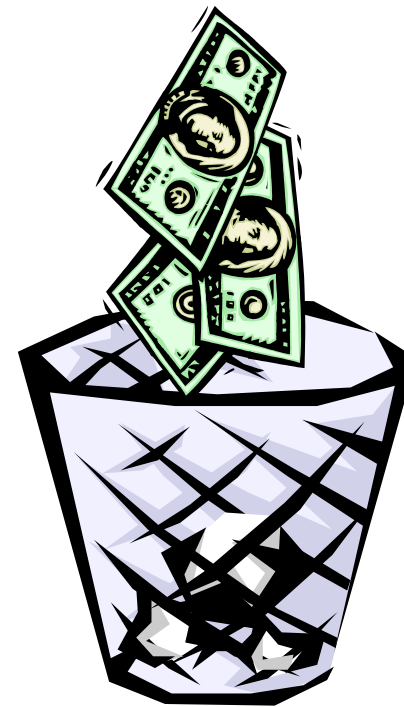
Steps to Changeover:



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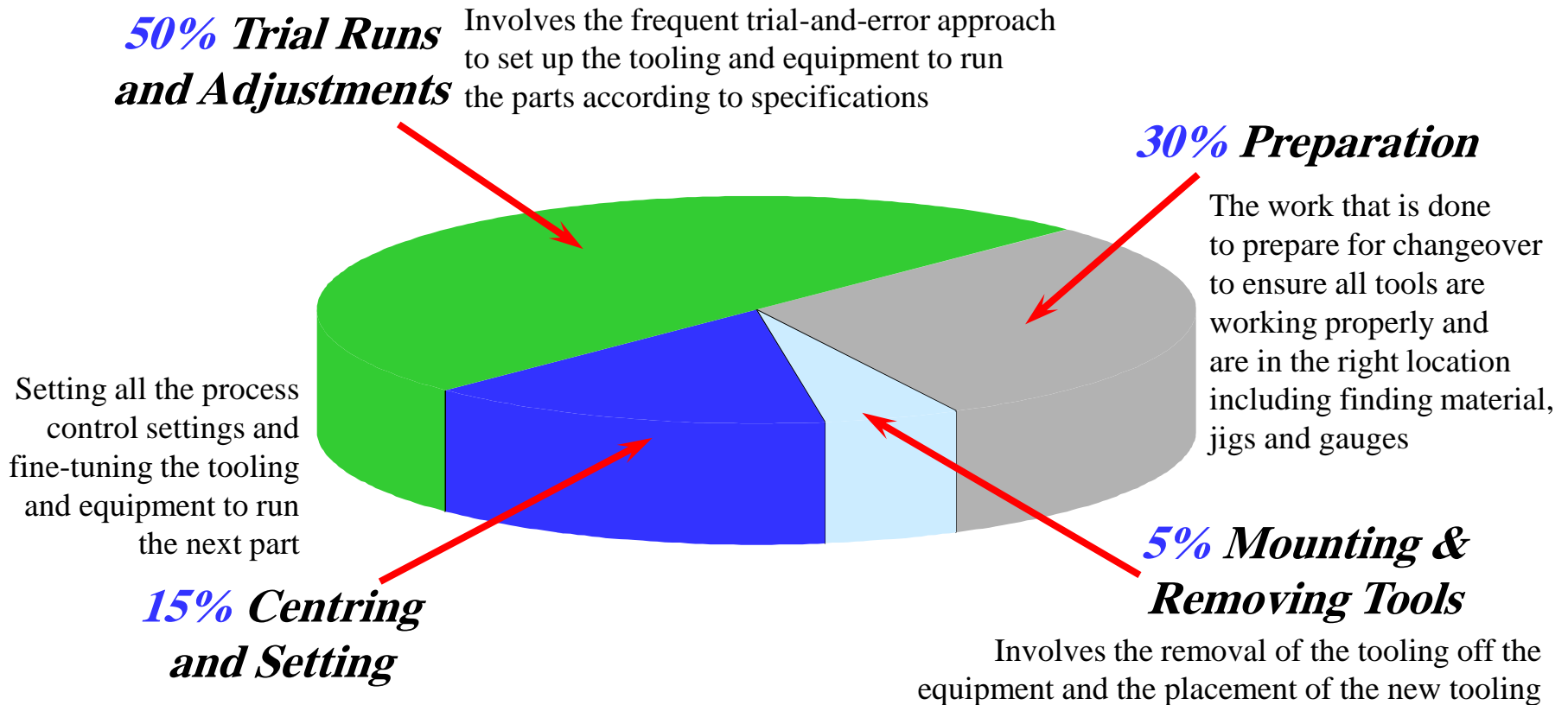


**Changeover times
causes productivity loss**



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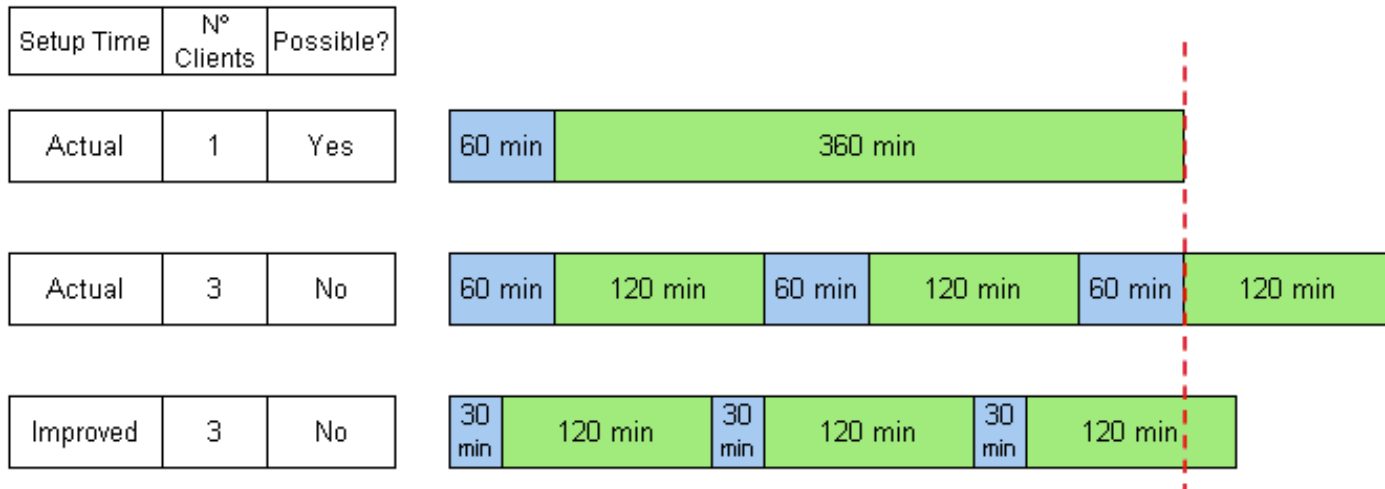
Typical Change Over Activity:



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Why Reduce Changeover Time?

- ❑ In the past, customer demands were for large volumes of the same product.
- ❑ Now, the current trend is moving towards smaller batches.
- ❑ If changeover time is not reduced, it will not be possible to produce the same volume in the same period of time.



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Changeover vs. Maintenance:

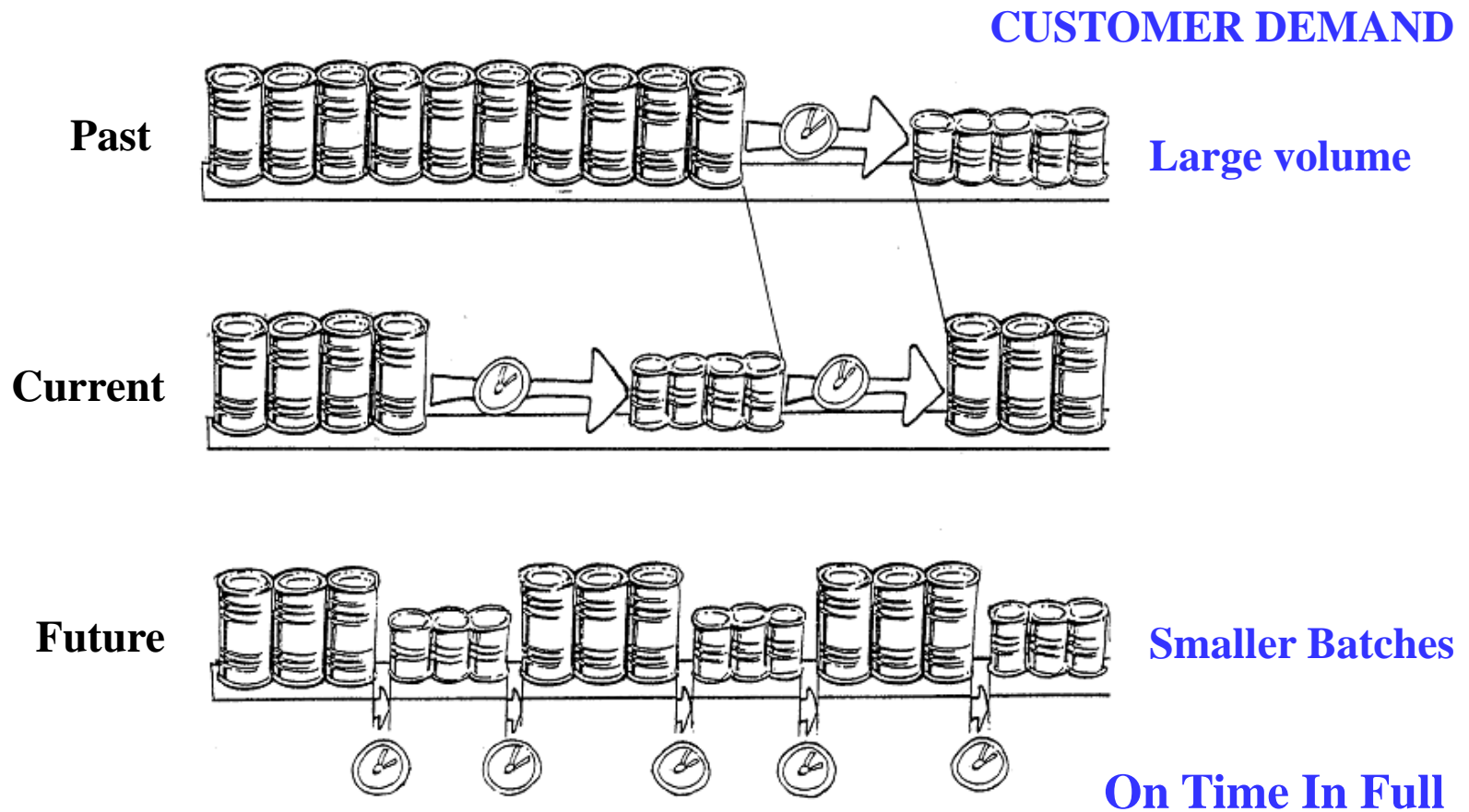
- ❑ **Changeover** is The removal/replacement/adjustment of alternative part(s).
- ❑ **Maintenance** is: The removal/replacement/adjustment of the same part(s).

Good changeover practice
equates to good maintenance
practice



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Why Reduce Changeover Time?



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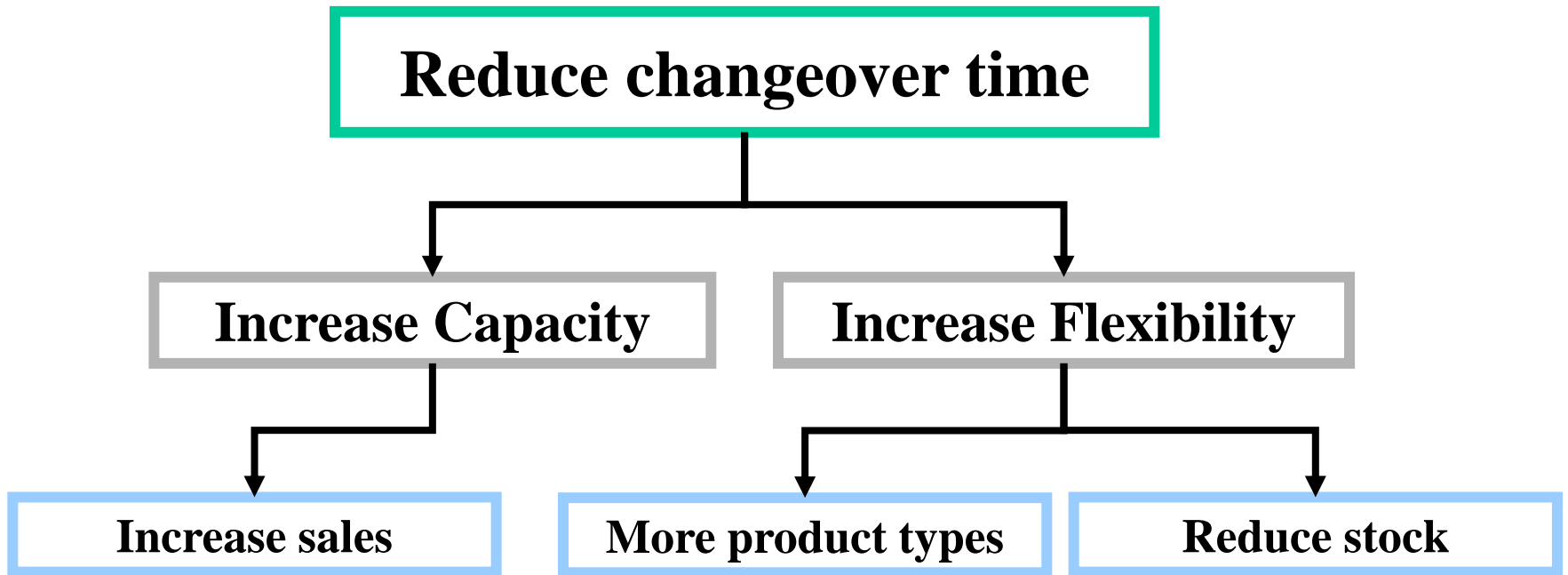
Example – An Illustration of a Demanding Marketplace:

- ❑ Year 2000 47 billion items / Year (2 brands)
- ❑ Year 2004 24 billion items / Year (> 100 brands)
- ❑ Year 2007 Factory was closed.



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Benefits:



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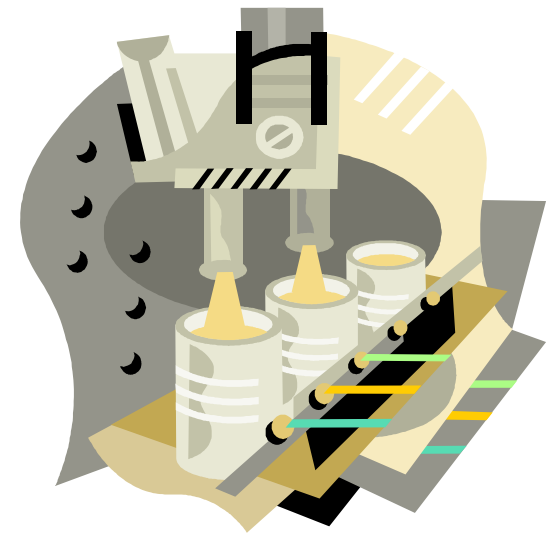
Benefits:

❑ **Increases Productivity (or reduce production time):**

- Shorter changeovers reduce downtime and Increase machine capacity.
- Which means a higher equipment productivity rate and an increase in profit.

❑ **Increases Flexibility:**

- Meet the demands of the growing market and the changing customer needs.
- Diversified product options.



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Benefits:

❑ Quicker Delivery:

- Small lot production means less lead time and less customer wait time.

❑ Improves Quality:

- Quick changeovers lower defects by reducing set-up errors and trial runs of the new product.
- This will improve customer satisfaction and retention.



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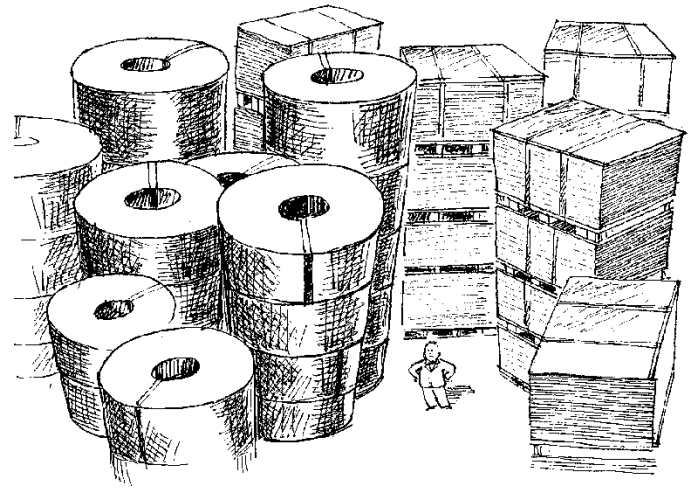
Benefits:

❑ **Increases Safety:**

- Planned and simpler changeovers decrease confusion.

❑ **Improves Process Flow (stockless production):**

- Reduce inventory levels which leads to reduction in working capital.
- Reduce batch sizes.
- Reduce WIPs.



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Other Benefits:

- ❑ Reduces waste in materials and parts.
- ❑ Increases worker utilization.
- ❑ Set-Up becomes easier which leads to operator's satisfactory.
- ❑ Lowers skills requirements since changes are now designed into the process.
- ❑ New attitudes amongst staff that will prevent deviation from standards.
- ❑ Improves workplace organization.



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Organizations Need to Become Leaner:

Customers are demanding:

Product diversity,

Lower cost,

Higher quality & reliability,

So

Organisations must:

Expand the diversity of products.

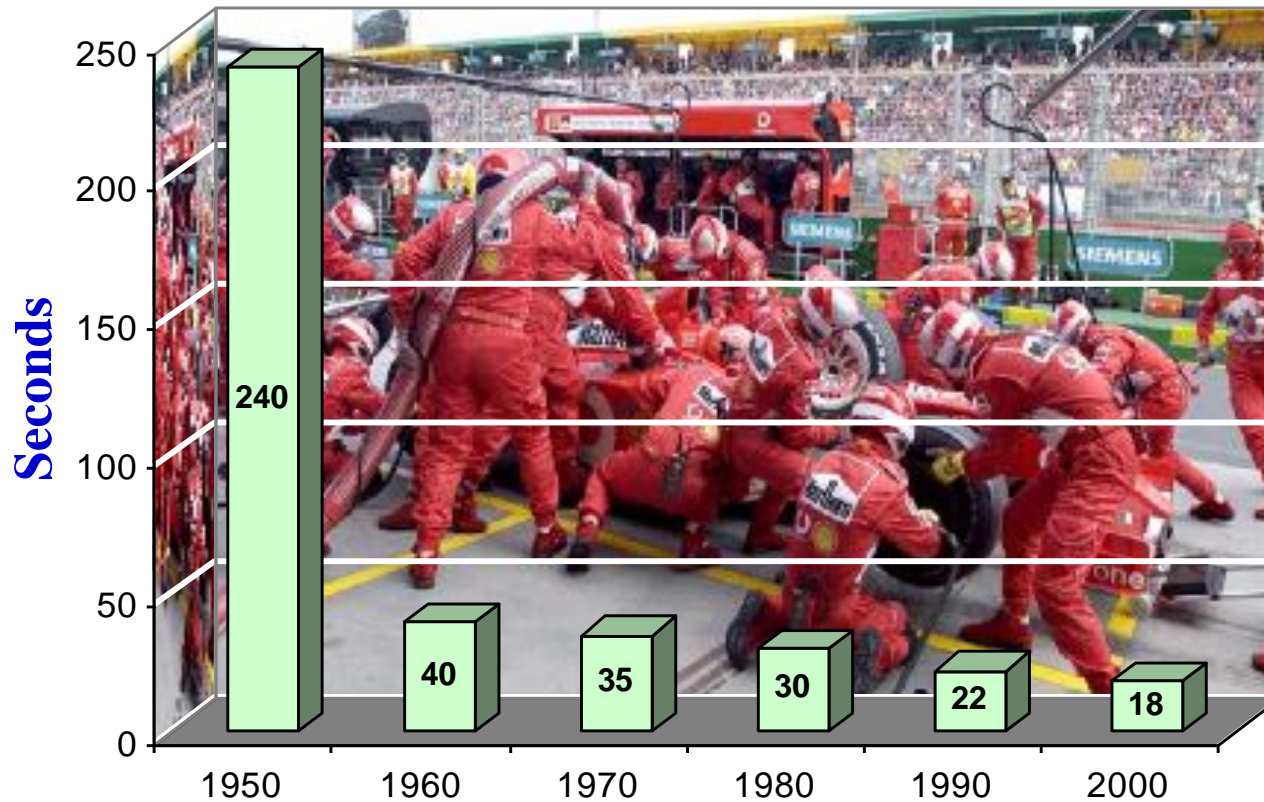
Remove waste in materials & parts.

Reduce quality defects.

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Can We Reduce Changeover Time?

Formula Racing



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Another Automotive Example:

Chain
45 minutes
1.5 minutes

Wheel
30 minutes
13 seconds



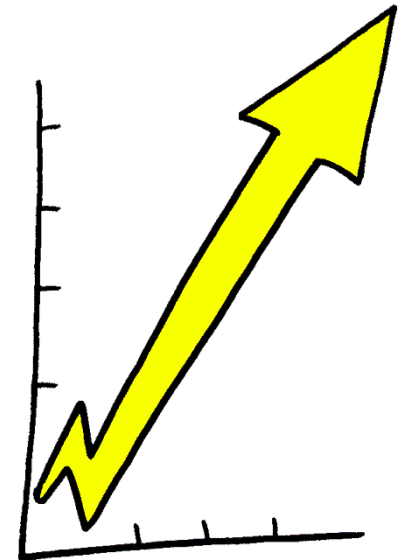
Wiring
5 hours
9 minutes

Pads
30 minutes
15 seconds

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Progression of Changeover Improvements:

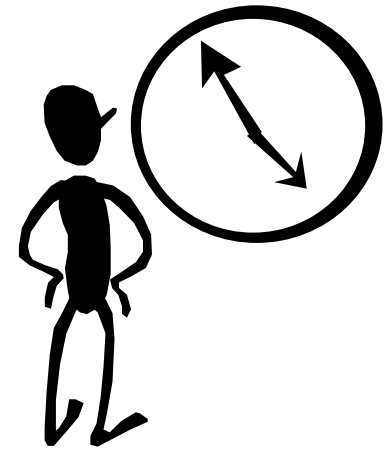
- ❑ **Rapid Changeovers:** Term evolved for non-stamping industries (since SMED was developed in the stamping industry).
- ❑ **Zero Changeovers:** The pursuit of changeovers in any industry taking (3) minutes or less.
- ❑ **Single Breath Changeovers:** The pursuit of perfection.



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Who Should Be Involved in SMED Program?

- ❑ Line operators and maintainers.
- ❑ Line supervisors and group leaders.
- ❑ Changeover team leaders.
- ❑ Process and line engineers.
- ❑ Technical and maintenance personnel.
- ❑ Commercial and quality personnel.
- ❑ Employees of supporting services.



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Roles of the team leader:

- ❑ Represents the team.
- ❑ Ensures the team challenge is clearly understood by all team members.
- ❑ Motivate the team to meet the targets.
- ❑ Allocate individual tasks to team members.
- ❑ Resolve conflicts.
- ❑ Present the status and results to management.
- ❑ Convey the feedbacks from management to team members.



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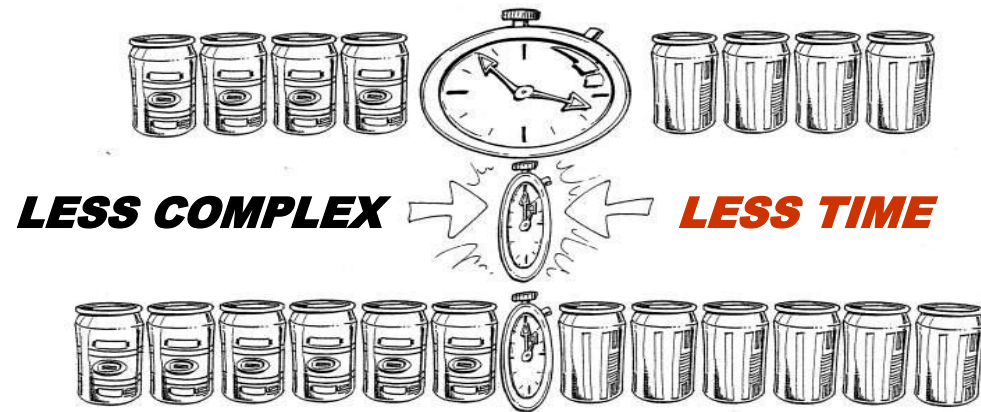
Two Objectives of SMED:

□ Reduce Time:

- Reduce changeover and adjustment times to few minutes

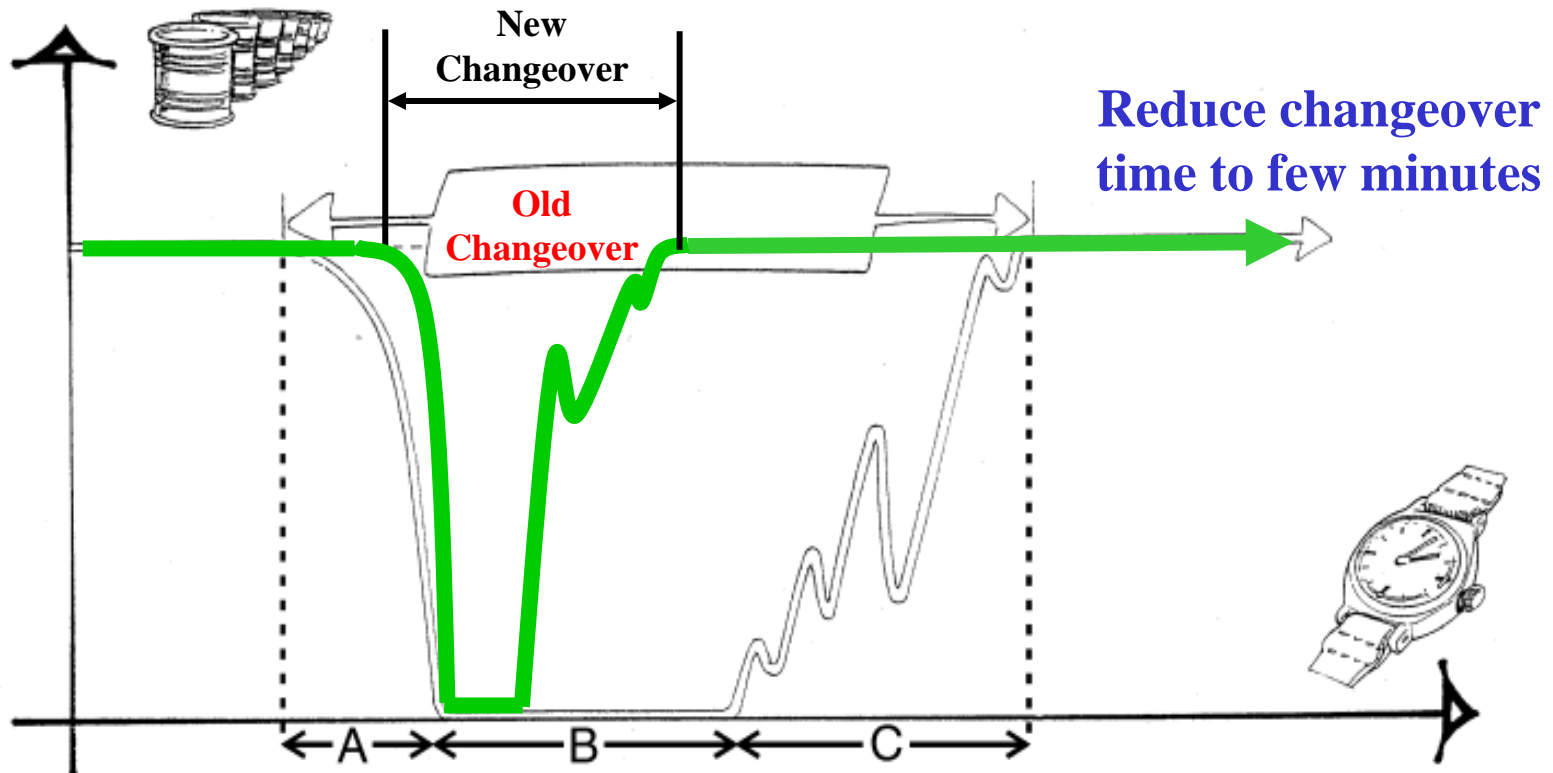
□ Reduce Complexity:

- Not only we are looking for faster changeovers, but also to a higher quality changeovers



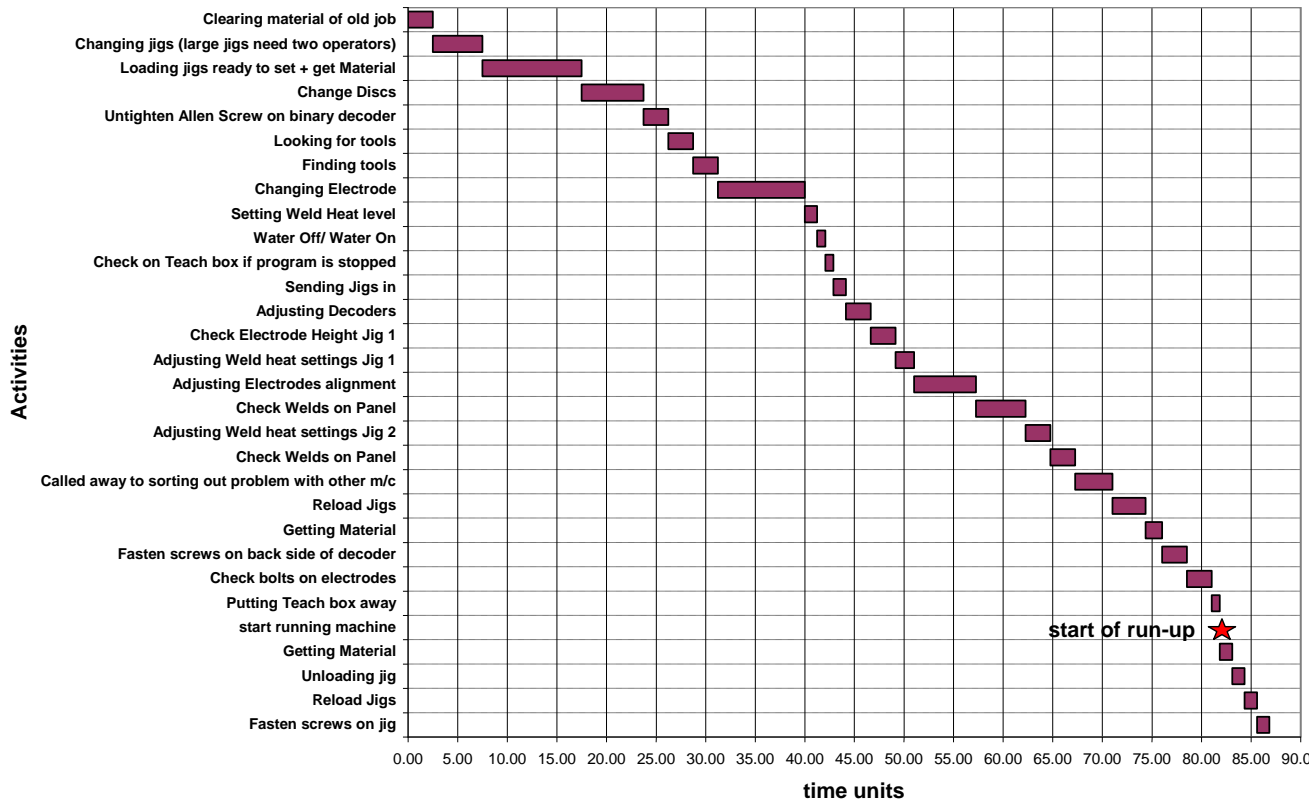
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Reduce Time:



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Reduce Complexity:



Simplification of the changeover activities leads to reduce both time and effort.

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- ❑ **Repeatability:** Few options and standard results.
 - ❑ **Reproducibility:** Same performance by all persons.
 - ❑ **Ensured quality:** No compromise, fewer checks.
 - ❑ **Ensured safety:** No compromise, ergonomical and symmetrical movements.
- Complexity & Variability**
- ❑ **Reduced time:** Quicker and manufacturing scheduling flexibility.
- Time**

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DESIGN TECHNIQUES

Alter **WHAT** tasks occur

Reduce Complexity:

- Reduce activity count.
- Reduce activity difficulty.

Reduce Variability:

- Standardize work practices.
- Standardize physical entities.

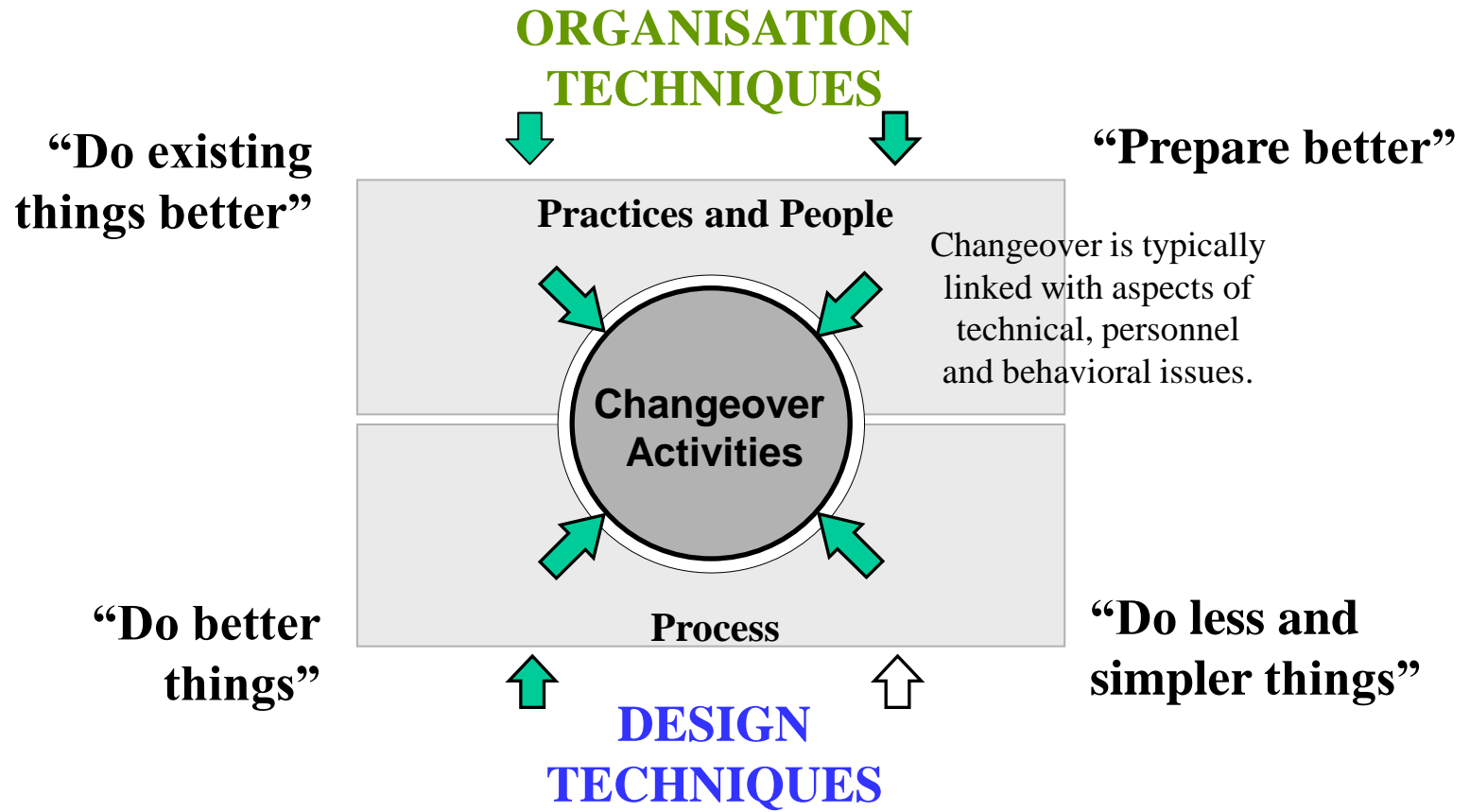
ORGANISATION TECHNIQUES

Alter **WHEN** tasks occur

Optimize Task Sequence:

- Optimize tasks to resources.
- Optimize resources to tasks.

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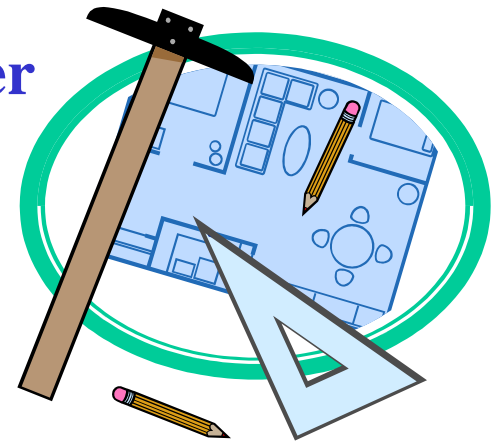


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Design considerations:

- Cost/benefit analysis.
- Internal rules.
- The design rules.
- Implementation time and difficulty.
- Skills required.
- Impact on the run-up.
- Impact on the product quality.
- Impact on safety.
- Sustainability.

**Work Smarter
not Harder**



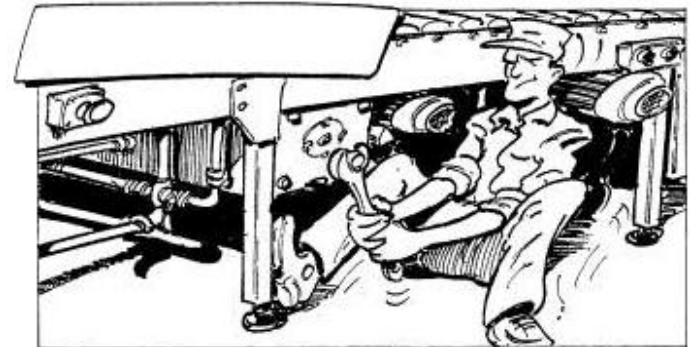
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Some Design Ideas:

- ❑ Reduce variability.
- ❑ Precision fixed locations.
- ❑ Pre-setting devices.
- ❑ Clamping/securing devices.
- ❑ Quick release fasteners.
- ❑ Less tools and parts.
- ❑ Foolproof (no skill).
- ❑ Better access.
- ❑ Modularization.
- ❑ Standardization and universality.
- ❑ Movement and handling aids.
- ❑ Automation and Mechanization.



“Do better things”



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Some Design Ideas:

- ❑ Simplify fittings and tightening.
- ❑ Minimize turning movements which request several grasp-release motions. Aim to fit at once in a single motion.
- ❑ Use shims and spaces to reduce the distance machine components need to move.
- ❑ Standardize types and size of parts and tooling (screws, nuts, bolts, etc.) based on commonality between changeovers. This will reduce the number of setup steps.
- ❑ Fabricate equipment improvements.
- ❑ Use technology and new tooling.



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Some Design Ideas:

□ Look for:

- Any attachment points that take more than one turn to fasten.
- Unheated molds which require several wasted tests before they will be at the temperature to work.
- Inadequate or incomplete repairs to equipment causing rework and delays.
- Mistakes or inadequate verification of equipment causing delays.
- Using devices to help in detecting errors.

Example of One Step Fastening



This clamp attachment requires one step to attach the die to a machine

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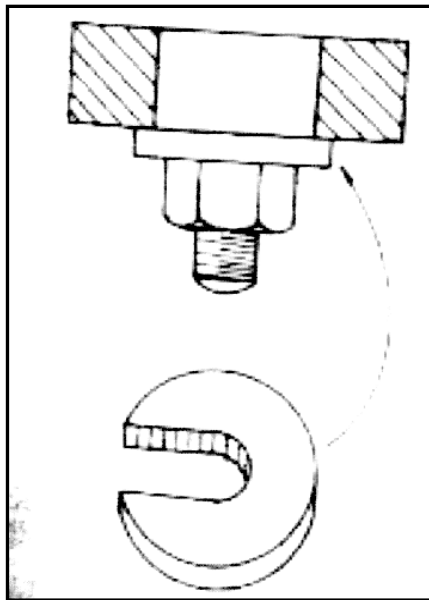
What Other Type of Attachment Devices That Can Be Used?

- ❑ Toggle clamps.
- ❑ Cam action clamps.
- ❑ Auto clamps (including mistake proofing devices).
- ❑ Hook clamps.
- ❑ Quick acting clamps.
- ❑ Swing “C” washers.
- ❑ Swing bolts.
- ❑ Quarter turn screws.
- ❑ Wedges.

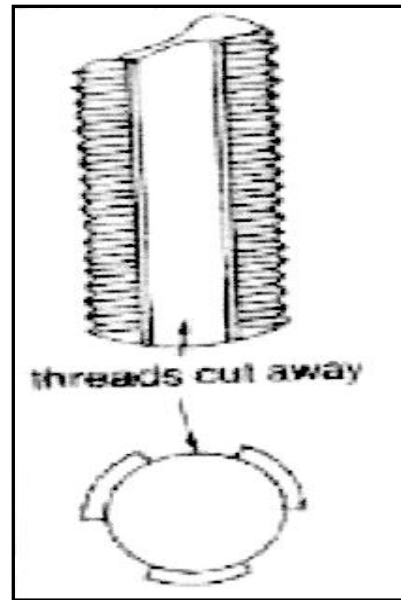


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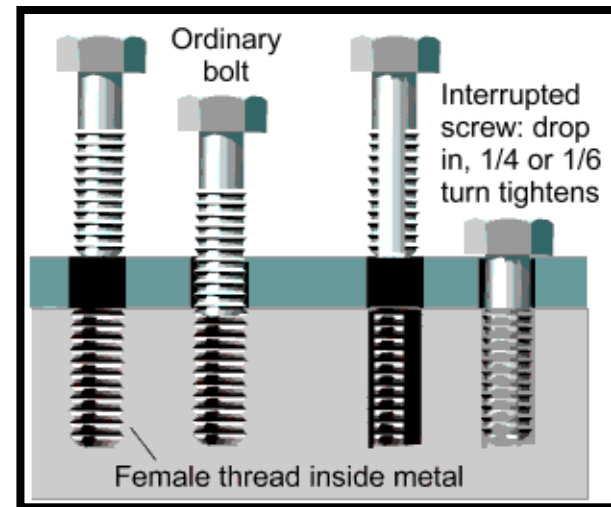
Some Design Ideas:



U-shaped washers



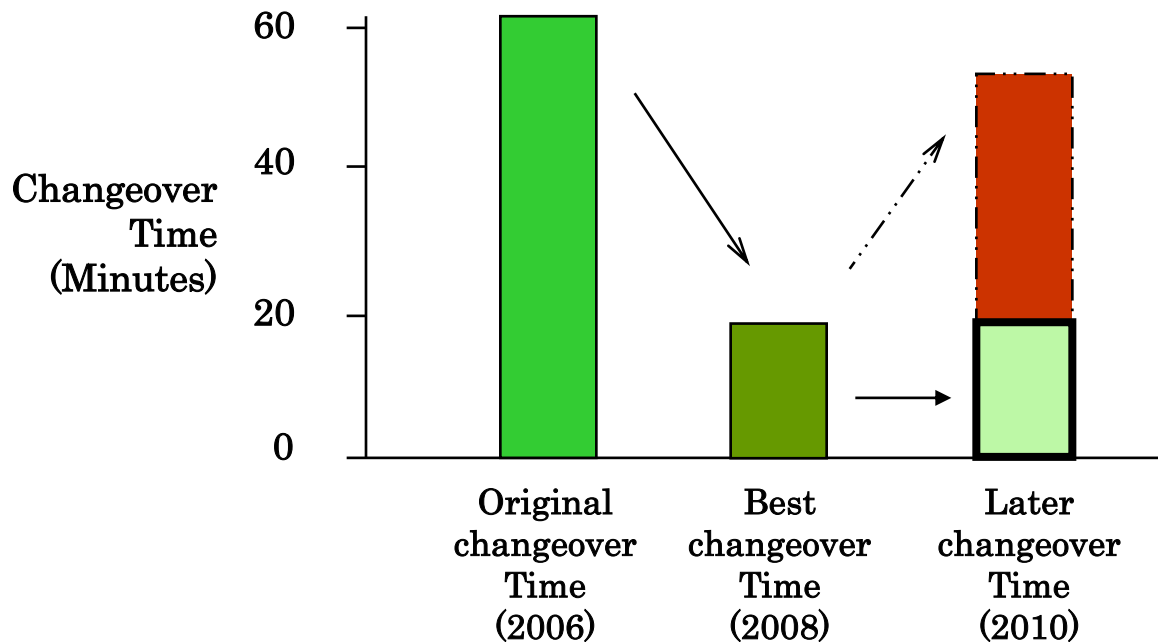
Split thread bolts



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Sustainability:

- ❑ Changeover gains are not necessarily easily sustained.
- ❑ Emphasis on design would help achieve sustainability.



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Typical Causes for Delays in Changeovers:

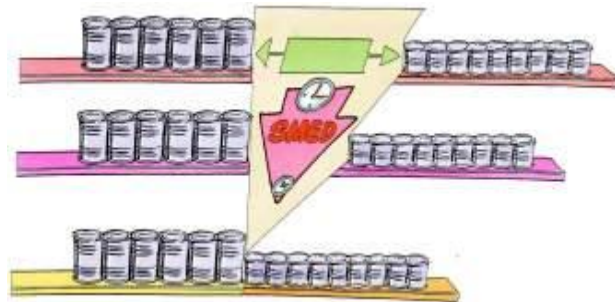
- ❑ Waiting.
- ❑ Searching.
- ❑ Missing tools / tooling.
- ❑ Lack of calibration.
- ❑ Poor schedule information.
- ❑ No checklist.
- ❑ Moving slowly.



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The 4 Steps to Reduce the Changeover Time:

1. Observe and measure.
2. Separate internal and external activities.
3. Convert internal to external activities.
4. Streamline, improve and standardize.



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STEP1: Observe and Measure:

- ❑ The aim is to record data about the way people work during changeover.
- ❑ Data need to be collected in order to analyze the changeover accurately.
- ❑ Production plan and schedule should be followed.
- ❑ Changeover operators should do the first changeover as normal.
- ❑ Analysis of changeover procedures using videotapes.
- ❑ Study the video in detail noting the time and motions involved in each stage.
- ❑ Record improvement ideas.



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STEP1: Observe and Measure:

- ❑ What is the problem?
- ❑ What is the target?
- ❑ What is the current changeover time?
- ❑ What time can we get it down to?
- ❑ What are the activities needed to perform the changeover?
- ❑ What is the actual average time length per activity?
- ❑ Who will participate in the team?



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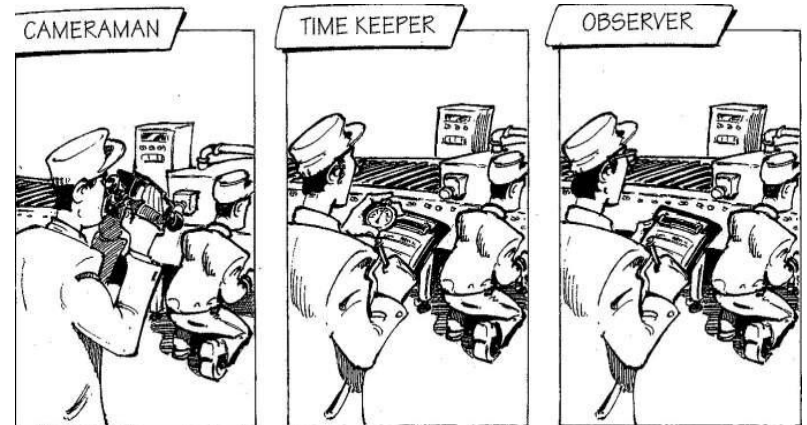
STEP1: Observe and Measure:

- ❑ Establish Roles:
 - C/O Leader & C/O Team.
 - Time Keeper.
 - Cameraman.
 - SOP Observer.
 - Safety Observer.
 - Time Waste Observer.

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First Changeover:

- ❑ Prepare the team for the changeover – who does what?
 - Cameraman: Follow the main activity.
 - Time keeper: Record time for each activity using stop-watch and the total cumulative time as well.
- ❑ Make sure a clear signal is given to the time keeper as to when changeover starts (when the machine runs down).



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First Changeover:

- ❑ The observation sheet is a document to be used by the time keeper.
- ❑ It's used to record both time and activity during the observation of the changeover.

OBSERVATION SHEET					
Changeover:			Date:		Time keeper:
No	Changeover activity	Time	Accumulative	Notes	
Total					

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- After performing the first changeover, the team needs to meet again to review the video and the observation sheet.

Changeover Wall Chart							
Activity							
First changeover date/time							
Internal?							
External?							
Ideas to improve							
Change in SOP?							
Next changeover date/time							
Standard/Benchmark							

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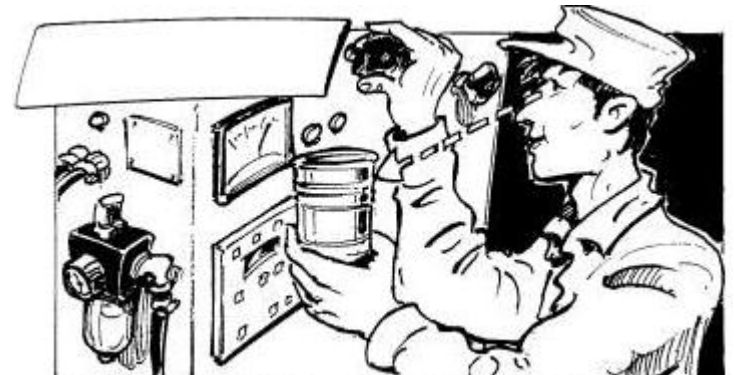
STEP2: Separate Internal and External Activities:

- ❑ Aim: Separate activities which can be done while the machine is running from those which must be done after it is switched off.
- ❑ **External Activities:**
 - Can be conducted while the machine is operating.
 - **Examples:**
 - Finding tools and transportation of tools and parts.
- ❑ **Internal Activities:**
 - Can only be performed when the machine is stopped.
 - **Example:**
 - Changing tools and dies.

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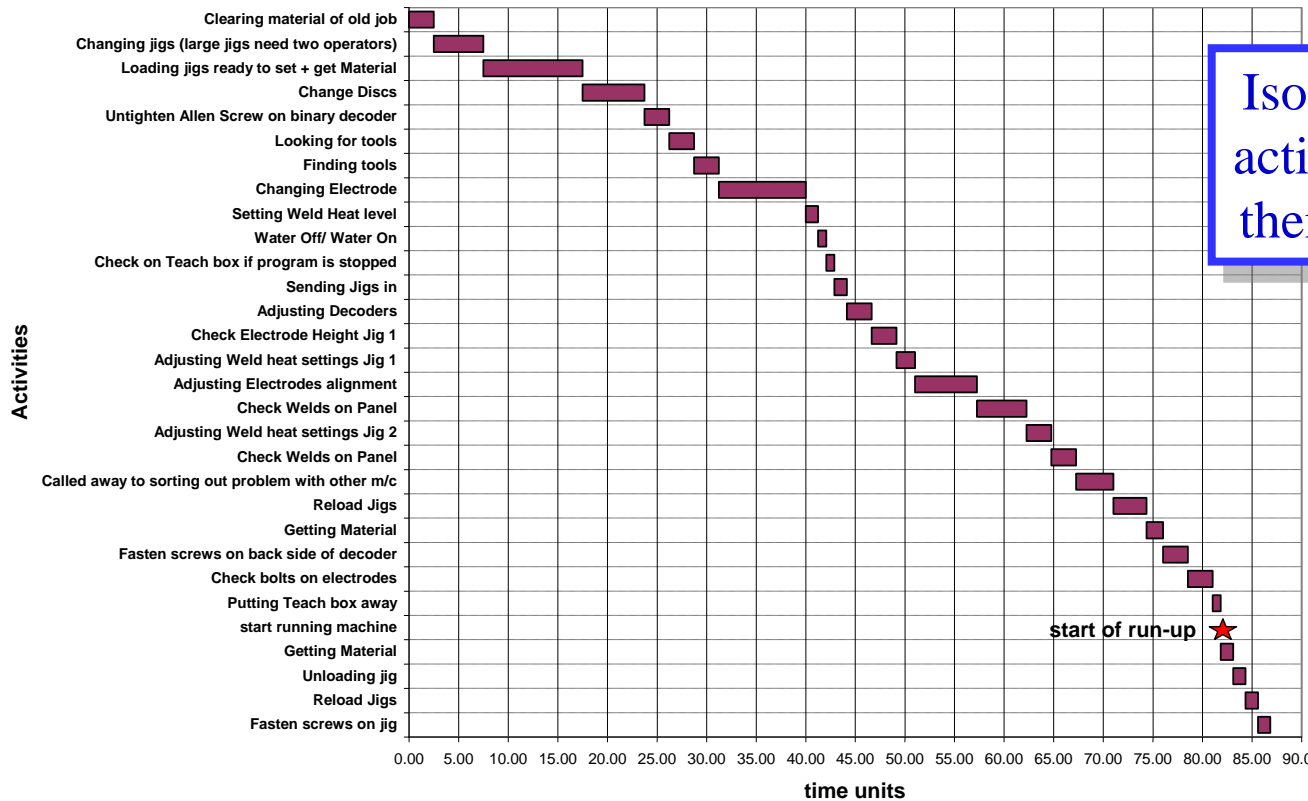
STEP2: Separate Internal and External Activities:

- ❑ Emphasize that tools should be found before the machine is switched off.
- ❑ Isolate individual activities then sort them sequentially.
- ❑ Separate them into internal and external activities.
- ❑ Reduce useless and non-value activities.
- ❑ Reduce adjustments and trials as much as possible
- ❑ Get it right the first time.



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STEP2: Separate Internal and External Activities:



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STEP2: Separate Internal and External Activities:

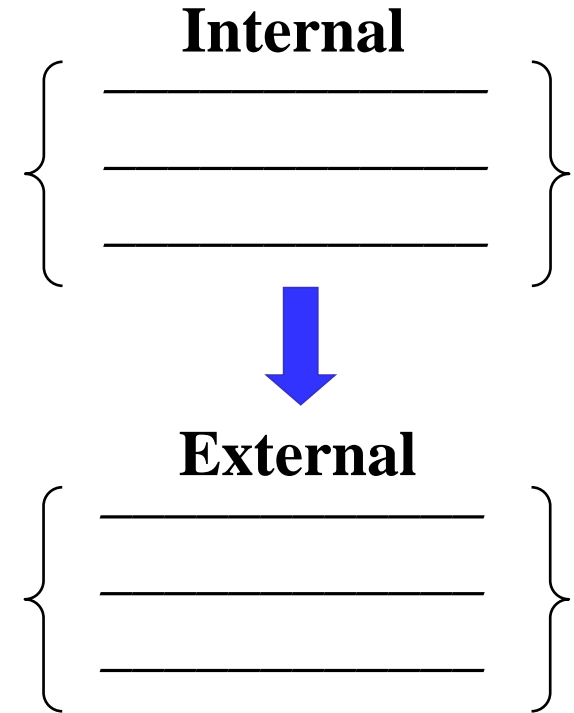
- Use **Changeover Wall Chart** to divide changeover into activities which need to be separated into internal and external activities.

Element									Time
Time									
Internal									
External									
Ideas to improve									
New time									

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STEP3: Convert Internal to External Activities:

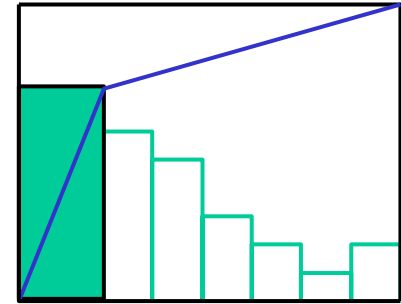
- ❑ Analyze each internal activity to determine whether or not it can be converted into external.
- ❑ Do as much as we can before the machine is switched off and after the machine has been turned on again.
- ❑ You might need to restructure the changeover or setup procedure.
- ❑ Or apply process innovation or technology.
- ❑ The SOP should then be adjusted.



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STEP4: Streamline, Improve and Standardize:

- ❑ The aim is to reduce the internal and external activity time and streamline the changeover process.
- ❑ Discuss each activity on the wall chart.
- ❑ To prioritize efforts, you might need to carryout a Pareto Analysis.
- ❑ It might be necessary to go on the gemba and work with other departments.

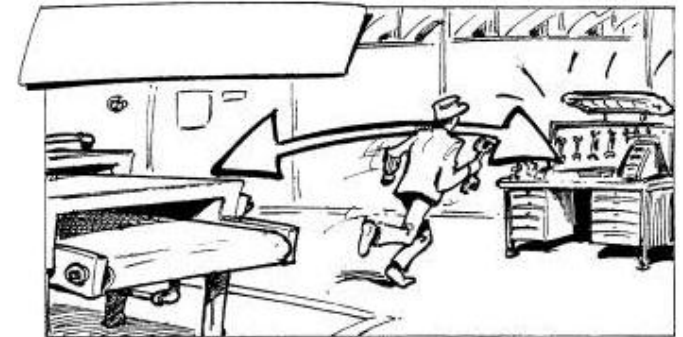


Safety should never be compromised in the effort to reduce changeover time.

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STEP4: Streamline, Improve and Standardize:

- ❑ Eliminate wasteful, unnecessary & redundant activities.
- ❑ Eliminating both in internal and external non-value activities to reduce overall setup time.
- ❑ Identify and eliminate wasted motions and movement around the machine.
- ❑ Eliminate all mechanical and physical variation.
- ❑ Reduce adjustments as possible.
- ❑ Implementing parallel activities as possible.

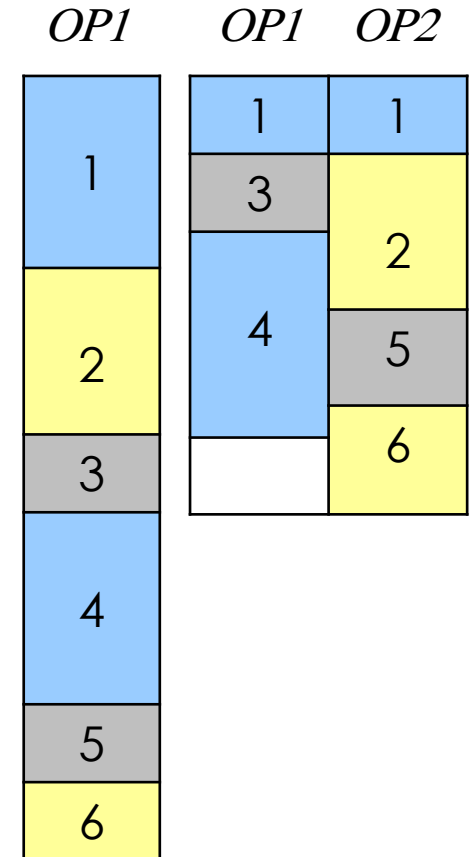


Eliminate All Waste

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STEP4: Streamline, Improve and Standardize:

- ❑ Implementing parallel activities as possible.
- ❑ It's possible to optimize setup time by implementing parallel operations using multiple operators.
- ❑ Effective communication is a must to ensure safety is assured where potentially noise or visually obstructive condition occur.



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STEP4: Streamline, Improve and Standardize:

- ❑ Analyze and minimize all setup tools and fasteners.
- ❑ Standardize tools, types and size of screws, nuts, bolts, etc.
- ❑ Use jigs and templates.
- ❑ Put tools and supplies close by and in an organized manner.
- ❑ Implement design techniques to reduce setup time.
- ❑ Improve storage and transportation of parts and tools.



Reduce and standardize tools

Are the current improvement tools sufficiently capable?

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STEP4: Streamline, Improve and Standardize:

Before



Tools should be available before machine is shutdown for changeover and should not put away until the machine is started for the next product

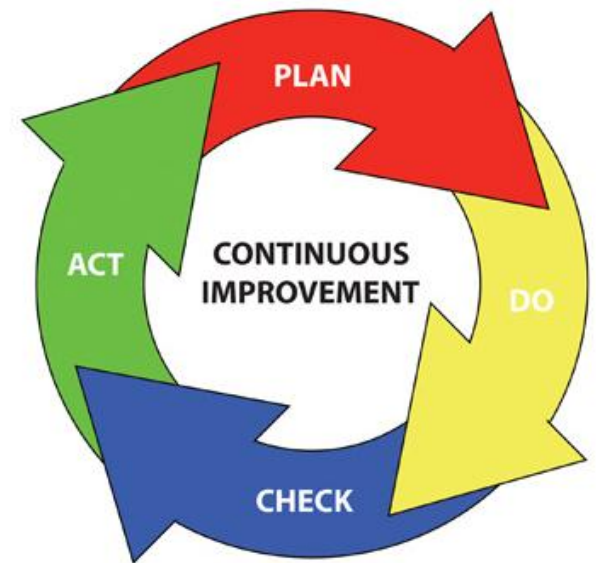
After



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STEP4: Streamline, Improve and Standardize:

- ❑ Improve both internal and external activities.
- ❑ Aim to make all activities instantaneous with no effort.
- ❑ Aim to prepare operating conditions in advance.
- ❑ Minimize internal and external time by:
 - Improving arrangement of activities.
 - Organizing the workplace.
 - Improving attachment operations.
 - Reducing or eliminating adjustments.
 - Reducing any use of experts during the changeover.



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STEP4: Streamline, Improve and Standardize:

- ❑ Standardize activities and organization.
- ❑ Document improvements and develop procedures.
- ❑ Develop standard checklists including tools and specifications.
- ❑ All activities should be sustained.
- ❑ Achieve visual management.
- ❑ Implement 5S.



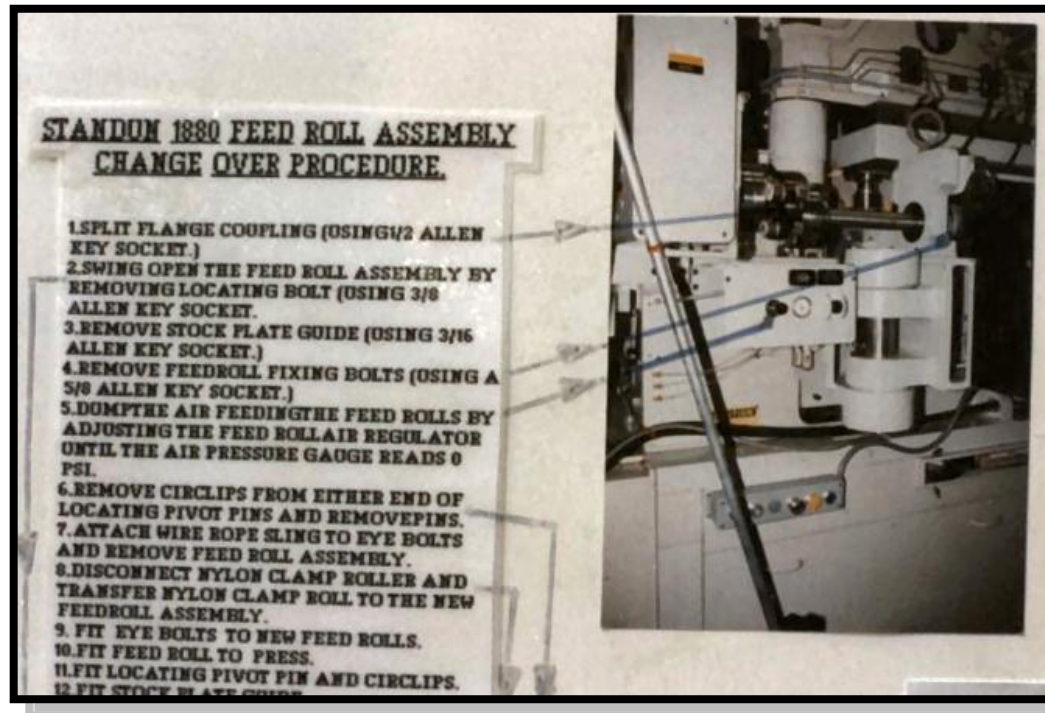
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- 5S:**
- ❑ 5S are activities designed to create and maintain a disciplined workplace.
 - ❑ 5S will provide a standard conditions in the workplace allowing an changeovers to be faster and more reliable.



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Changeover Procedure Example:



Team Exercise

- The target is to permanently reduce the average changeover time and set standards to sustain the improvement.



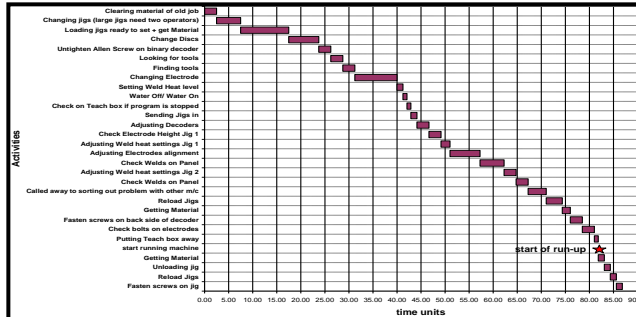
What time can we get it down to?

Team Exercise

- What is the problem?
- What is the target?
- What is the current changeover time?
- What time can we get it down to?
- What are the activities needed to perform the changeover?
- What is the actual average time length per activity?
- Who will participate in the team?



Team Exercise

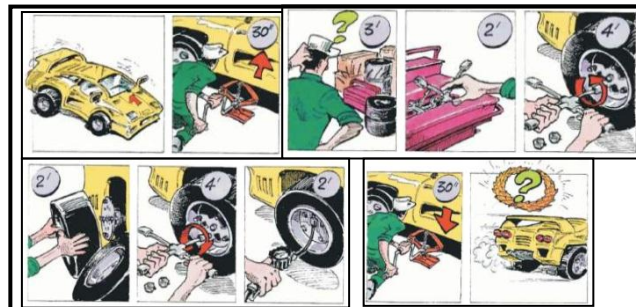


Gantt Chart

Element							Time
Time							
Internal							
External							



Changeover wall chart

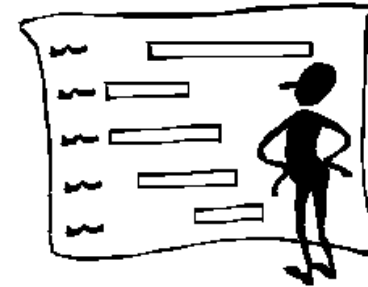


Pictures

Team Exercise

Example of Performance Activities:

- Preparation ? minutes
- Pre-meeting ? minutes
- Clean fountains ? minutes
- Wash up cleaning ? minutes
- Stop machine ? minutes
- Remove cylinders ? minutes
- Add new inks ? minutes
- Put new cylinders ? minutes
- Run machine ? minutes
- Registration ? minutes
- Color adjustment ? minutes



**Total actual
changeover time
= 40 minutes**

Team Exercise

Remember:

- Data need to be collected in order to analyze the changeover correctly.
- Persons carrying out the changeover should always be the same as far as is possible.
- Production plan and schedule should be adopted.

Who else?

Assistant Leader 2nd man



Changeover team

Team Exercise

Think of:

- Can we externalize activities?
- Some items take a long time because they are complex, can we simplify them?
- Can we re-design to eliminate activities?
- Can we combine activities so they can be done quicker?
- Can we perform tasks in parallel?
- Can we reduce the amount of time taken in any way?
- How can we create a more disciplined workplace in which changeovers are faster and more reliable?



Team Exercise

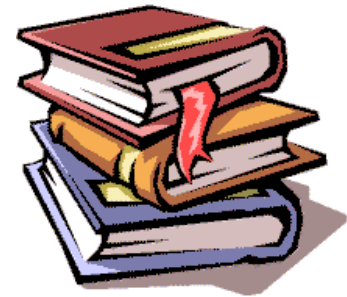
Second Changeover:



Team Exercise

What's Next:

- A new Standard Operating Procedure(SOP) must have been developed and agreed by the shop floor people.
- The team should develop a continuous improvement action plan.
- The team should put what was taken from the workshop into practice.
- The team may conduct some practice runs to be more comfortable with the new practices.
- Continuous evaluation and exploration of further improvements is absolutely necessary.



Practice Makes perfect

Team Exercise

Post-workshop Improvement Action Plan:

- The action plan should be validated by the management.
- The team leader should ensure that the action plan is properly implemented within the agreed timescale.

IMPROVEMENT ACTION PLAN

Changeover:		Update:		Controlled by:					
Action	Priority	Category	Resp.	Week1	Week2	Week3	Week4	Week5	Week6

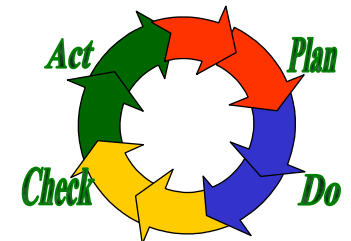
Categories: Organizational action, Technical improvement, Training or Resources

**Priorities: 1: during the workshop, 2: after 6 weeks, 3: after 12 weeks,
4: more than 12 weeks (capital expenditure)**

Team Exercise

Date:

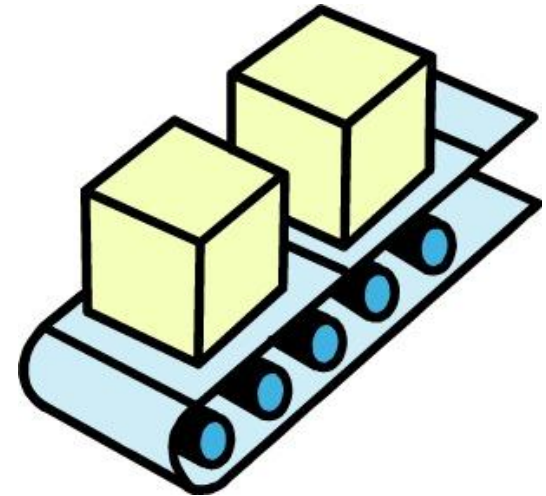
Area/Department		Machine/Equipment Name		Set-up Tools Required		Operator Number		Standard Set-up Time	
						Date Prepared		Minutes	
CURRENT PROCESS			CURRENT TIME		IMPROVEMENT			PROPOSED TIME	
NO.	Task/Operation	Internal	External				Internal	External	
Current Total:				Improve Total					



- SMED Workshop

Training Summary:

- ❑ SMED helps achieve higher productivity, greater flexibility, and higher throughput.
- ❑ SMED needs to be treated as a constant improvement program.
- ❑ SMED is a tool which will allow us to focus on eliminating waste.
- ❑ The causes of wastes will be systematically detected, analyzed and eliminated.
- ❑ SMED needs to be treated as a constant improvement program.
- ❑ Continuous evaluation and exploration of further improvements is absolutely necessary.
- ❑ Practice makes perfect.



- SMED Workshop

Reference:

Productivity Press:
ISBN 0-915299-03-8

