UNIVERSITÀ DEGLI STUDI DI TRIESTE

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INDUSTRIAL PLANTS II

Chapter one – part 5:

Lean manufacturing

OVERALL EQUIPMENT EFFECTIVENESS

SINGLE MINUTE EXCHANGE DIE

TOTAL PRODUCTIVE MAINTENANCE

FAILURE MODE EFFECTS ANALYSIS

DOUBLE DEGREE MASTER IN

“PRODUCTION ENGINEERING AND MANAGEMENT”

CAMPUS OF PORDENONE

UNIVERSITY OF TRIESTE

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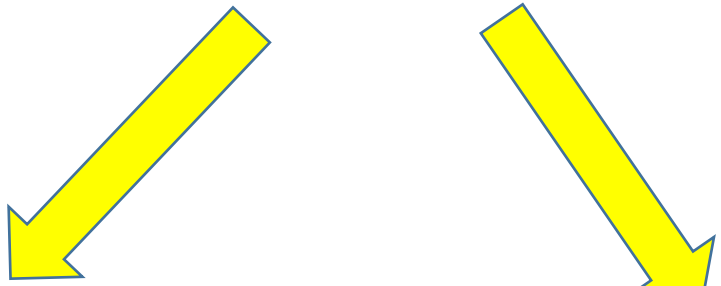
TECHNIQUES AND TOOLS					7 TOOLS	DATA COLLECTION SHEETS	
						STRATIFICATION	
						CORRELATION	
						PARETO'S DIAGRAM	
						ISTOGRAMS	
						CONTROL CHARTS	
						ISHIKAWA DIAGRAM	
					ONE POINT LESSON		
					A3	5 WHYS	
					KEY PERFORMANCE INDICATORS		
					5 S		
				YAMAZUMI	ANDON		FLASH MEETINGS
				TAKT TIME	VISUAL MANAGEMENT		GROUP WORK
			ERGONOMY	KANBAN	STANDARDIZATION		EMPOWERMENT
			TPM	KAIKAKU	PDCA		INVOLVEMENT
			SMED	JIT	POKAYOKE		AGREEMENT
		SPAGHETTI CHART	OEE	HEIJUNKA	KAIZEN		INFORMATION
	WASTES	LABOUR TIMES STUDY	ONE PIECE FLOW	FROM PUSH TO PULL	SIX SIGMA		COMMUNICATION
	HOSHIN KANRI	CURRENT VMS	FUTURE VSM	PULL	JIDOKA		MOTIVATION RESEARCH
PRINCIPLES	DEFINE THE VALUE	IDENTIFY THE VALUE FLOW	SET UP FLOW ACTIVITIES	MANUFACTURE PULLING THE PRODUCTION	RESEARCH PERFECTION		ATTENTION TO PEOPLE
FOCUS	CUSTOMER				QUALITY		EMPLOYEES

OVERALL EQUIPMENT EFFECTIVENESS
O E E



WHAT IS IT?

OEE is an efficiency measure

OEE focus is the increase of the utilization of equipment and techical systems

WHY IS IT SO USEFUL?

OEE includes the most common and important unefficiency causes gathered into categories, in order to monitor, control and improve the performance

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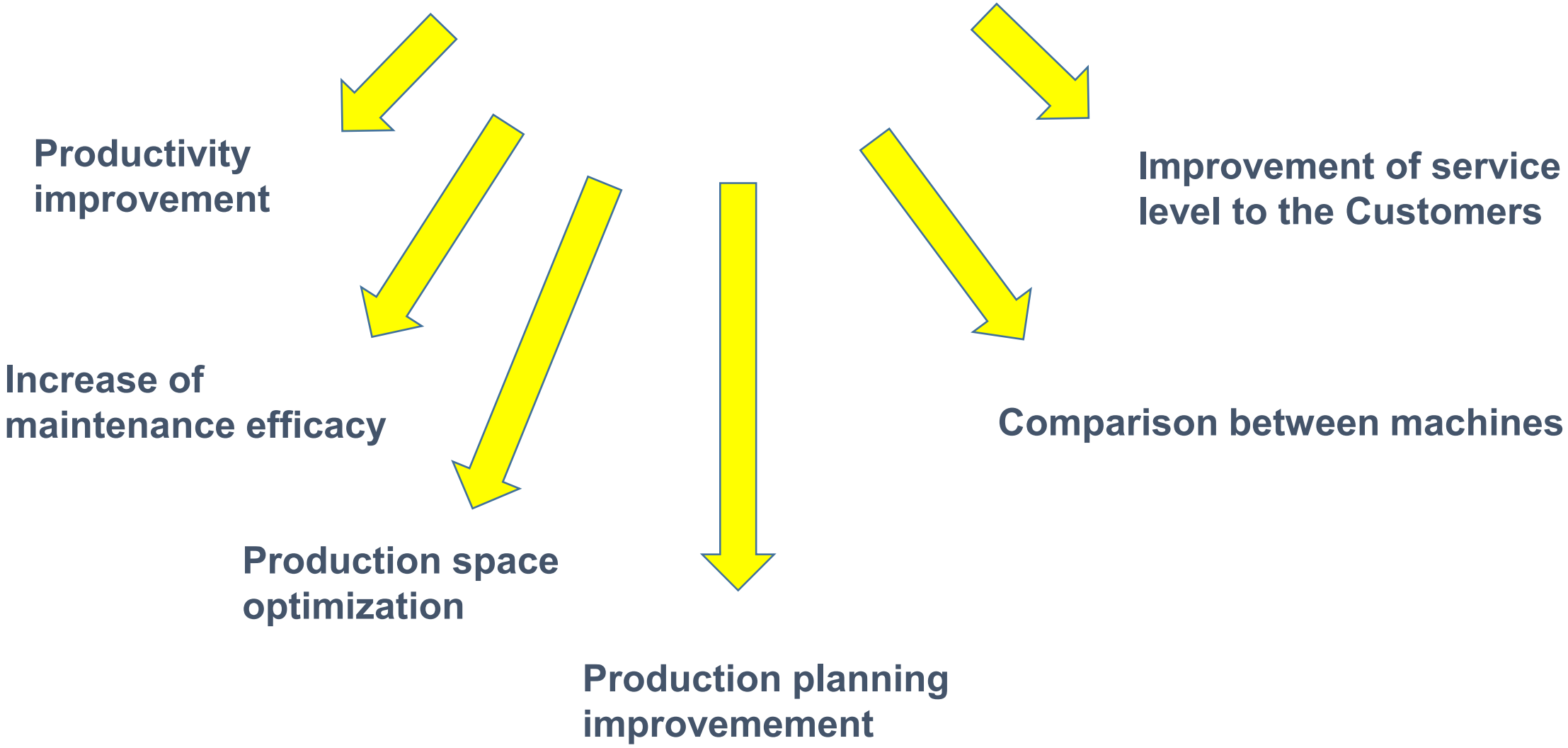
Measure and Improve OEE is crucial to implement different areas



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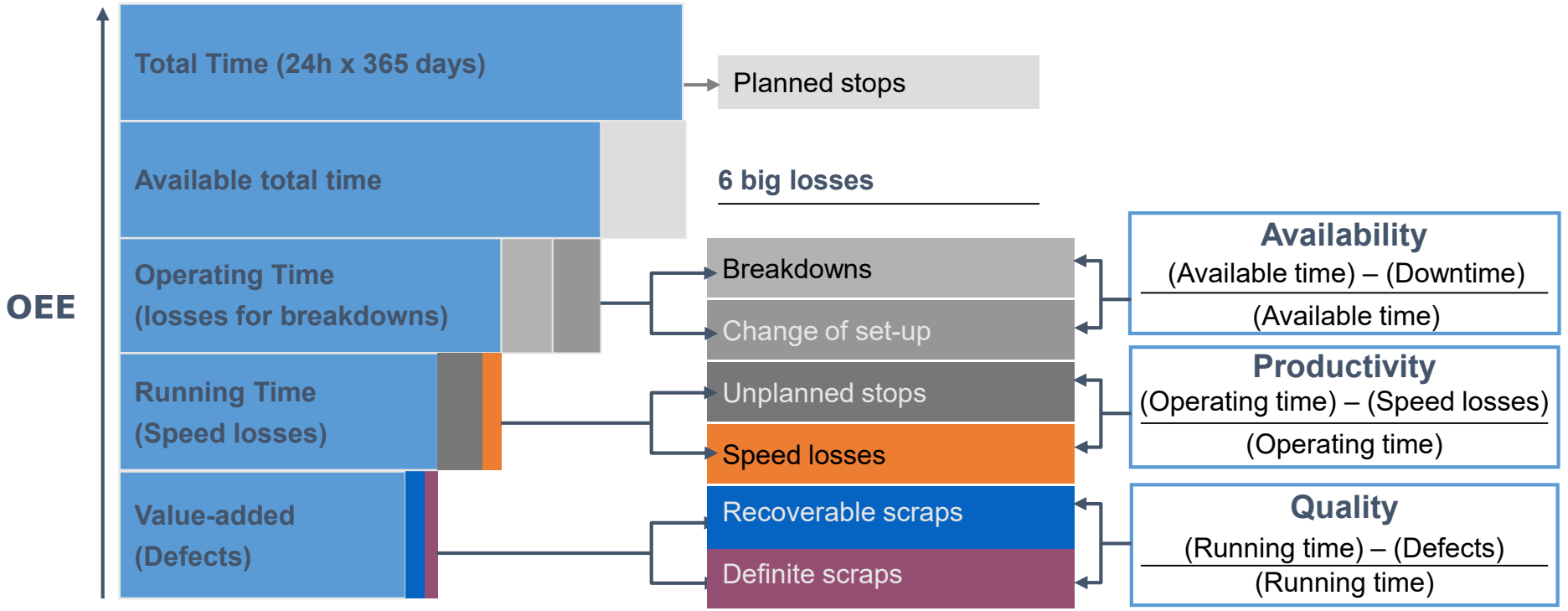
SIX MAIN LOSSES CATEGORIES

OEE (Overall Equipment Effectiveness) = AVAILABILITY x PRODUCTIVITY x QUALITY



PLANNED STOPS

Definitions	Countermeasures
Idle Production line (eg weekends, holidays, night shifts), and scheduled stops (preventive maintenance, cleaning, lunch break, etc.) **Data source: Production planning** **Things to avoid:** • **Be careful not to consider scheduled stops for long set-up times or stops for maintenance** • **Properly consider lunch or shower breaks or for any other contractual arrangement)** • **Distinguish scheduled stops from stops due to lack of programs**	If it is necessary to reduce the scheduled stops to recover production capacity, the calendar must be analyzed and for eg.: • Organize shifts and lunch breaks to have operators always present without stopping the machines • Review the organization of holidays, taking into account the use of temporary staff • Extend production to the third shift • **PUSH ON SALES!!!**

Fonte: McKinsey

STOPS DUE TO BREAKDOWN/FAILURE

Definitions

Wasted time due to a machine breakdown

Data source (exemples)

Production Log book (preferred)

Machine Computer

Maintenance

Things to avoid:

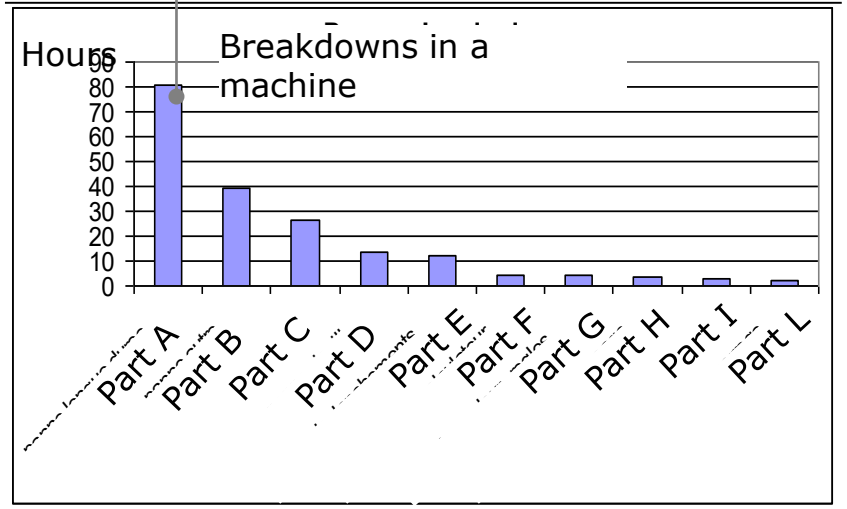
- **Time lost due to machine breakdowns may not be fully recorded**
- **For long break periods, if multiple shifts cannot work, the hours are often counted as "scheduled stops"**
- **Machine downtime should be recorded from the minute the machine stops until it starts, producing without defects.**
- **Most of the time, maintenance only records the intervention time of the maintenance technicians**
- **Some breaking times can only be partially identified, or not declared**
- **Pay attention to temporary solutions**

Countermeasures

- TPM - FMEA
- Analysis of breakdown causes (eg.Pareto)
- 5 whys

The attention is focalised on important breakdowns

Example



Fonte: McKinsey

STOPS DUE TO SET-UP

Definitions

Time lost due to set-up changes, calculated from the last piece produced (without defects) to the first new piece produced (without defects) at a normal speed

Data source (examples)
Production log book (preferred)
Machine computer
Observation / analysis

Things to avoid

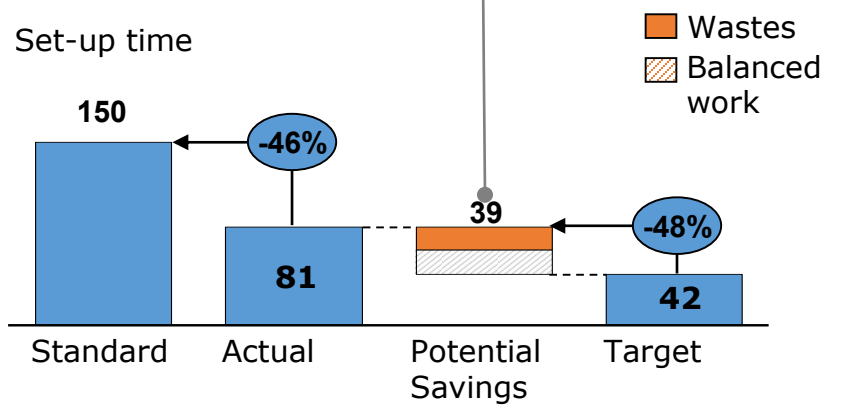
- Often the losses due to the change of set up are not fully recorded
- Set-up changes may not be taken into account for the calculation of the OEE and there is no specific action to reduce their duration
- If the change of set up occurs before a scheduled stop (eg Weekend), the time may not be recorded or the recorded duration may be incorrect
- It is not calculated as the time between the last piece produced without defects and the new piece produced without defects
- It is rounded

Countermeasures

- SMED
- Maintenance or production log book that records all set up changes and durations
- Careful performance management to compare set changes made with standard duration

- 150 minutes are considered for the calculation of the OEE while the change of set up can be done in 81 minutes
- Balancing the work between technicians can reduce time by 48%

Example



Fonte: McKinsey

UNSCHEDULED STOPS

Definitions

- **Lost time due to unscheduled stops different from breaks or set up changes**
- Data source (examples)
- Production log book (preferred)
- Machine computer

Things to avoid

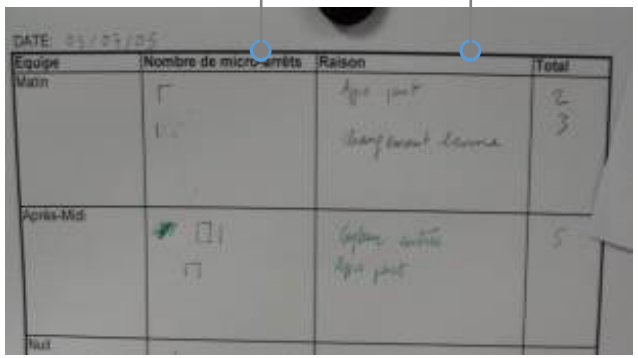
- Most of the time unscheduled stops are not recorded
- The level of recording of unscheduled stops strongly depends on the level of performance management and process repeatability
- Stops shorter than 5 minutes are not reported as no one pays attention to them
- When there is a computer for the machine, they are often reported with wrong reasons (e.g. other stops)
- Unscheduled stops also take into account late starts / early termination of shifts

Countermeasures

- Strong presence of the team leader in the production area to enforce production schedules
- Continuous monitoring of production (eg. an hourly basis) to highlight any deviation from the standard
- Registration of all small stops
- Analysis and solution of the causes of stoppages
- **It is possible to record unscheduled stops with a computer connected to the machinery and prompt operators to enter the reasons for the stop**

Example

Short stops and pertinent causes record



Fonte: McKinsey

SPEED LOSSES

Definitions

Time lost due to the machine running at a lower speed than the standard

Data source (example)
Machine computer
Production

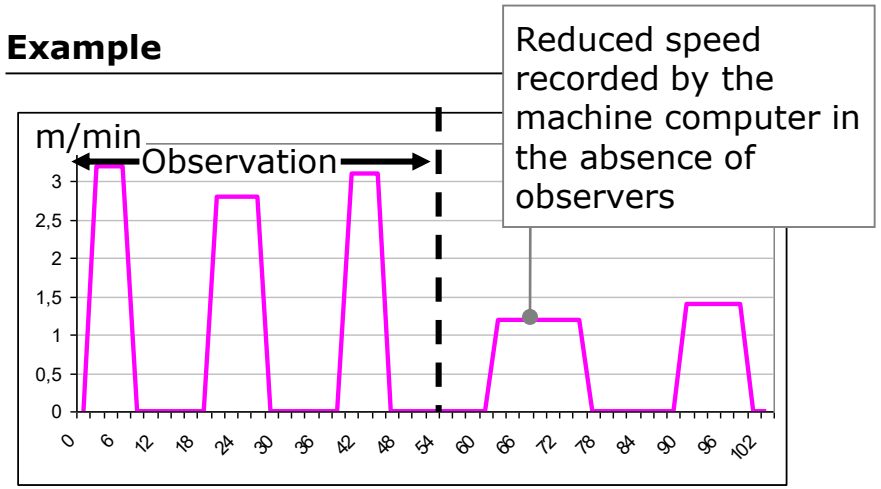
Things to avoid

- Speed reductions are often not recorded
- The speed must be compared to the nominal one and the nominal speed must be verified "live"
- It is often difficult to separate speed losses from reductions and losses from short unscheduled stops

Countermeasures

- Measure "live" with a stopwatch the current speed of the machine. It may be higher than the standard production speed
- In this case, update the standard speed by taking the speed that repeats several times
- Reduce the gap with standard speed through Kaizen workshops
- Increase standard speed through continuous improvement
- Sometimes, the machine's computer records the running time, and it is possible to deduce the speed from the number of parts produced

Example



Fonte: McKinsey

REPARABLE SCRAPS

Definitions

Time lost in manufacturing parts that are not in line with specifications that are rejected during the process, BUT STILL RECOVERABLE

Data source (example)
Quality
Production (Line carryovers)

Things to avoid

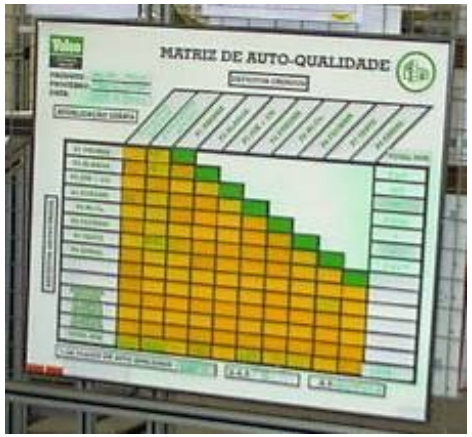
- If there is a specific machinery (external to the production line) to repair the defective pieces and the defective pieces are then re-inserted into the production line, these will not appear in the calculation of the OEE
- Assume that the entire production cycle time is lost for the production of defective parts
- Do not count the parts produced during the set up of the machine, they are already counted in the losses due to the change of set up

Countermeasures

- Root cause analysis and problem solving to eliminate the reasons for defects
- If the problem is due to the raw materials used, define strict quality specifications
- The pieces damaged on the line must be registered at the production site. You can use "auto quality" matrices to count defects and show causes

Example

Auto Quality Matrix



Fonte: McKinsey

SCRAPS

Definition

Time wasted on manufacturing parts that are rejected at the end of the manufacturing process (or later)
Data source (example) Production report Quality

Things to avoid:

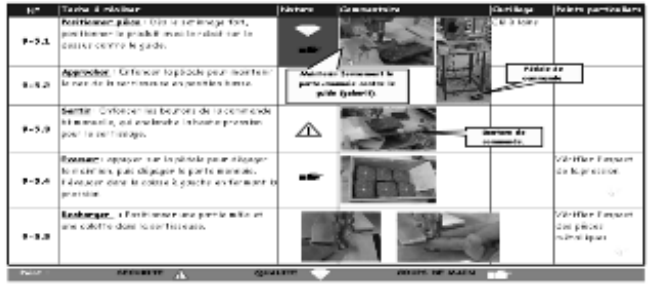
- Quality defects should include defects found later on other production lines, and not only defects found during the final inspection on the line.
- Sometimes, defective parts can be attributed to another order with different specifications and are not counted as quality defects.
- Defects attributed to other manufacturing processes may not be recorded

Countermeasures

- Manually record all quality defects found on the line
- Cause analysis and problem solving
- Production time follow-up
- Define clear standards for operations and quality verification
- Whiteboards showing examples to identify specification acceptance limits or any quality problems that can be identified
- blackboards to follow the production
- techniques to carry out quality controls in specific points of production

Example

Clear Standard showing quality problems



Fonte: McKinsey

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IMPROVEMENT LEVERS

Loss Category		LEVERS: standard work	SMED	TPM	Process Improvements (Kaizen)	Performance monitoring
Availability	▪ Breakdows					
	▪ Setup change					
performance	▪ Unscheduled stops					
	▪ Speed losses					
Quality	▪ Scraps					
	▪ Reparation					

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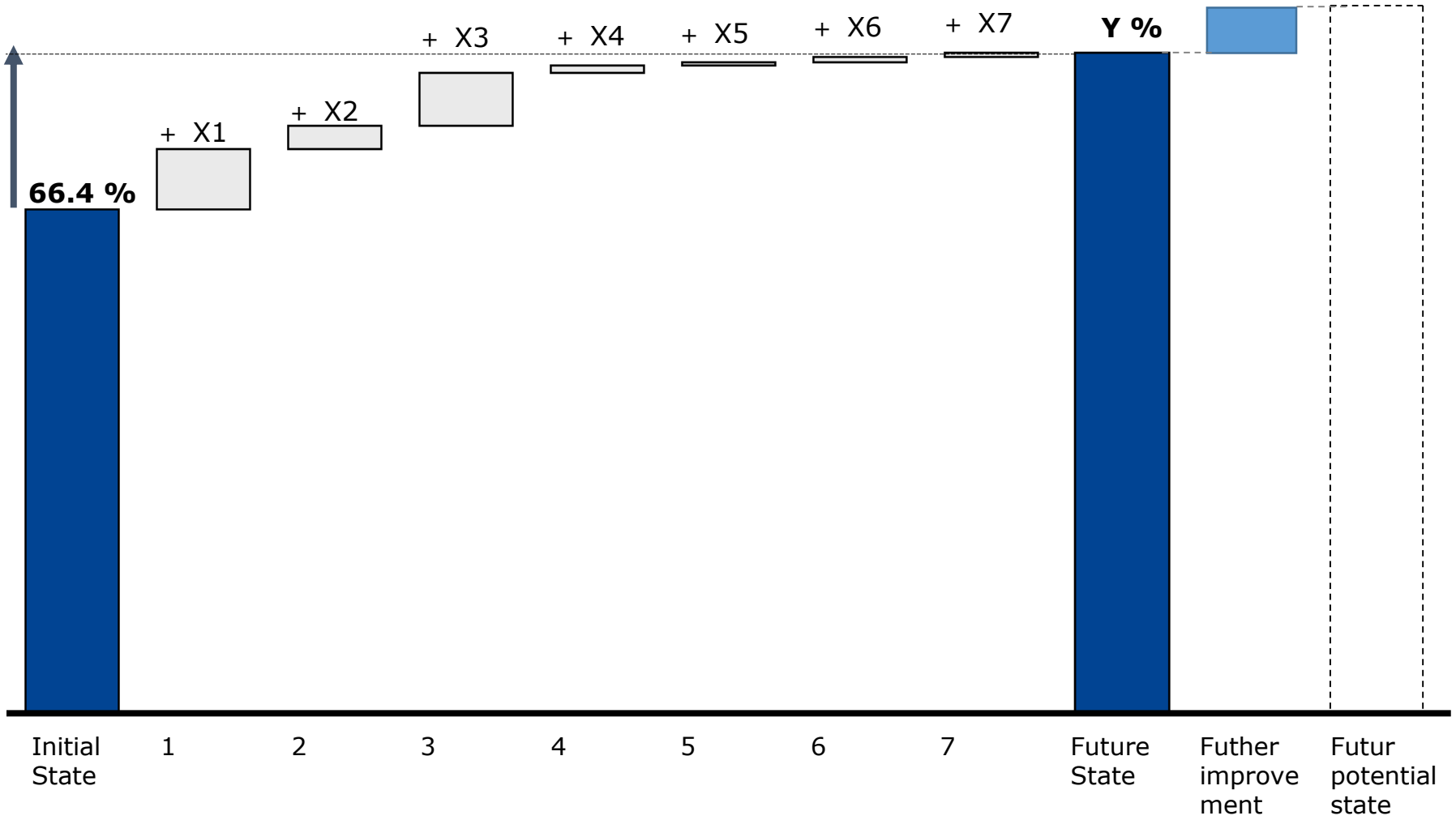
IMPROVEMENT PROCESS



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SMED

Single Minute Exchange of Die

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SET-UP

Set-up **represent all the activities located between the last piece of the present production and the first piece of the successive production**

Problems that could be present normally in a Set-Up:

- No standard method available, therefore activities based on the "mood of the day"
- Variations of change times by model or change of the set-up
- frequency
- Molds, jigs and tools placed incorrectly (waste of time)
- Unnecessary number of loosening and tightening bolts
- Only a worker knows how to fine-tune the next change
- Too many (or too long) running tests follow the change
- …….

Inside and Outside Set-up

- **IED (Inside Exchange Die): Inside *set-up* is done while the machine is idle (eg. Every part substitution).**

- **OED (Outside Exchange Die): Outside *set-up* is done while the machine is operating (eg. During the preparation of the materials necessary for the new batch).**

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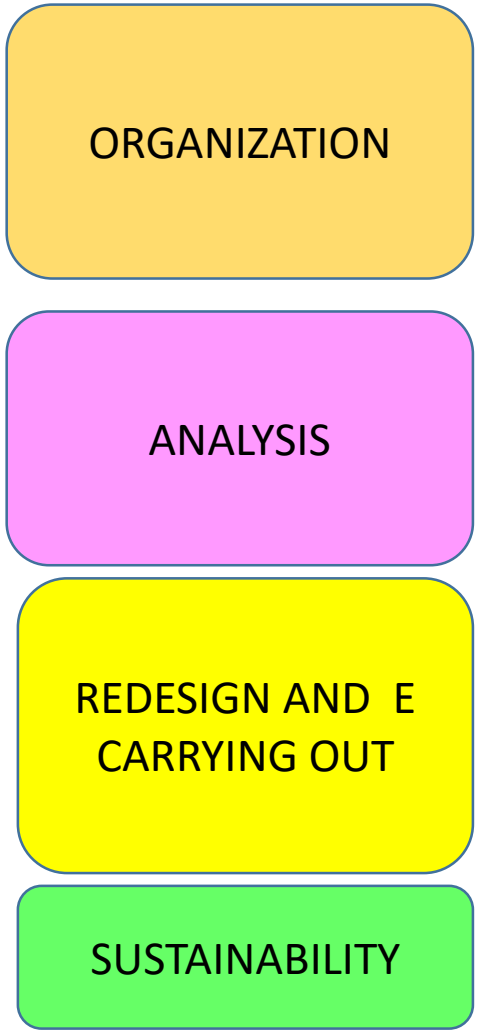
SMED PROCESS

1. Training
2. Team creation
3. Plant / machine selection
4. Data collection
5. Survey by video and observation
6. Setup analysis - stage 1
7. Setup analysis- Stage 2 time separation
8. Stage 3 - Conversion of activities from internal to external, elimination of unnecessary activities
9. Improvement of internal and external activities stage 4
10. Standardization



MEASURE THE CHANGE TOTAL TIME REPORTING ALL THE ACTIVITIES WITH THE PERTINENT TIME

Date:

Machine:

Internal Activities

Observation sheet for set-up

Change from :

to:

External Activities

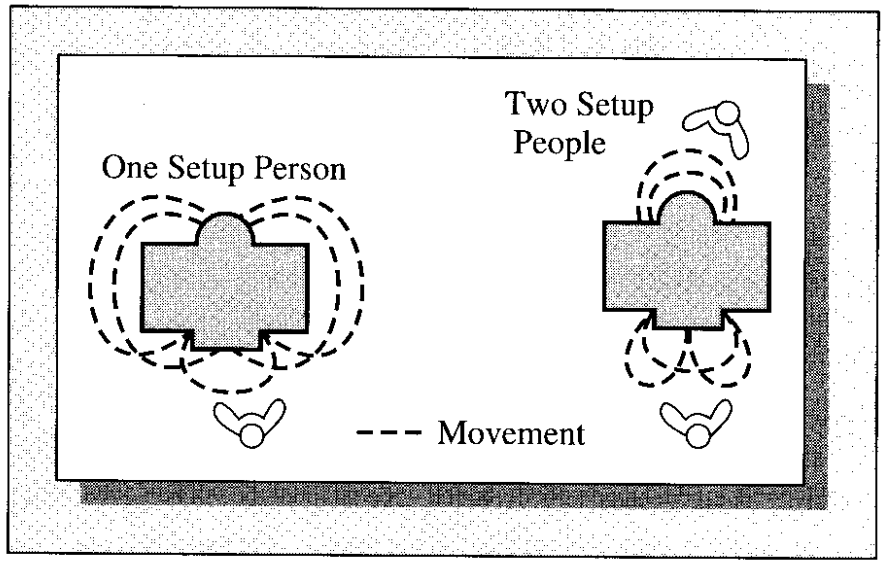
No	List of activities	Attività Int	Attività Est	Tempo Secondi	Osservazioni
1	Take the tools box			12	
2	Take the grip and loose screw la vite			18	Unprecise place for the grip. Time lost looking for the grip
3	Unhook the de from the machine			3	
4	Remove the die from the machine			2	
5	Take the new tool			8	
6	Recover the fixing screws			45	
7	Look for the grip			10	
8	Loose and move a little the fixing system			15	
9	Insert the new die			4	
10	Look for the dynamometer			5	Unprecise place for the grip. Time lost looking for the grip
11	Set the fixing couple			105	
12	Position the dynamometer			55	
13	Fix stabilythe die			7	
14	Remove the tools			28	
15	AggioUpdate the machine log book			35	
	Total:			**352**	

List of the activities

Report the measured time

PARALLEL ACTIVITIES

- Ideally, two people can do a job in half a person's time
- Think of the pit stop in Formula
- Prepare tooling kits and trolleys
- Keep equipment, etc., near the machine
- Improve handling



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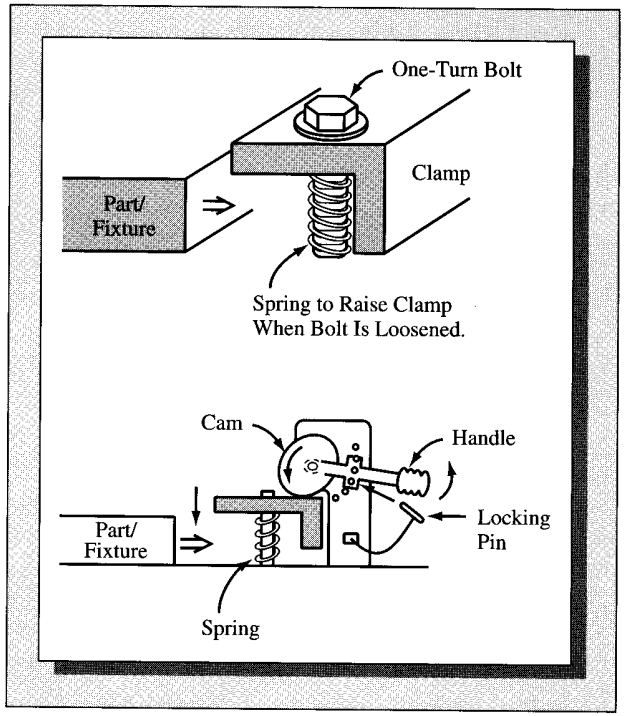
QUICK FASTENERS

FIGURE 6.7

Examples of simple clamping devices.



One-turn bolt attachment devices.

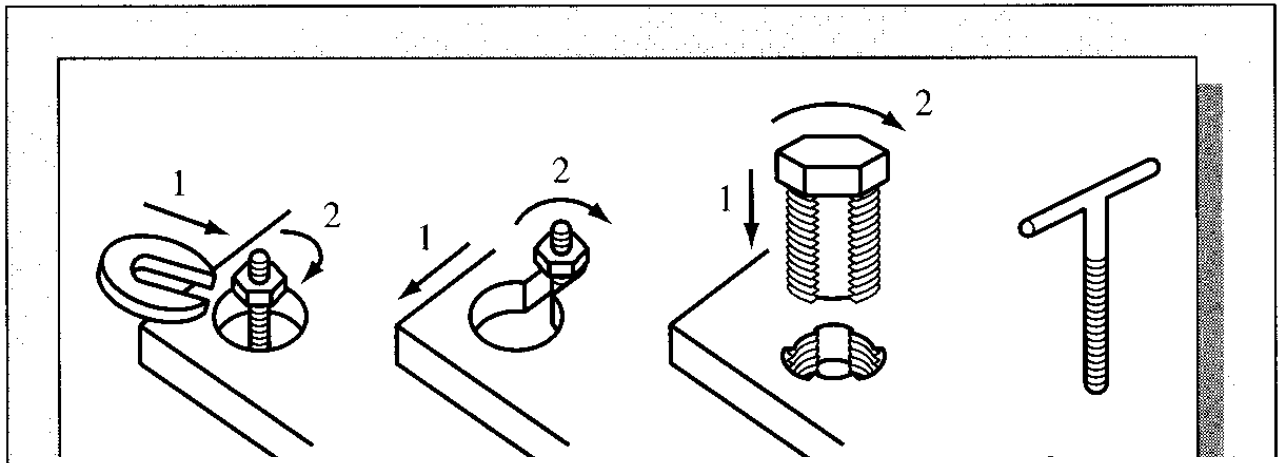
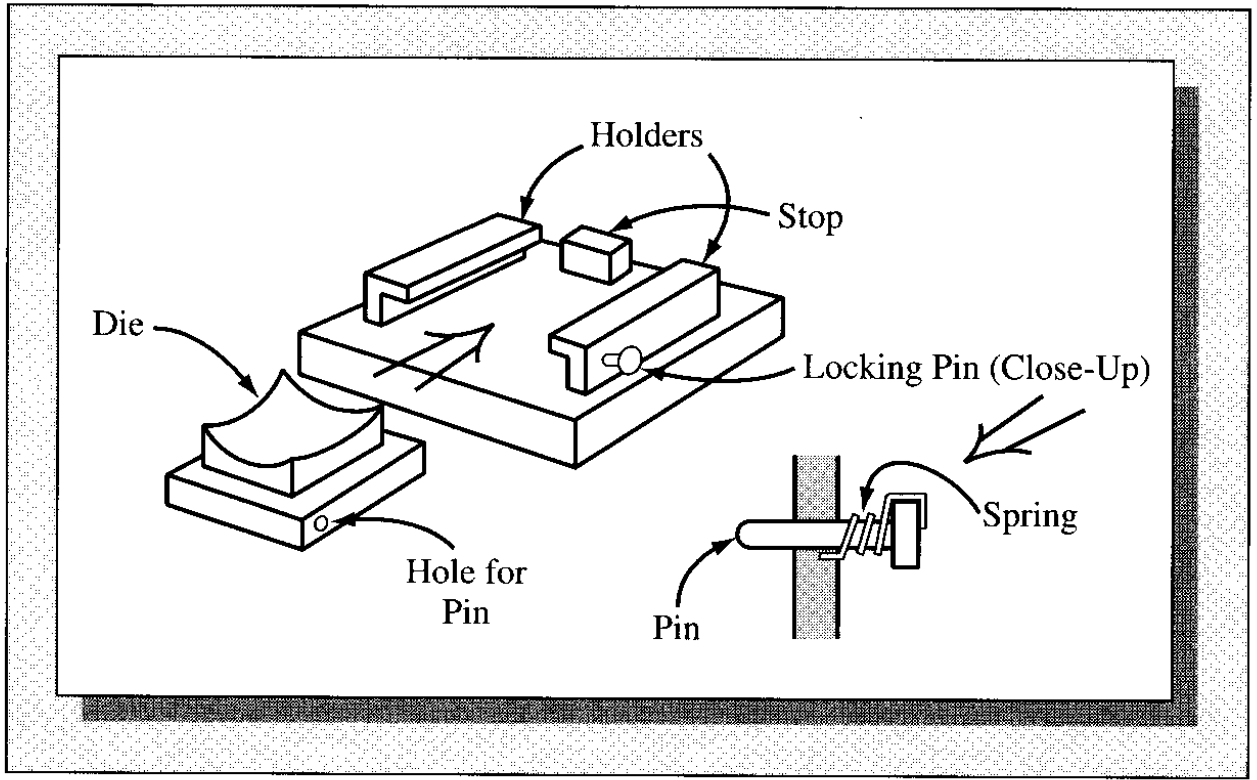


FIGURE 6.6

Attachment with fixed holders and pins.



CUT OR REDUCE ALL REGULATIONS

FIGURE 6.9

Use of shims and cassette-type holders with fixed-position holders on machine.

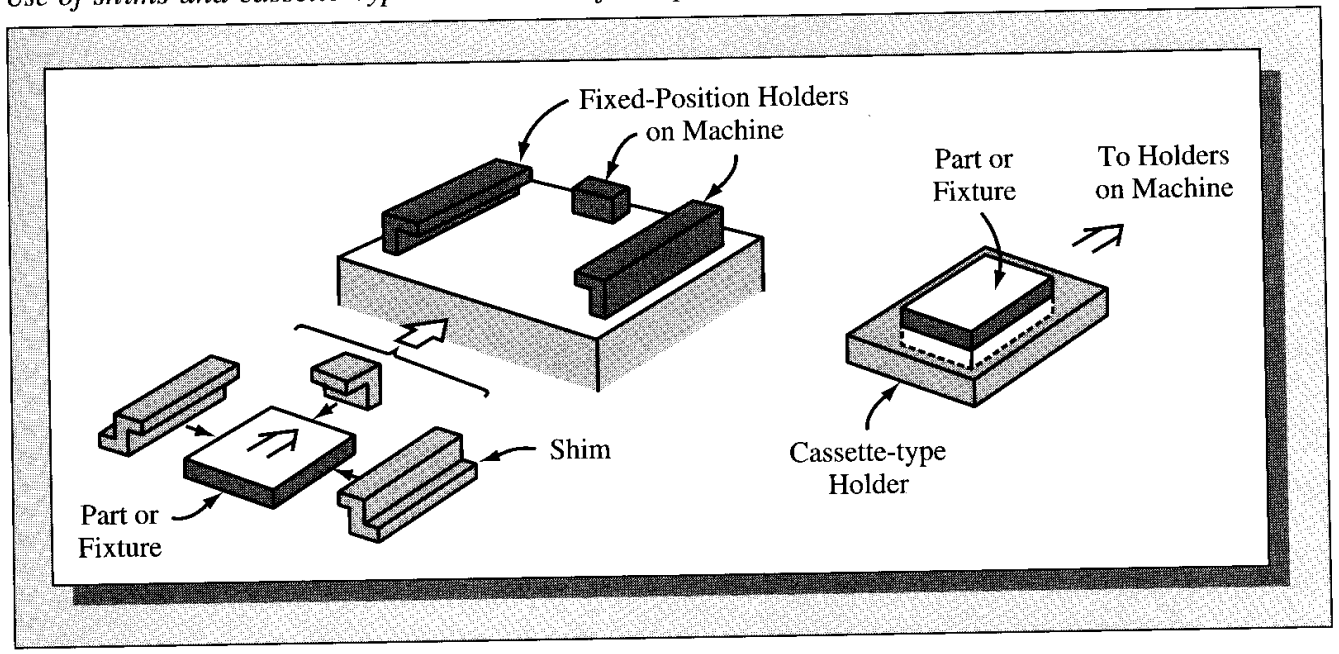
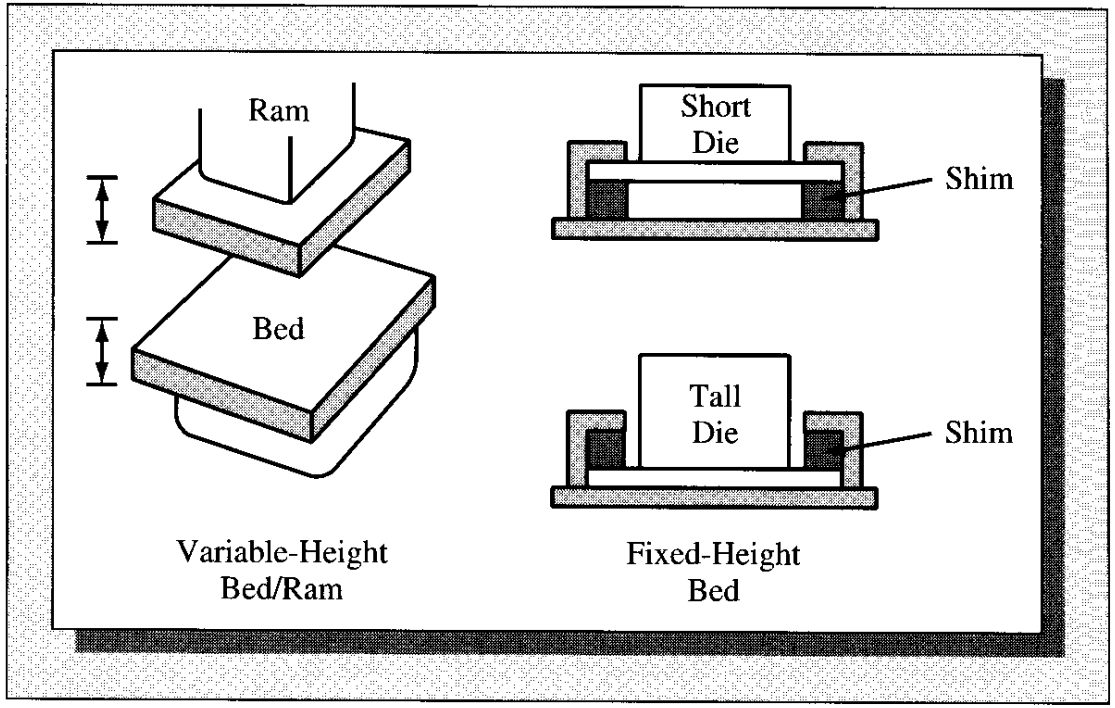


FIGURE 6.10

Accommodating variable-height dies without making adjustments.

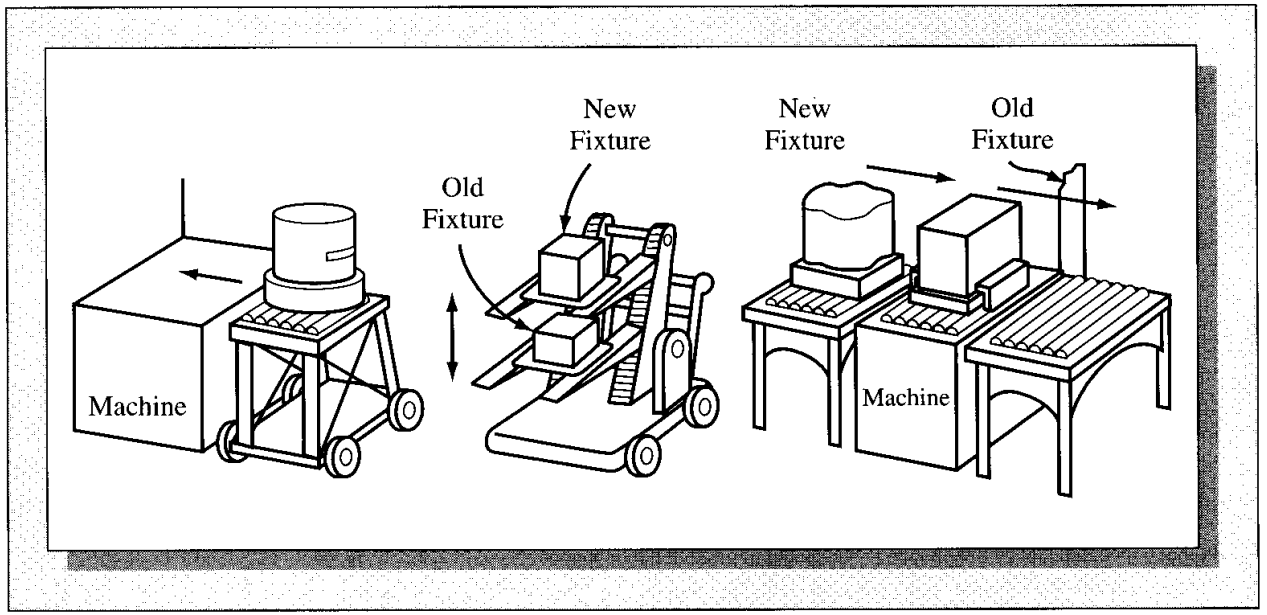


IMPROVEMENT OF INTERNAL SET-UP

- Prepare tools kits and trolleys
- Keep tools/jigs, etc., close to the machine
- Improve handling

FIGURE 6.13

Examples of material-handling equipment.



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Set-up Check List (example)

1. WORKING DOCUMENTS
   - PROCESSING SHEETS
   - TECHNICAL DRAWING PART TO WORK
   - CONTROL/NUMERICAL PROGRAM
   - …
2. WORK PLACE
   - KEYS AND HAND TOOLS
   - CONTAINER OF PIECES TO WORK
   - CARRIAGE IN THE MACHINE AREA
   - COMPARATOR
   - …
3. EQUIPMENT
   - NEW EQUIPMENT
   - LIFTING RING AND RELATIVE WASHERS
   - CONTAINER FOR TOOL TO BE DISASSEMBLED
   - …… ..
4. TOOLS
   - TOOL TROLLEY TO BE ASSEMBLED IN FRONT OF THE TOOL MAGAZINE
   - TOOL TROLLEY TO BE DISASSEMBLED IN FRONT OF TOOL STORAGE
   - ……

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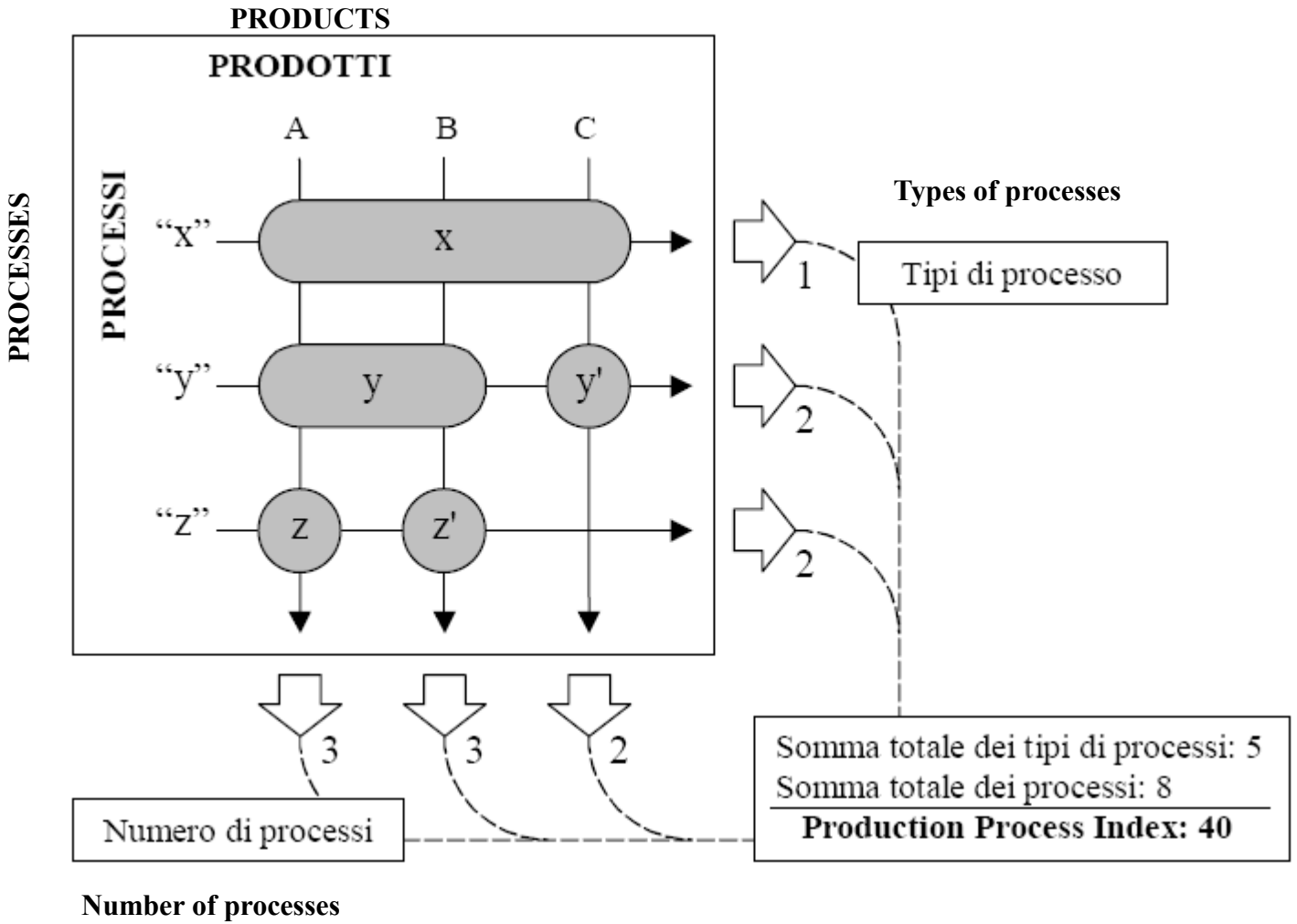
IDENTITY A PRODUCT FAMILY (GROUP): PRODUCT-PROCESS ANALYSIS

			Macchine							
Prodotti e Quantità			**M#1**	**M#2**	**M#3**	**M#4**	**M#5**	**M#6**	**M#7**	**M#8**
	1500	**P#1**	x	x	x		x	x		
	12000	**P#2**		x		x		x		x
	10000	**P#3**		x		x		x		x
	5400	**P#4**	x	x	x	x	x	x		
	3000	**P#5**			x		x	x	x	x
	2800	**P#6**	x	x	x		x	x	x	
	2700	**P#7**	x		x			x	x	x
	1500	**P#8**	x		x			x	x	x

Famiglia	**Prodotti**	**Quantità totale**
F#1	P#1,P#4,P#6	9700
F#2	P#2,P#3	22000
F#3	P#5,P#7,P#8	7200

QUANTITY': PIECES OR HOURS OR EUROS?

IDENTITY A PRODUCT FAMILY (GROUP): PRODUCT-PROCESS ANALYSIS (indexes)



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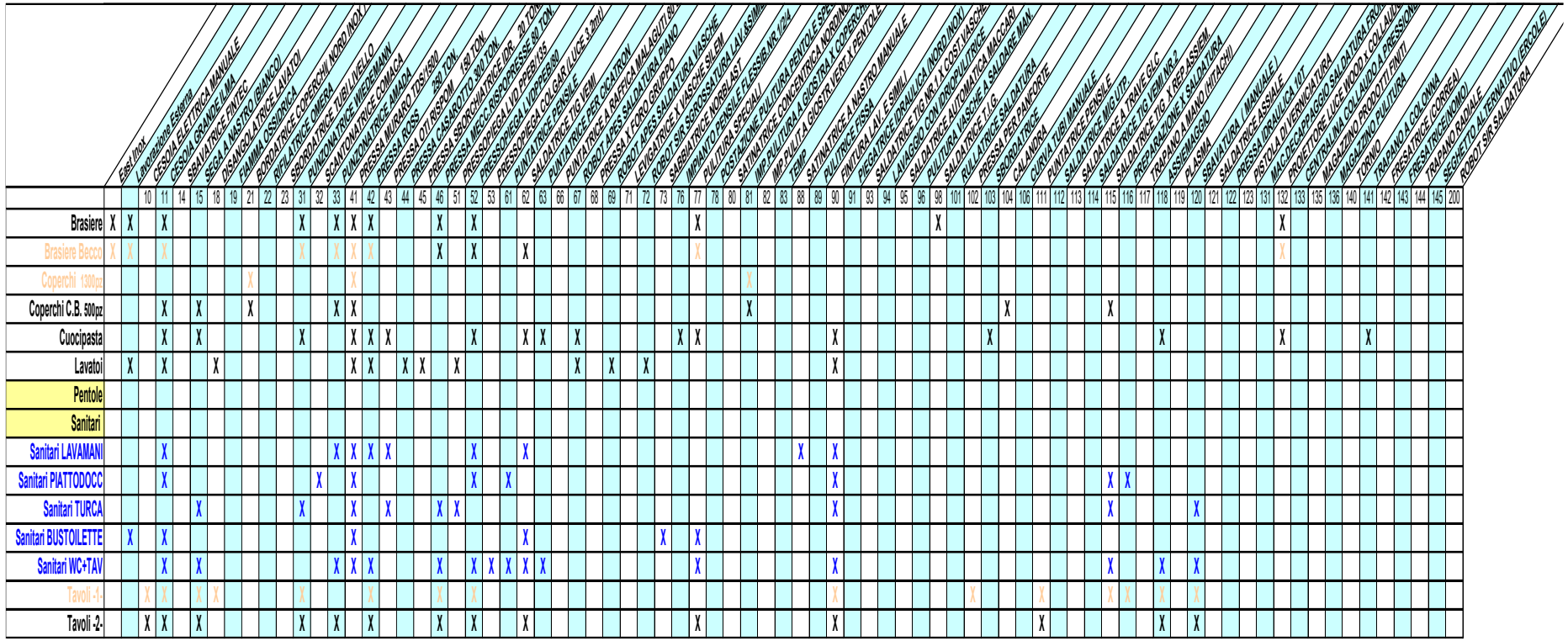
IDENTITY A PRODUCT FAMILY (GROUP): PRODUCT-PROCESS ANALYSIS

PROCESSES

PRODUCTS' FAMILIES



COMPLEXITY INDEX: 141 x 20 = 1820

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FOR FUTHER REDUCTION OF SET-UP TIME…

- **STANDARDIZATION: Reduce or eliminate differences between parts**
- **INTEGRATION: Combine parts or tooling steps**
- **SPECIALIZATION: Dedicate machines to a family of products (Simpler machines instead of a large and expensive machine)**
- **SIMPLIFICATION: Simplify setup so that it can be done by operators**
- **TEND TO OTED (one-touch exchange of dies): Set-up with no more than one movement**

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5-10 Sec.