



Hey! I think I might breakdown tomorrow.

Don't worry, I can handle your jobs, if you want.

Thanks! I will be back in a day. 🙌



# Industry Academia Consortium on Smart Manufacturing (IndAC-SM)

<http://indacsm.iiti.ac.in/>

# Digitalization in SME: A Case Study

## Where did we do this study?

MP Engineering & Machine Tools (MPEMT), Indore

## Why did we select MPEMT ?

- Showed initial interest during the workshop
- Looked highly motivated to move forward on their digitalization journey
- Clear long term vision
- Committed and cooperative management



# Digitalization in SME: A Case Study

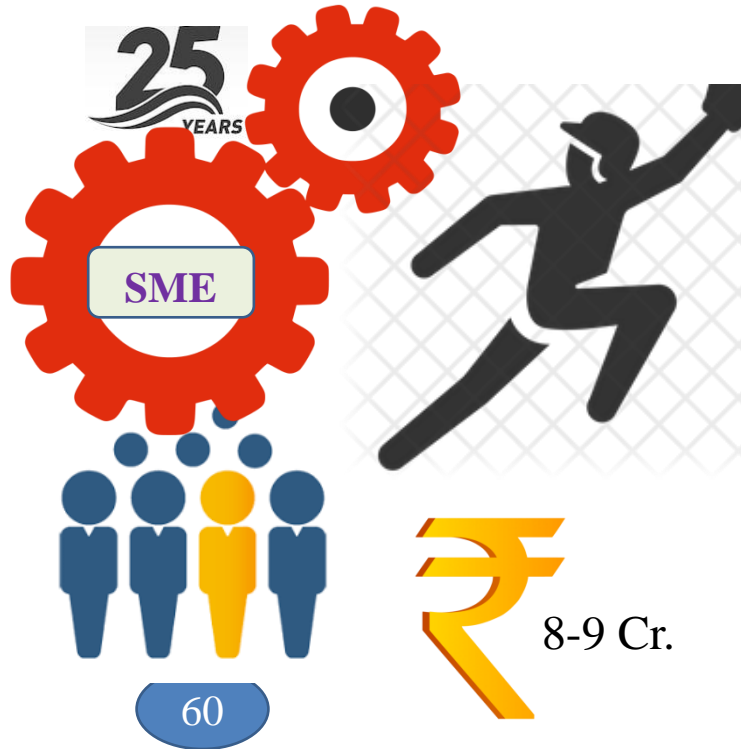
- I. Company Overview
- II. Digitalization Assessment
- III. Proposed Solution



# I. Company Overview



# Company Overview: Goal



## Goal: Get higher customer ranking

- Improved quality
- Lower operations cost
- On-time delivery



MPEMT is highly focused on quality and aims to continuously improve and maintain their customer ranking

# Company Overview: Customers and Suppliers

## Customers

CASE Construction, Indore  
 (Major Customer)  
 Kamayani Metal Pvt. Ltd., Indore  
 Metal Man Pvt. Ltd., Indore  
 AutoMech Pvt. Ltd., Indore  
 Gatiman Auto Pvt. Ltd., Indore  
 Surin Auto Pvt. Ltd., Indore  
 Nawaj Ispath Pvt. Ltd., Indore

## Suppliers

Suppliers	Location	Raw Material	Lead time
Nakoda Steel	Ludhiana	Bars	2-3 weeks
Mayura Pvt. Ltd	Kolhapur	Casting items	3-4 weeks
Hindustan Forge	Faridabad	Forged items	1 week
Local dealers	Indore	Tools & Consumables	1-4 hours



# Company Overview: Products



**Raw Material Orders:** Experience based, based on demand, finished goods/raw materials/in-process inventory, lead time

**Raw Material Inventory:** for one month

**Quantity:** Minimum order quantity

**Machines: 36**

- 6 CNC
- 4 Automatic
- 26 conventional lathe



**Are these figure optimal???**

**Orders:** 1 month (confirm)+1 month (tentative)

**Dispatch schedule:** based on past experience, daily, uncertainty exists (4-10 times in a month)

**Transportation:** Taken care by customers mainly

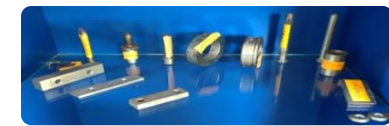
**Order receiving mechanism:** Customer portal/email

**Demand variation:** 5-10%

**Is production planning optimal ????**

**Products: 260+**

- Earth moving machine parts,
- Automobile parts,
- Turned and Machined parts, etc.



# Company Overview: Material flow



**Raw material**



**Cutting**



**Drilling**



**Turning, facing, etc.**



**Drilling, threading, etc.**



**CNC machining**



**Packaging & Dispatch**



**Marking/Engraving**



**Pre dispatch inspection**



# Company Overview: Information flow



Heat number (TC sheet) provided by **supplier** also marked on bar with paint

M.P. ENGINEERING & MACHINE TOOLS			
RAW MATERIAL			
MATERIAL TYPE	Round		
SIZE	Ø 116		
GRADE	20mn2	DATE	
BATCH NO.	225-1	30.9.19	

TEST CERTIFICATE

Date: - 03/10/2019

Party Name: Shree Nakoda Steel & Alloys  
Indore

T.C.No. :-  
P.O.No. & Date:-  
Vehicle No. :-PB13W8646

Invoice No. & Date: - DSSC-195 DT.03/10/2019

Grade	Rolling Route and Size	Heat No.	Manufacturing Process	Finish Size	Qty. Dispatch
20MN2 L.H.T		KCI-623/KCI-626/624		Round-93MM	20.225

CHEMICAL COMPOSITION

Sr No.	GRADE	Heat No.	SIZE	C%	Mn%	Si%	S%	P%
1.	20MN2	KCI-623	Round-93MM	0.19	1.47	0.30	0.022	0.034
2.	20MN2	KCI-626	Round-93MM	0.20	1.48	0.28	0.021	0.030
3.	20MN2	KCI-624	Round-93MM	0.20	1.51	0.33	0.017	0.031

Incoming material batch identification sheet created by **MPEMT**, not linked with TC

# Company Overview: Information flow



M.P. ENGINEERING & MACHINE TOOLS			
RAW MATERIAL			
MATERIAL TYPE	Round		
SIZE	Ø 116		
GRADE	20mm2	DATE	
BATCH NO.	225-1	30.9.19	

- Production sheet generated by **operator** at each station and are retained at that station only.
- Goal to measure work done by operator
- Verbal coordination, no consistency.

M.P. ENGINEERING & MACHINE TOOLS

IN PROCESS INSPECTION REPORT

Operator name: *Sandeep Rajatek* Machine No.: *A001* Part checked per 10 Nos: *73 73 73 73 73*

DATE	Part No.	OPERATION	STD. DIMENSION & TOL.	INSTRUMENT	OK Qty	Reject Qty	operator sign	Quality Appr/sg	REMARK
6/11/19	35801110	Cutting of 1x73	Vlc	73	73	73		<i>S. Rajatek</i>	

Batch-Lots-198  
1/1/2018



Machining stations

# Company Overview: Information flow



TOP COPY/RE  
Date: 01/12/2014

Part Name: Sheet Metal Steel & Alloy  
Item:

T.C.No. /  
P.O.No. & Date:

Invoice No. & Date: 0852/01/12/2014

Grade	Adding Size	Heat No.	Rolling Process	Finish Size	Qty. Request
TMARL 1.01			Hot Rolled	1.01	20.00

CHEMICAL COMPOSITION

Sr. No.	GRADE	Heat No.	C	Mn	P	S	Fe
1.	TMARL 1.01	0.01	0.40	0.20	0.02	0.02	0.02
2.	TMARL 1.01	0.01	0.40	0.20	0.02	0.02	0.02
3.	TMARL 1.01	0.01	0.40	0.20	0.02	0.02	0.02

Heat number sheet

M.P. ENGINEERING & MACHINE TOOLS

**RAW MATERIAL**

MATERIAL TYPE	Tool Steel	
SIZE	16	
GRADE	20Mn2	DATE
BATCH NO.	2251	30.9.19

Raw material batch identification sheet

M.P. ENGINEERING & MACHINE TOOLS

IN PROCESS INSPECTION REPORT

Operation name: Sandeep Aggarwal

Part checked per 30 Nos

DATE	Part No.	OPERATION	INS	QTY
6/11/19	350011	6111111111111111	Vic	73 73 73 73 73

Production sheet

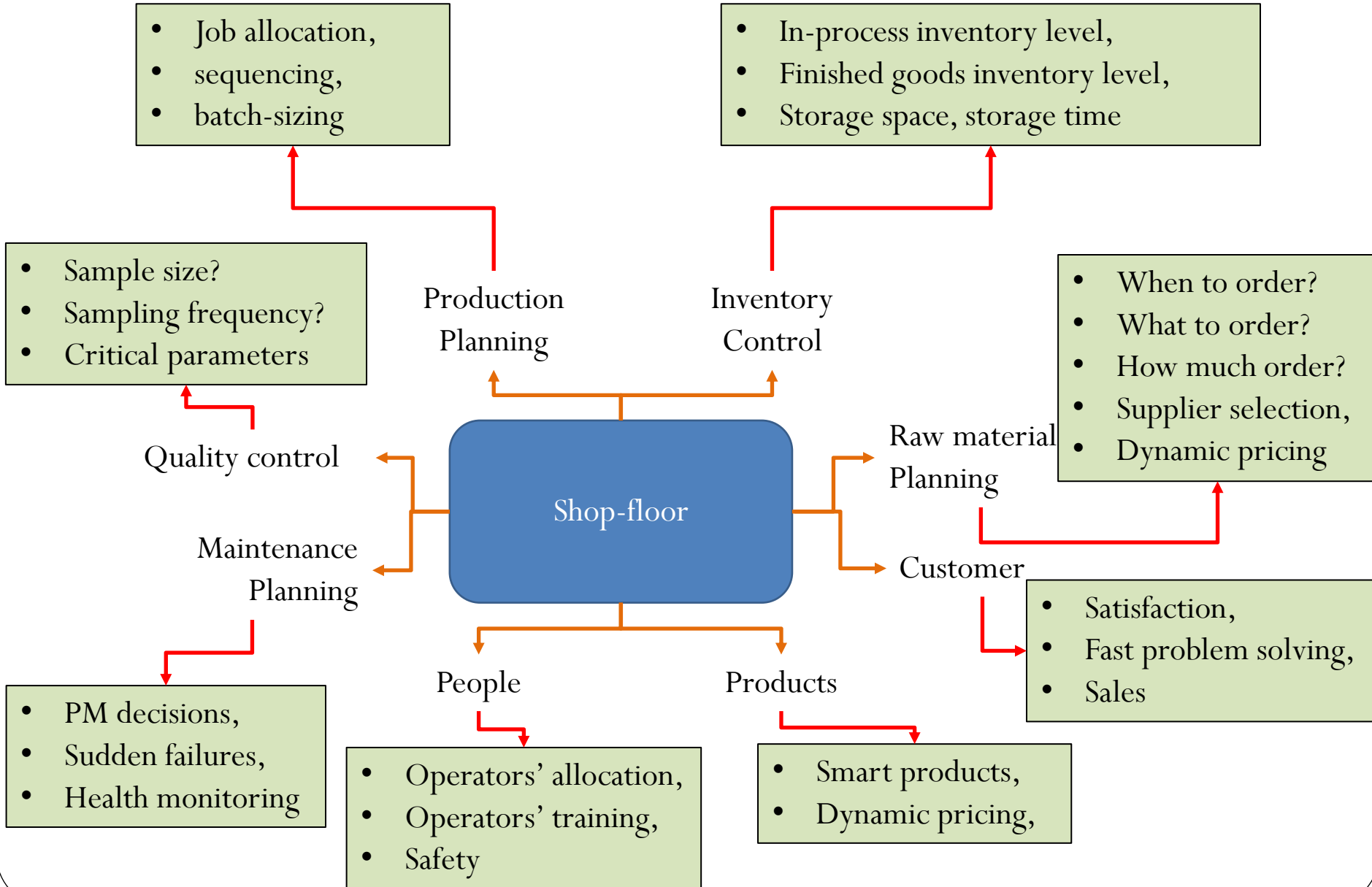


- Inspection report generation for the lot, mentioning inspection parameters...
- no linking with heat number or raw material



- Engraving to identify the final product,
- not proper link with production sheet, heat number or TC sheet...
- linked with inspection sheet only

# Company Overview: Shop floor Planning



# Company Overview: Shop floor Planning

Experience based decision-making

- Job allocation, sequencing, batch-sizing

Experience based decision-making

- In-process inventory level,
- Finished goods inventory level,
- Storage space, storage time

Experience based decision-making

- Sample size?
- Sampling frequency?
- Critical parameters

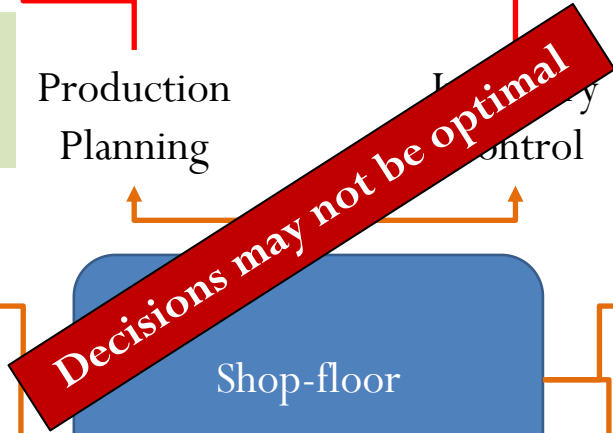
Production Planning

Inventory Control

Experience based decision-making

- When to order?
- What to order?
- How much order?
- Supplier selection,
- Dynamic pricing

Quality control



Raw material Planning

Customer

Experience based decision-making

- Satisfaction,
- Fast problem solving,
- Sales

Maintenance Planning

Experience based decision-making

- PM decisions,
- Sudden failures,
- Health monitoring

People

Products

- Operators' allocation,
- Operators' training,
- Safety

- Smart products,
- Dynamic pricing,

Experience based decision-making

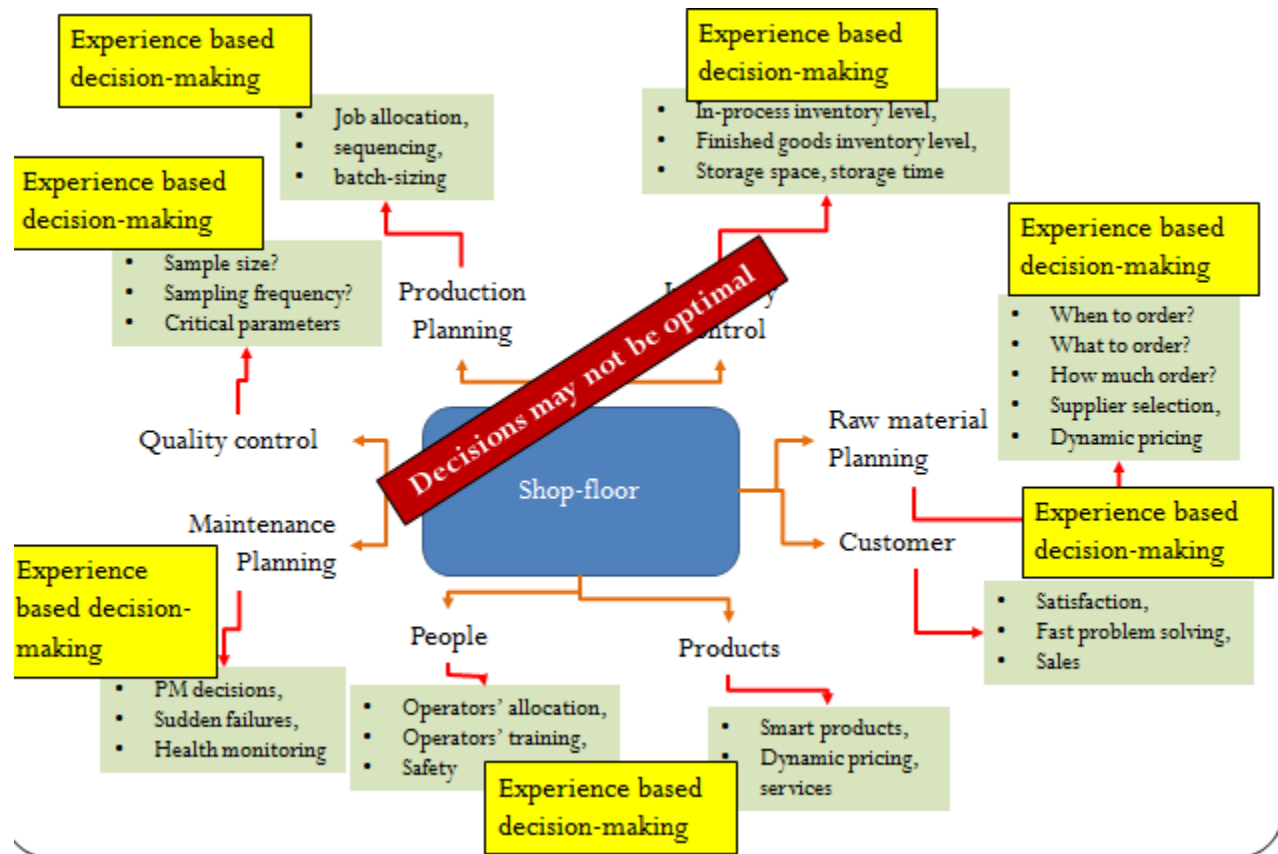
# Company Overview: Shop floor Planning

## Effects on

- On-time delivery,
- Operations cost,
- Quality,

## Uncertainties

Demand change, change in dispatch schedule, operator absentees, machines failures, power failure, etc.



# Digitalization in SME

1. Even for a small size industry, many shop floor decision makings are involved.... **Do these industries appreciate the important of the same?** (hands-on on simulation)
2. Many of the commercially available decision making tools are normally not used in such industries.... **Do we need online decision making tools?** (Demo)
3. Experience based decision making is widely adopted practice in many of the industries.... **Will it really be optimal?** (hands-on on simulation)
4. Industries have evolved their own ways to meet their customers' requirements...
5. In the absence of proper digitalization such practices become non-user friendly, time consuming, and makes the customer away from the benefits of possible analytics
6. Many simple cost effective solutions may be available... **cheaper or cost effective**



# Digitalization in SME: A Case Study

## II. Digitalization Assessment





# Why assess Digitalization Need ?



- What technologies?
- Implementation roadmap
- Economic impact

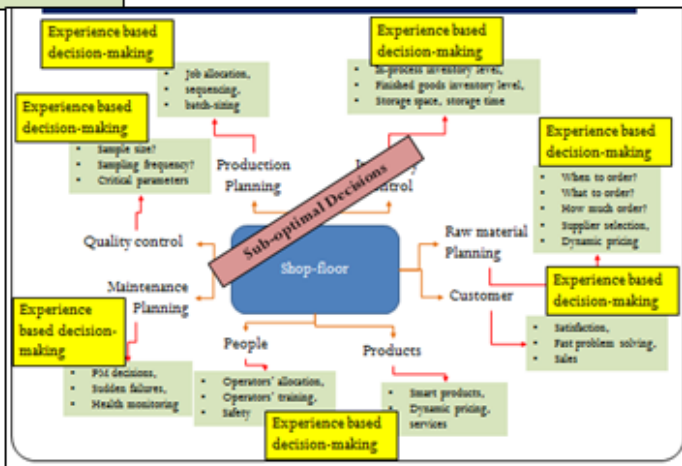
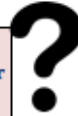
## Company Overview: Sh

### Effects on

- On-time delivery,
- Operations cost,
- Quality,
- production

### Uncertainties

Demand change, change in dispatch schedule, operator absentees, machines failures, power failure, etc.



# Digitalization Assessment

**Objective: Get higher customer ranking**

**Sub-objectives:**

**Improved quality**

**Lower operations cost**

**On-time delivery**

**Functions:**

- Quality
- Maintenance

- Suppliers/Raw material
- Production
- Maintenance
- Inventory
- Quality
- Customers

- Suppliers/Raw material
- Production
- Maintenance
- Inventory

Functions	Sub-category	Associated items
Customers	Autonomous system to deal with customer's requirements	ICT competence w.r.t. customers
		Product customization
		Pricing
		Orders
		Product quality
		Rating
		On-time delivery
		Real-time production status
	Data generation & consumption	Data generation
		Data analysis
		Data consumption
	ICT Infrastructure	ICT Infrastructure
	Decision-making	Decision-making
		Responsiveness

Functions	Sub-category	Associated items	
Suppliers & Raw materials	Raw material Planning	Raw material Planning	
	Suppliers	Suppliers	ICT competence w.r.t. suppliers
			Pricing
			Transportation
			Orders
			Raw material quality
			Rating
			On-time delivery
			Real-time production status
	Data generation & consumption	Data generation & consumption	Data generation
			Data analysis
			Data consumption

# Digitalization Assessment

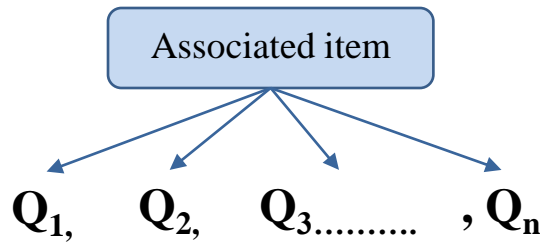
Functions	Sub-category	Associated items
<b>Production</b>	Production Planning	Production Planning
	Process	Shop-floor ICT Infrastructure
		Smart product
		Shop-floor production monitoring
		Material handling
		Daily production
		In-process product quality
		Data generation & consumption
	Data generation	
	Data analysis	
	Data consumption	
	Decision-making	Decision-making
		Responsiveness
	Employee	Performance monitoring
		Awareness, training

Functions	Sub-category	Associated items
<b>Maintenance</b>	PM & CM	PM decision
		Predictive maintenance decision
		CM priority decision
	Data generation & consumption	Communication
		Data generation
		Data analysis
		Data consumption
	Decision-making	Decision-making
		Responsiveness
	Employee	Performance monitoring
		Awareness, training
		Technicians allocation

Functions	Sub-category	Associated items
<b>Quality</b>	Sampling plan & gauges	Sampling plan
		Gauges
		Technicians allocation
	Data generation & consumption	Communication
		Data generation
		Data analysis
		Data consumption
	Decision-making	Decision-making
		Responsiveness
	Dispatch & Packaging	Pre dispatch inspection
		Engraving
	Employee	Packaging
Performance monitoring		
	Awareness, training	

Functions	Sub-category	Associated items
<b>Inventory</b>	Inventory control	Inventory control
	Data generation & consumption	Communication
		Data generation
		Data analysis
		Data consumption
	Decision-making	Decision-making
		Responsiveness

# Digitalization Assessment



- Information
- Current status
- Target
- Score

**Q.** What is the type of your production system?

- A. Intermittent
- B. Continuous

Response: A

**Q.** Do you monitor machine's health in real-time?

- A. Yes
- B. Partially
- C. Beginner
- D. No

Response: D, score: 0

Target: A, score: 4

Readiness level	Value (Imp.)	Value (Very Imp.)
	<b>1</b>	<b>1.5</b>
Level 0: Outsider	0	0
Level 1: Beginner	1	1.5
Level 2: Intermediate	2	3
Level 3: Experienced	3	4.5
Level 4: Expert	4	6

$$A_i = \frac{\sum_{j=1}^n Q_{ij}}{n};$$

$$S_k = \frac{\sum_{i=1}^m A_i \times w_i}{m}$$

$$F_p = Avg. (S_1, S_2, \dots, S_l); L_o = Avg. (F_1, F_2, \dots, F_6)$$

Associated item

Weightage

Sub-category

Functions

Overall

Current status

Target

Requirements

Technology

Expected benefits



# Questionnaire

## Rating

Q1. Do your customers rate you?

- A. Yes
- B. No

Response: A

Q2. What are the parameters of rating?

Response: Based on number of defective products

Q3. How do you resolve quality issues?

- A. Manually
- B. Automatically

Response: A, score: 1

Target: B, score: 4

Q4. Are you able to resolve the issue effortlessly?

- A. Yes
- B. Partially
- C. Moderate
- D. No

Response: C, score: 1

Target: A, score: 4

Q5. Are you able to easily identify the product details, root cause of issue?

- A. Yes
- B. Partially
- C. Moderate
- D. No

Response: C, score: 1

Target: A, score: 4

Q6. To what extent can products be tracked throughout their lifecycle?

- A. No
- B. Very Limited product tracking
- C. limited product tracking
- D. Complete product tracking

Response: B, score: 1

Target: D, score: 4

$$\text{Current status} = (1+1+1+1)/4 = 1$$

$$\text{Target} = (4+4+4+4)/4 = 4$$



# Industry 4.0 Assessment Report

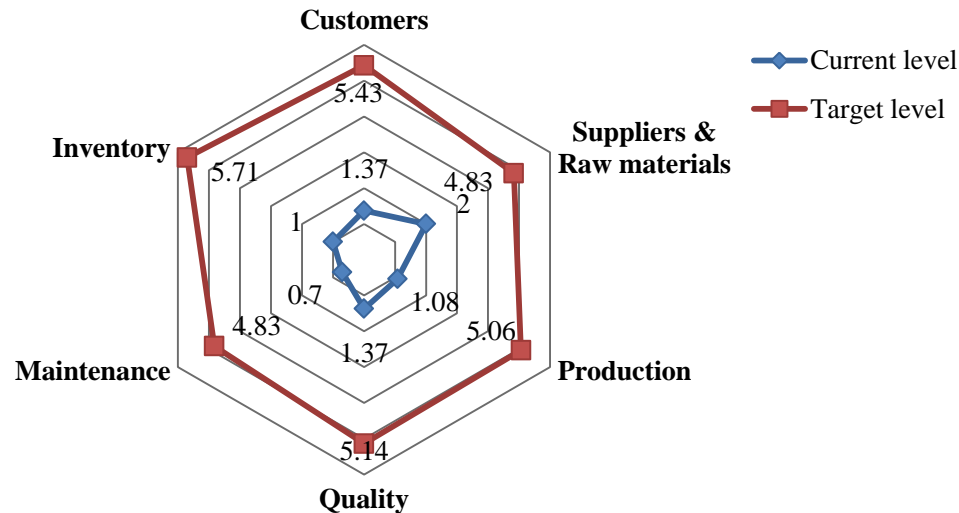
Industry: MP Engineering & Machine Tools (MPEMT), Indore

❑ Current Level of Industry 4.0: 1.25 (Beginner)

❑ Target level of Industry 4.0: 5.16 (Expert)

**Objective:** Get higher customer ranking

**Functions:** Customers, Suppliers & Raw materials, Production Quality, Maintenance, Inventory

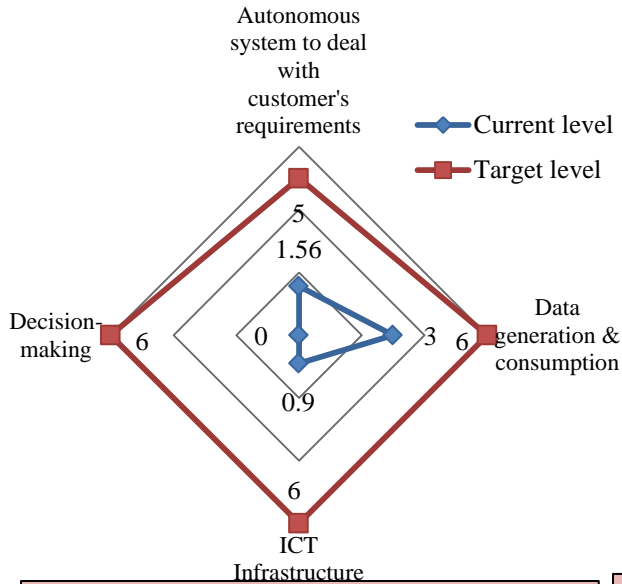


Sub-category → Associated items → Interest? → Current status → Target → Requirements → Technology → Expected benefits

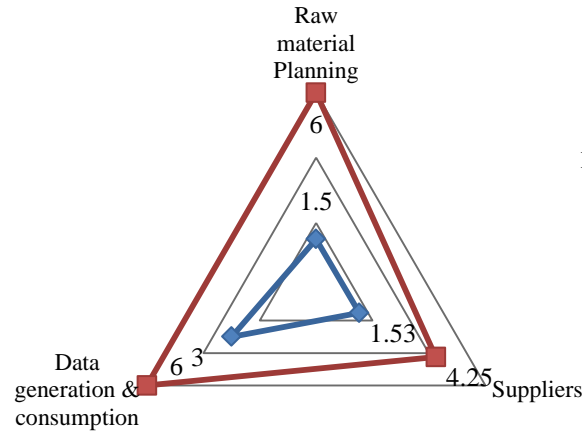


# Industry 4.0 Assessment Report

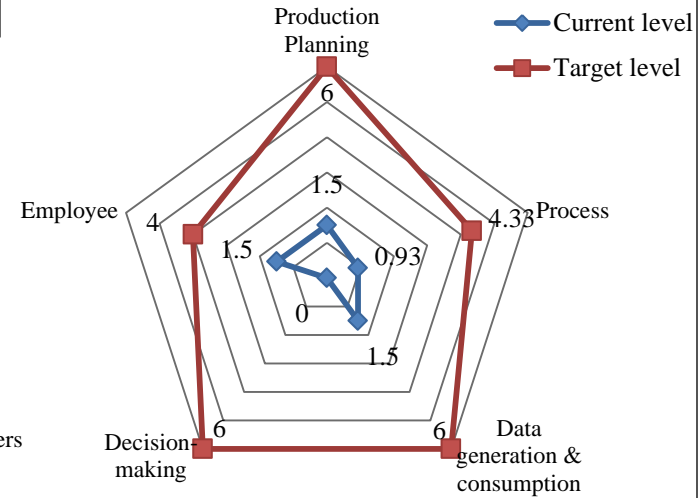
## Customers: CL (1.37) & TL(5.43)



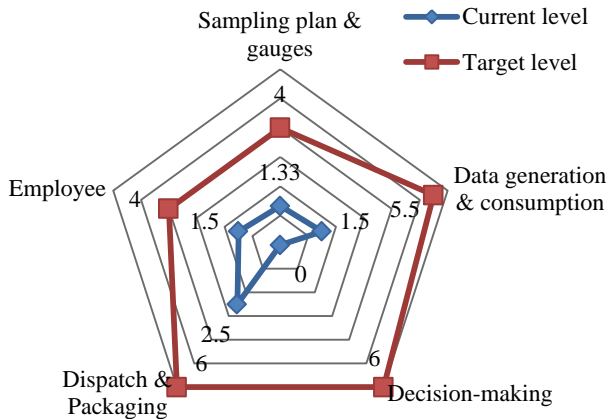
## Suppliers & Raw materials: CL (2) & TL(4.83)



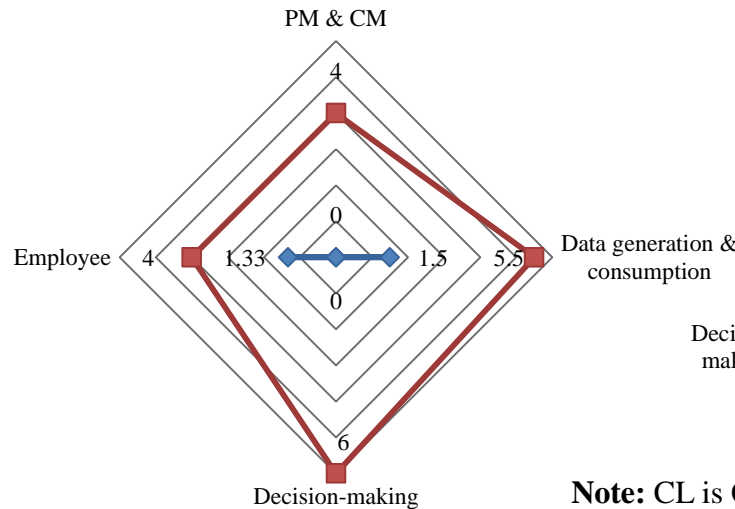
## Production: : CL (1.08) & TL(5.06)



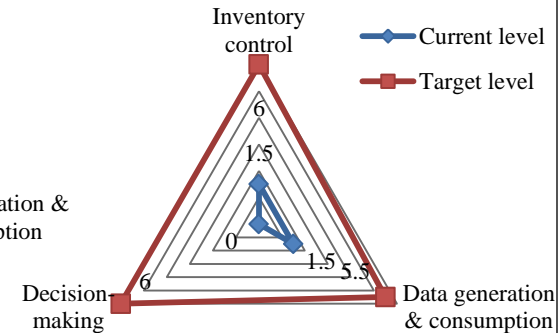
## Quality : CL (1.37) & TL(5.14)



## Maintenance: : CL (0.7) & TL(4.83)



## Inventory : CL (1) & TL(5.71)



Note: CL is Current Level & TL is Target Level

# Industry 4.0 Assessment Report (Function: Customer)

Associated items	Interest?	Current status	Target	Requirements	Technology	Expected benefits
ICT competence w.r.t. customers	Yes	Beginner	High (as per need)	Web based portal, smart communication, smart assets/products, autonomous decision-making, interoperability	Web based portal development, API, Sensors, IoT, AAS, Computation devices, AI/ML, CPS, Interoperability	Higher responsiveness, fast decision-making, improved rating, better coordination & communication, can attract more customers
Product customization	Yes	Moderate	Autonomous system	Web based portal, smart communication, smart assets/products, autonomous decision-making, interoperability, online customization, production access	Web based portal development, API, Sensors, smart devices, IoT, AAS, Computation devices, AI/ML, CPS, Interoperability	improved rating, can attract more customers, helps in operations management, operations cost reduction
Pricing	Yes	Moderate	Autonomous system	Web based portal, smart communication, smart assets/products, autonomous decision-making, interoperability, digital integration of suppliers, production operations, sales, & customers	Web based portal development, API, Sensors, smart devices, IoT, AAS, Computation devices, AI/ML, algorithms, CPS, Interoperability	Real-time price control, cost reduction
Transportation	No	-	-	-	-	-
Orders	Yes	Offline	Web based portal to deal orders	Web based portal, smart communication, autonomous decision-making, interoperability, digital integration of raw materials, production, inventories, sales, & customers	Web based portal development, API, Sensors, smart devices, IoT, AAS, Computation devices, AI/ML, CPS, Interoperability	Helps in operations planning, improved rating, better coordination & communication
Product quality	Yes	80-90%	90-100%	Smart gauging system, automatic sampling plan, smart packaging system	Smart gauges, Standard quality control practices, Cp, Cpk, Cloud computing, Computation devices, AI/ML, algorithms, sensors, smart HMI, CPS, IoT, Simulation modelling, interoperability	Improved quality
Rating	Yes	Green zone	Always be in green zone	Web based portal, digital integration of customers & manufacturer, online access of product manufacturing details, product traceability, standardization	Web based portal development, API, IoT, AAS, Computation devices, Interoperability, DBMS, Blockchain, 5S, ISO, automation, ICT infrastructure	Improved rating
On-time delivery	Yes	Partially	Completely	Smart communication, smart assets/products, autonomous decision-making, interoperability, intelligent operations planning	Data analytics, smart devices, IoT, Computation devices, AI/ML, CPS, Interoperability, DBMS, Blockchain,	Improved rating, reduces production loss
Real-time production status	Yes	No	Yes	Sensors, smart communication, smart assets/products, autonomous decision-making, interoperability, digital integration of production & operations, real-time data collection & utilization, autonomous decision-making	AR, Sensors, IoT, AAS, Computation devices, algorithms, AI/ML, CPS, Interoperability, big data & analytics, smart HMIs, smart devices, automation, DBMS, Blockchain	Real-time online production monitoring, helps in operations planning, better production control, cost reduction, on-time delivery
Data generation	Yes	Partially	Online data collection	Smart devices, Automatic data collection	Sensors, CPS, smart HMI, storage devices	Helps in accurate decision-making, improved responsiveness, improved rating, cost reduction
Data analysis	Yes	Partially	Data analysis tool	Automatic data analysis, computation devices	Smart devices, IoT, big data & analytics, Computation devices, algorithms, AI/ML, simulation	Helps in accurate decision-making, improved responsiveness, improved rating, cost reduction



# Digitalization in SME: A Case Study

## III. Proposed Solution



# Product traceability: Stage I

## MP Engineering & Machine Tools, Indore

Raw Material Type: Round bar      Component no.: 85700130      Batch no.: 255      Bin no.: 14

Arrival Date: 30.09.2019      Grade: 20MN2      Size: Dia. 116 mm      Quantity: 1

Heat no.	C%	Mn%	Si%	S%	P%
KCI-623	0.19	1.47	0.30	0.022	0.034



### Process flow

Operations	Cutting	Drilling	Drilling (ID)	Drilling(OD)	ID Final	CNC Machining	Threading
Tick (✓)							
Operators Sign							

### Quality inspection by operator

Components	1	2	3	4	5	6	Operator's sign
Cutting							
Drilling							
Drilling (ID)							
Drilling (OD)							
ID Final							
CNC Machining							
Threading							

### Quality inspection by QC technician

Components	1	2	3	4	5	6	Technician's sign
Cutting							
Drilling							
Drilling (ID)							
Drilling (OD)							
ID Final							
CNC Machining							
Threading							

Pre dispatch inspection (PDI) no.:      Engraving:      Dispatch Date:

Helps in  
real-time  
Inventory  
tracking

Round bar

KCI-623      Batch: 255

# Product traceability: Stage I

## 1. Cutting



Process flow



Operations	Cutting	Drilling	Drilling (ID)	Drilling(OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓						
Operators	sk						
Sign							

Quality inspection by operator

Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70.0	69.9	70.1	sk
Drilling							
Drilling (ID)							
Drilling (OD)							
ID Final							
CNC Machining							
Threading							

Quality inspection by QC technician

Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs

## 2. Drilling



Process flow



Operations	Cutting	Drilling	Drilling (ID)	Drilling(OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓	✓					
Operators	sk	ng					
Sign							

Quality inspection by operator

Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70.0	69.9	70.1	sk
Drilling	45.1	45.0	45.3	45.2	44.9	45.0	ng
Drilling (ID)							
Drilling (OD)							
ID Final							
CNC Machining							
Threading							

Quality inspection by QC technician

Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs
Drilling	45.0	45.3	45.0	44.8	45.1	45.2	am

## 7. Threading



Process flow



Operations	Cutting	Drilling	Drilling (ID)	Drilling(OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓	✓	✓	✓	✓	✓	✓
Operators	sk	ng	vm	np	gs	vp	km
Sign							

Quality inspection by operator

Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70.0	69.9	70.1	sk
Drilling	45.1	45.0	45.3	45.2	44.9	45.0	ng
Drilling (ID)	42.1	42.	42.	42.	42.	42.	Vm
Drilling (OD)	55.0	55.2	55.0	55.0	54.9	55.1	Np
ID Final	42.2	41.9	42.1	42.0	42.1	42.2	Gs
CNC Machining	30.1	30.2	30.0	30.1	30.3	29.9	Vp
Threading	5.05	5.1	5.15	4.95	5.1	5.05	km

Quality inspection by QC technician

Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs
Drilling	45.0	45.3	45.0	44.8	45.1	45.2	am
Drilling (ID)	42.0	42.1	42.2	42.1	42.3	41.9	Hp
Drilling (OD)	55.1	55.0	54.9	55.2	55.3	55.1	Lk
ID Final	42.1	42.0	42.2	41.9	42.2	42.1	Rs
CNC Machining	30.0	30.1	30.3	29.9	30.2	30.1	Js
Threading	5.1	5.05	5.15	4.95	5.1	5.05	mg

# Product traceability: Stage I

## Pre dispatch inspection



MP Engineering & Machine Tools, Indore

Raw Material Type: Round bar Component no.: 85700130 Batch no.: 255 Bin no.: 14

Arrival Date: 30.09.2019 Grade: 20Mn2 Size: Dia. 116 mm Quantity: 1

Heat no.	C%	Mn%	Si%	S%	P%
KCI-623	0.19	1.47	0.30	0.022	0.034



Process flow

Operations	Cutting	Drilling	Drilling (ID)	Drilling(OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓	✓	✓	✓	✓	✓	✓
Operators Sign	sk	ng	vm	np	gs	vp	km

Quality inspection by operator

Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70.0	69.9	70.1	sk
Drilling	45.1	45.0	45.3	45.2	44.9	45.0	ng
Drilling (ID)	42.1	42.	42.	42.	42.	42.	Vm
Drilling (OD)	55.0	55.2	55.0	55.0	54.9	55.1	Np
ID Final	42.2	41.9	42.1	42.0	42.1	42.2	Gs
CNC Machining	30.1	30.2	30.0	30.1	30.3	29.9	Vp
Threading	5.05	5.1	5.15	4.95	5.1	5.05	km

Quality inspection by QC technician

Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs
Drilling	45.0	45.3	45.0	44.8	45.1	45.2	am
Drilling (ID)	42.0	42.1	42.2	42.1	42.3	41.9	Hp
Drilling (OD)	55.1	55.0	54.9	55.2	55.3	55.1	Lk
ID Final	42.1	42.0	42.2	41.9	42.2	42.1	Rs
CNC Machining	30.0	30.1	30.3	29.9	30.2	30.1	Js
Threading	5.1	5.05	5.15	4.95	5.1	5.05	mg

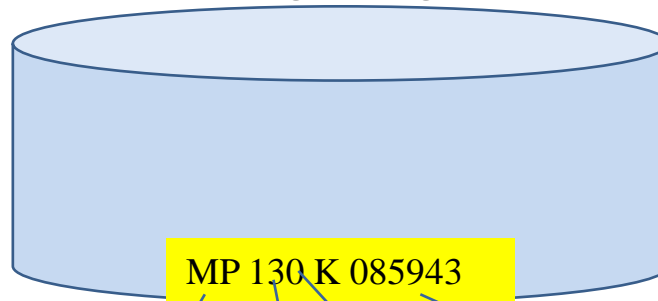
Pre dispatch inspection (PDI) no.: K 32

Engraving:

Dispatch Date:



## Engraving



Company name      Month      Sheet barcode

Last three digit of component no.

MP Engineering & Machine Tools, Indore

Raw Material Type: Round bar Component no.: 85700130 Batch no.: 255 Bin no.: 14

Arrival Date: 30.09.2019 Grade: 20Mn2 Size: Dia. 116 mm Quantity: 1

Heat no.	C%	Mn%	Si%	S%	P%
KCI-623	0.19	1.47	0.30	0.022	0.034



Process flow

Operations	Cutting	Drilling	Drilling (ID)	Drilling(OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓	✓	✓	✓	✓	✓	✓
Operators Sign	sk	ng	vm	np	gs	vp	km

Quality inspection by operator

Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70.0	69.9	70.1	sk
Drilling	45.1	45.0	45.3	45.2	44.9	45.0	ng
Drilling (ID)	42.1	42.	42.	42.	42.	42.	Vm
Drilling (OD)	55.0	55.2	55.0	55.0	54.9	55.1	Np
ID Final	42.2	41.9	42.1	42.0	42.1	42.2	Gs
CNC Machining	30.1	30.2	30.0	30.1	30.3	29.9	Vp
Threading	5.05	5.1	5.15	4.95	5.1	5.05	km

Quality inspection by QC technician

Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs
Drilling	45.0	45.3	45.0	44.8	45.1	45.2	am
Drilling (ID)	42.0	42.1	42.2	42.1	42.3	41.9	Hp
Drilling (OD)	55.1	55.0	54.9	55.2	55.3	55.1	Lk
ID Final	42.1	42.0	42.2	41.9	42.2	42.1	Rs
CNC Machining	30.0	30.1	30.3	29.9	30.2	30.1	Js
Threading	5.1	5.05	5.15	4.95	5.1	5.05	mg

Pre dispatch inspection (PDI) no.: K 32

Engraving: MP 130 K 085943

Dispatch Date:

## Packaging



MP Engineering & Machine Tools, Indore

Raw Material Type: Round bar Component no.: 85700130 Batch no.: 255 Bin no.: 14

Arrival Date: 30.09.2019 Grade: 20Mn2 Size: Dia. 116 mm Quantity: 1

Heat no.	C%	Mn%	Si%	S%	P%
KCI-623	0.19	1.47	0.30	0.022	0.034



Process flow

Operations	Cutting	Drilling	Drilling (ID)	Drilling(OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓	✓	✓	✓	✓	✓	✓
Operators Sign	sk	ng	vm	np	gs	vp	km

Quality inspection by operator

Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70.0	69.9	70.1	sk
Drilling	45.1	45.0	45.3	45.2	44.9	45.0	ng
Drilling (ID)	42.1	42.	42.	42.	42.	42.	Vm
Drilling (OD)	55.0	55.2	55.0	55.0	54.9	55.1	Np
ID Final	42.2	41.9	42.1	42.0	42.1	42.2	Gs
CNC Machining	30.1	30.2	30.0	30.1	30.3	29.9	Vp
Threading	5.05	5.1	5.15	4.95	5.1	5.05	km

Quality inspection by QC technician

Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs
Drilling	45.0	45.3	45.0	44.8	45.1	45.2	am
Drilling (ID)	42.0	42.1	42.2	42.1	42.3	41.9	Hp
Drilling (OD)	55.1	55.0	54.9	55.2	55.3	55.1	Lk
ID Final	42.1	42.0	42.2	41.9	42.2	42.1	Rs
CNC Machining	30.0	30.1	30.3	29.9	30.2	30.1	Js
Threading	5.1	5.05	5.15	4.95	5.1	5.05	mg

Pre dispatch inspection (PDI) no.: K 32 Engraving: MP 130 K 085943 Dispatch Date 22.10.2019

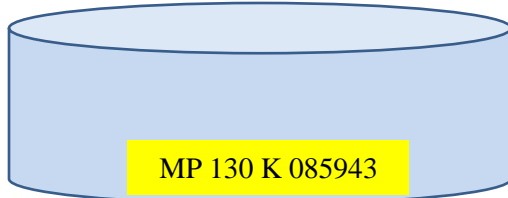
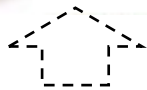
# Product traceability: Stage I

Stage I

Scan sheets and save with engraving number

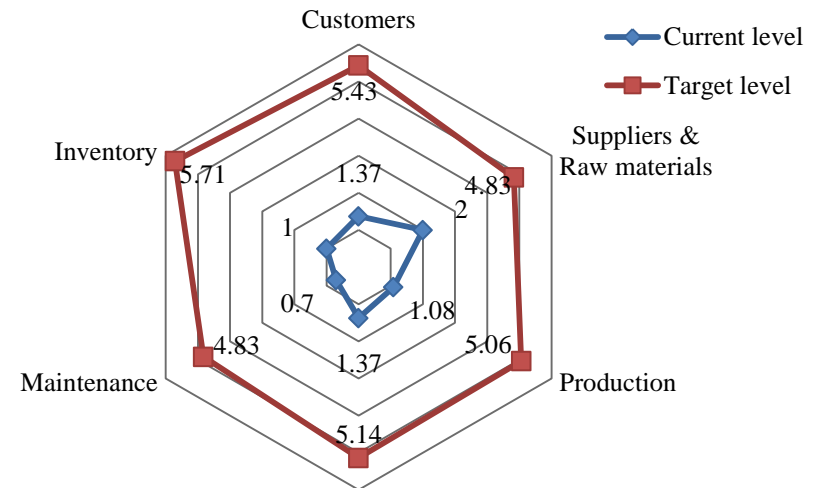


MP 130 K 085943

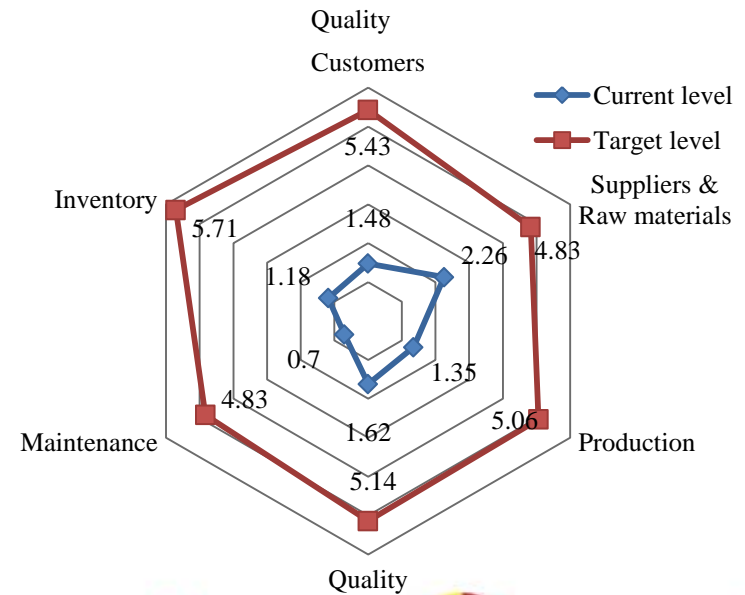


MP 130 K 085943

**Before**  
Score: 1.37



**After**  
Score: 1.48



# Product traceability: Stage I

Stage I

Scan sheets and save with engraving number



MP 130 K 085943

**Before**  
Score: 1.37

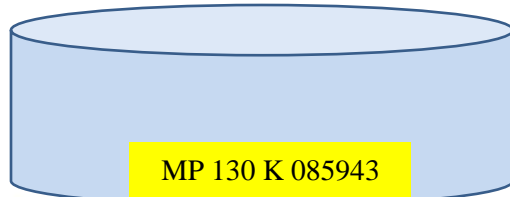
Q6. To what extent can products be tracked throughout their lifecycle?

- A. No
- B. Very Limited product tracking
- C. limited product tracking
- D. Complete product tracking

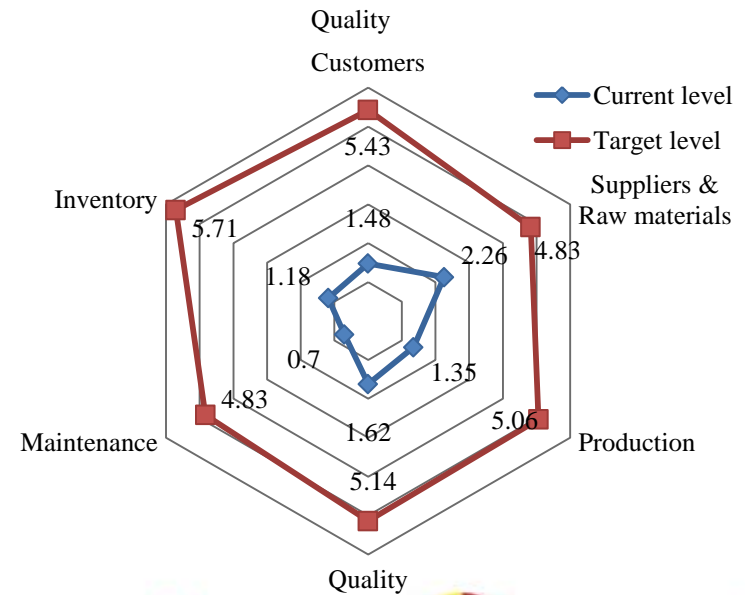
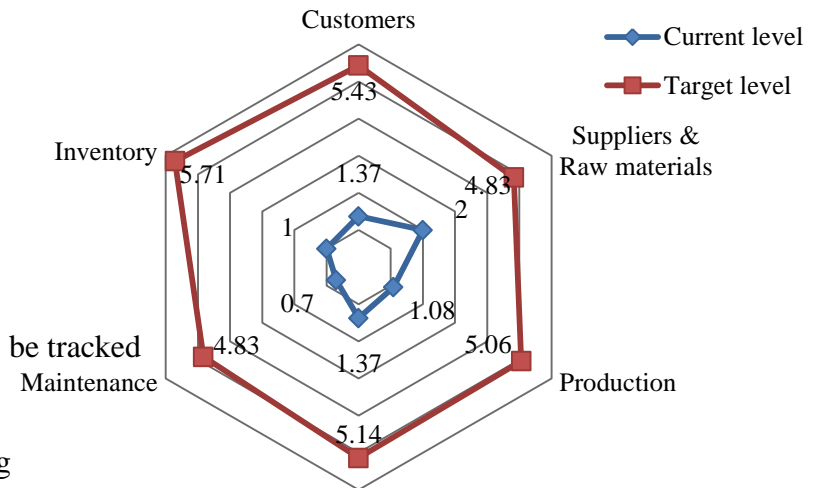
Response: B → C, score: 1 → 2

Target: D, score: 4

**After**  
Score: 1.48



MP 130 K 085943

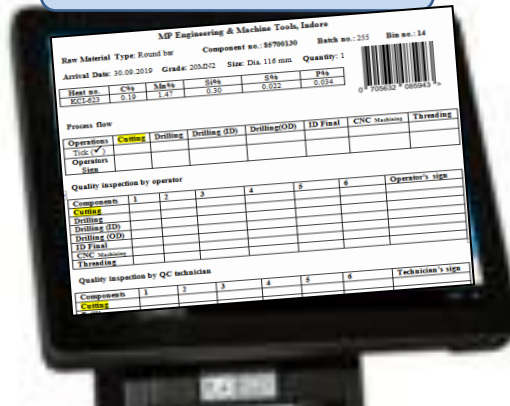


# Product traceability: stage II

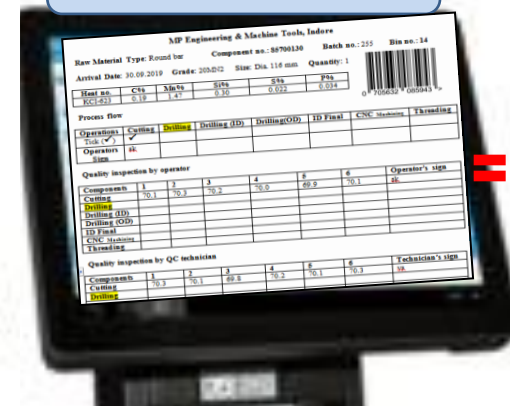
Store section



Cutting station



Drilling station



Threading

PDI

Engraving

Packaging & Dispatch



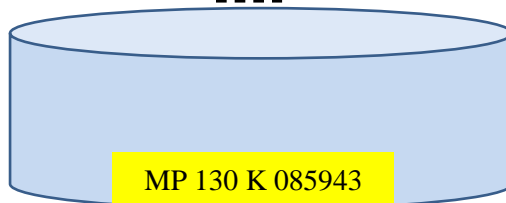
# Product traceability: stage II

Data collected at each station and stored

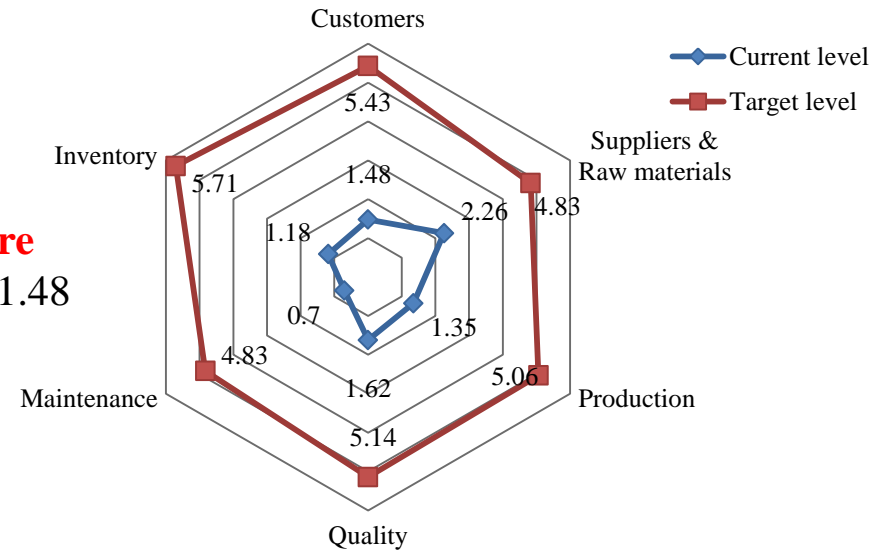


MP 130 J32 085943 - Microsoft Excel

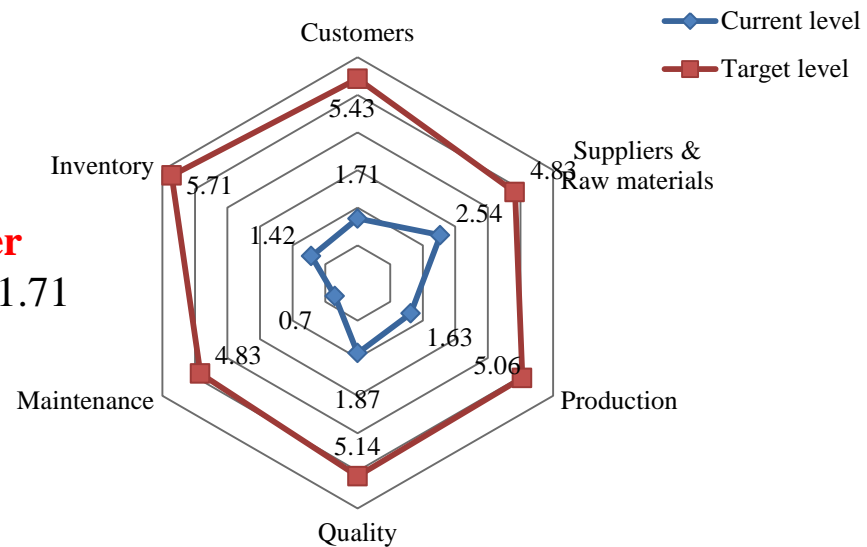
MP Engineering & Machine Tools, Indore							
Raw Material Type: Round bar	Component no.: 85; Bin no.: 14						
Heat no.: KCI-623	Batch no.: 255	Arrival Date: 30.09.2019					
Grade: 20Mn2	Size: D1	Quantity: 20					
Process flow							
Operations	Cutting	Drilling (g)	Drilling (ID)	Drilling (OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓	✓	✓	✓	✓	✓	✓
Operators Sign	sk	ng	vm	np	gz	vp	km
Quality inspection by operator							
Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70	69.9	70.1	sk
Drilling	45.1	45	45.3	45.2	44.8	45	ng
Drilling (ID)	42.1	42	42	42	42	42	vm
Drilling (OD)	55	55.2	55	55	54.9	55.1	np
ID Final	42.2	41.9	42.1	42	42.1	42.2	gz
CNC Machining	30.1	30.2	30	30.1	30.3	29.9	vp
Threading	5.05	5.1	5.15	4.95	5.1	5.05	km
Quality inspection by QC technician							
Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs
Drilling	45	45.3	45	44.8	45.1	45.2	am
Drilling (ID)	42	42.1	42.2	42.1	42.3	41.9	hp
Drilling (OD)	55.1	55	54.9	55.2	55.3	55.1	lk
ID Final	42.1	42	42.2	41.9	42.2	42.1	rp
CNC Machining	30	30.1	30.3	29.9	30.2	30.1	js
Threading	5.1	5.05	5.15	4.95	5.1	5.05	mg
Pre dispatch inspection (PDI) no.: K 32      Engraving: MP 130 J32 085943							



**Before**  
Score: 1.48



**After**  
Score: 1.71





# Product traceability: stage III

MP Engineering & Machine Tools, Indore

Raw Material Type: Round bar    Component no.: 85700130    Batch no.: 255    Bin no.: 14

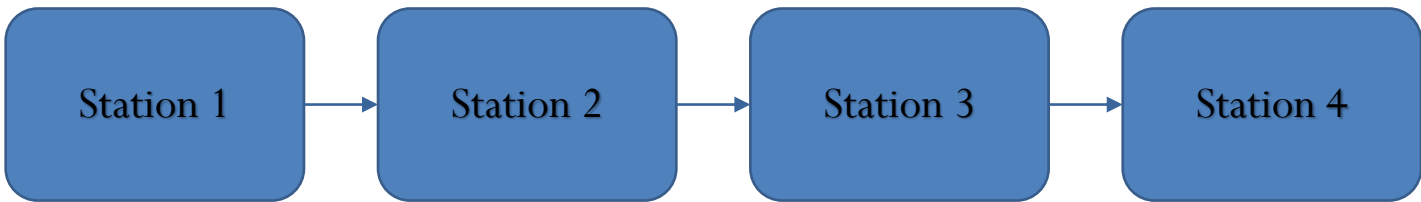
Arrival Date: 30.09.2019    Grade: 20MN2    Size: Dia. 116 mm    Quantity: 1

Heat no.	C%	Mn%	Si%	S%	P%
KCI-623	0.19	1.47	0.30	0.022	0.034

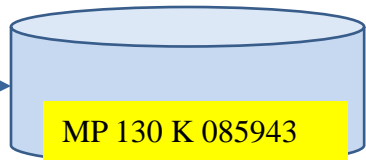


The material information is passed to all the stations through barcode

The respective stations fill the measured details. Along with material data from barcode and station data is saved for further validation.



Component	1	2	3	4	5	6	Operator Sign



The material data along with component unique id after validation is saved to BLC. The component unique id can also be used as nonce.



Insert Component ID

---

MP Engineering & Machine Tools, Indore

Raw Material Type: Round bar    Component no.: 85700130    Bin no.: 14

Heat no.: KCI-623    Batch no.: 255    Arrival Date: 30.09.2019

Grade: 20MN2    Size: Dia. 116 mm    Quantity: 20

Process Flow

Order	Cutting	Drilling	Drilling O/D	Drilling O/D	ID Final	QC Station	Grinding
Slk	Slk	Slk	Slk	Slk	Slk	Slk	Slk
Size	Size	Size	Size	Size	Size	Size	Size
24	24	24	24	24	24	24	24
24	24	24	24	24	24	24	24

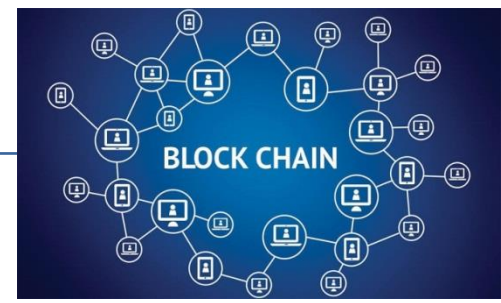
Quality inspection by operator

Component	1	2	3	4	5	6	Operator's sign
Cutting	20.0	20.0	20.0	20.0	20.0	20.0	
Drilling O/D	20.0	20.0	20.0	20.0	20.0	20.0	
ID Final	20.0	20.0	20.0	20.0	20.0	20.0	
Grinding	20.0	20.0	20.0	20.0	20.0	20.0	

Quality inspection by QC technician

Component	1	2	3	4	5	6	Technician's sign
Cutting	20.0	20.0	20.0	20.0	20.0	20.0	
Drilling O/D	20.0	20.0	20.0	20.0	20.0	20.0	
ID Final	20.0	20.0	20.0	20.0	20.0	20.0	
Grinding	20.0	20.0	20.0	20.0	20.0	20.0	

Pre dispatch inspection (PDI) no.: K 32    Engraving: MP 130 J32 085943



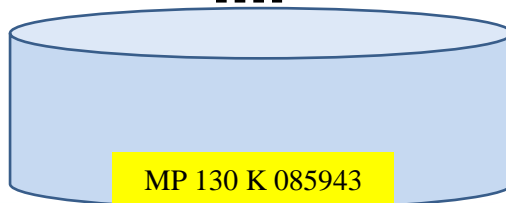
# Product traceability: stage II

Data collected at each station and stored

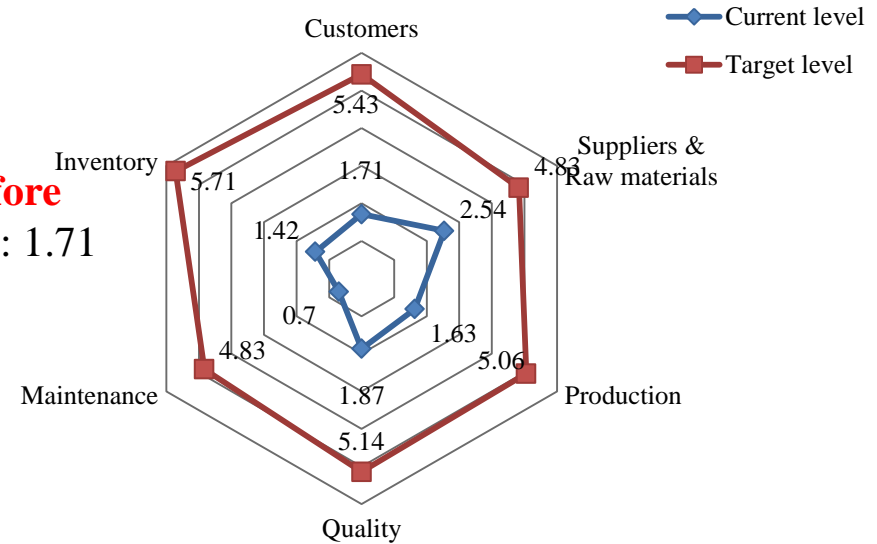


MP 130 J32 085943 - Microsoft Excel

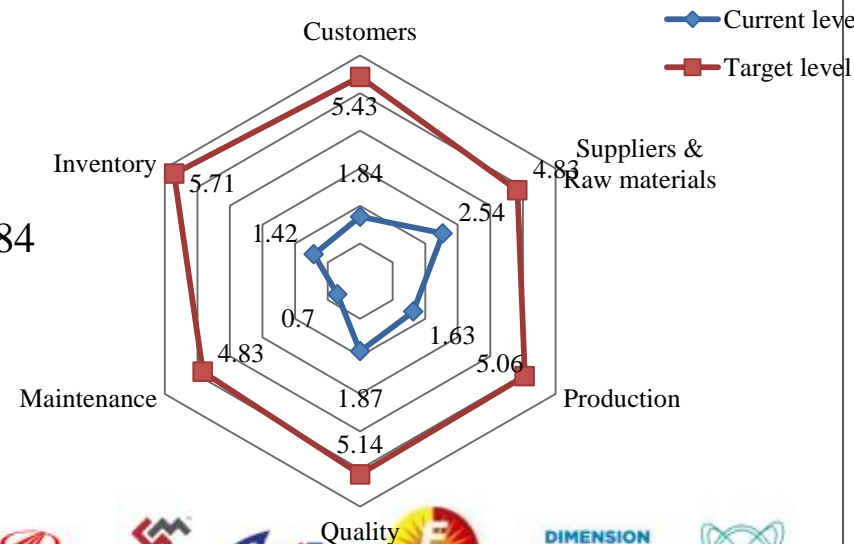
MP Engineering & Machine Tools, Indore							
Raw Material Type: Round bar		Component no.: 85; Bin no.: 14					
Heat no.: KCI-623		Batch no.: 255		Arrival Date: 30.09.2019			
Grade: 20Mn2		Size: D1		Quantity: 20			
Process flow							
Operations	Cutting	Drilling (g)	Drilling (ID)	Drilling (OD)	ID Final	CNC Machining	Threading
Tick (✓)	✓	✓	✓	✓	✓	✓	✓
Operators Sign	sk	ng	vm	np	gz	vp	km
Quality inspection by operator							
Components	1	2	3	4	5	6	Operator's sign
Cutting	70.1	70.3	70.2	70	69.9	70.1	sk
Drilling	45.1	45	45.3	45.2	44.8	45	ng
Drilling (ID)	42.1	42	42	42	42	42	vm
Drilling (OD)	55	55.2	55	55	54.9	55.1	np
ID Final	42.2	41.9	42.1	42	42.1	42.2	gz
CNC Machining	30.1	30.2	30	30.1	30.3	29.9	vp
Threading	5.05	5.1	5.15	4.95	5.1	5.05	km
Quality inspection by QC technician							
Components	1	2	3	4	5	6	Technician's sign
Cutting	70.3	70.1	69.8	70.2	70.1	70.3	vs
Drilling	45	45.3	45	44.8	45.1	45.2	am
Drilling (ID)	42	42.1	42.2	42.1	42.3	41.9	hp
Drilling (OD)	55.1	55	54.9	55.2	55.3	55.1	rp
ID Final	42.1	42	42.2	41.9	42.2	42.1	lp
CNC Machining	30	30.1	30.3	29.9	30.2	30.1	js
Threading	5.1	5.05	5.15	4.95	5.1	5.05	mg
Pre dispatch inspection (PDI) no.: K 32		Engraving: AP 130 J32 085943					



**Before**  
Score: 1.71



**After**  
Score: 1.84

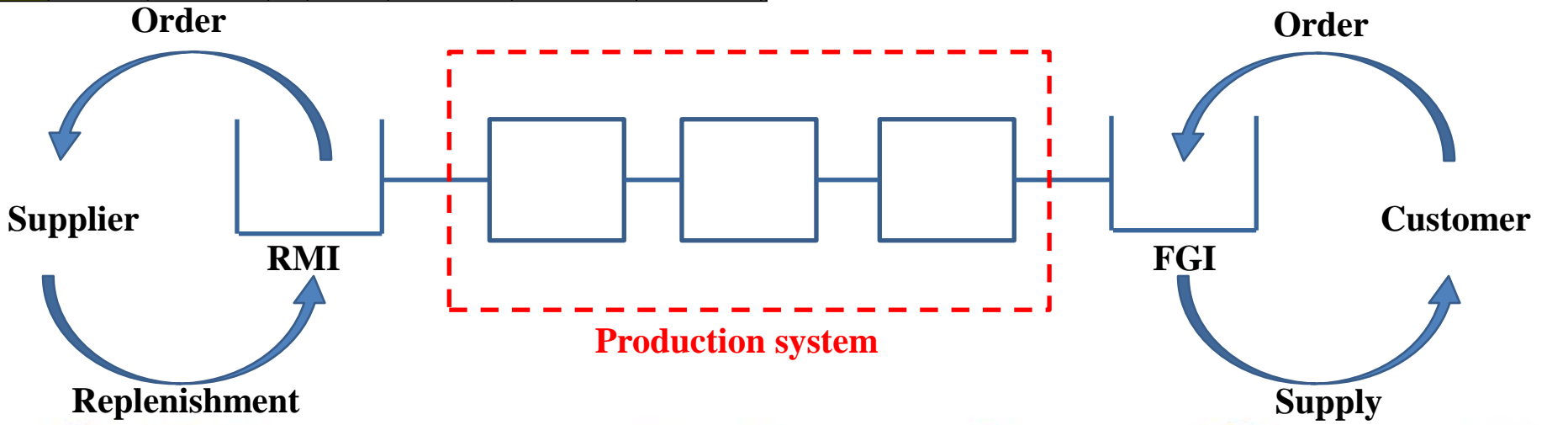


# Benefits of Product Traceability

- Better customer ranking
  - In the current solution product tractability will also help in better data analytics, for example, which machine is mostly creating problem, process capability, etc.
  - More analytical decision making is possible, for example, accurate delivery commitment, production planning, inventory control
- 
- ✓ Multi stage technology road map may be useful for SMEs
  - ✓ Industries may decide whereto stop on digitalization

# Two-bin Inventory control: Stage I

Functions	Sub-category	Associated items	Intrest?	Current	Target	Requirements	Technology	Functions	Sub-category	Associated items	Intrest?	Current	Target	Requirements	Technology		
Production	Production Planning					<b>Autonomous/distributed decision-making system</b> , computation devices, real-time data collection, digital integration of suppliers, production, operations, sales, & customers, standardization	Web based portal development, Computation devices, <b>Two-bin system</b> , AI/ML, algorithms, sensors, smart HMI, CPS, IoT, Simulation modelling, optimization.	Inventory	Inventory control					<b>Autonomous inventory control system</b> , smart communication, smart devices, Smart bins, <b>product traceability</b> , <b>autonomous decision-making</b> , interoperability, digital integration of suppliers, production, operations, sales, & customers	<b>Two-bin system</b> , Web based portal development, API, Sensors, smart HMIs, smart bins, scanner, DBMS, Blockchain, smart devices, IoT, AAS, Computation devices, AI/ML, algorithms, CPS, Interoperability, simulation, cloud computing		
	Production Planning	Yes	Experience-based	Autonomous decision-making						Yes	Exp. based	Autonomous					
	Process																
	Shop-floor ICT Infrastructure	Yes	Beginner	Excellent					Sensors, smart communication, smart assets-products, <b>autonomous decision-making</b> , interoperability, digital integration of suppliers, production, operations, sales, & customers	Sensors, IoT, AAS, Computation devices, AI/ML, CPS, Interoperability, big data & analytics, smart gauges, smart HMIs, smart devices, cloud computing	Data generation & consumption	Communication	Yes	Offline	Online	Smart communication system	Smart devices, IoT, Computation devices, algorithms
	Smart product	Yes	No	Complete traceability					<b>Product traceability</b> , DBMS, Blockchain, Sensors, smart bins, smart panel, data storage, comutation devices, smart communication	DBMS, Blockchain, Sensors, smart HMIs, smart bins, data storage devices, comutation devices, IoT, smart engraving	Data generation	Data generation	Yes	Partially	Online data collection	Smart devices, Automatic data collection	Sensors, CPS, smart HMI, storage devices
Shop-floor production monitoring	Yes	No	Yes				Smart communication, interoperability, digital integration of suppliers, raw material production & operations, real-time data collection & utilization	AR, Sensors, IoT, AAS, Computation devices, algorithms, AI/ML, CPS, Interoperability, big data & analytics, smart HMIs, smart devices, automation, DBMS, Blockchain	Data analysis	Data analysis	Yes	Partially	Data analysis tool	Automatic data analysis, comutation devices	Smart devices, IoT, big data & analytics, Computation devices, algorithms, AI/ML, simulation		
									Data consumption	Data consumption	Yes	Partially	Completely	Automatic data analysis, comutation devices, Autonomous decision-making	Smart devices, IoT, Computation devices, algorithms, AI/ML, simulation modelling, optimization		



# Solution: Two-bin Inventory control

**Step 1:** Estimate production cycle duration

**Step 2:** Estimate variation in demand

**Step 3:** Determine FGI quantity 'Q' based on service level

**Step 4:** Produce quantity Q and keep ready at  $t=0$ ; this is '**Bin 1**'

**Step 5 :** At the end of cycle, Bin 2 be ready, swap Bin 1 with Bin 2  
Determine the consumed quantity from Bin1, it will be lot size for next cycle.

**Step 6 :** The procedure will repeat

- Real-time monitoring of FGI & SFGI
- Automated order generation
- Automated scheduling of job orders
- Automated order placement for raw materials
- Dynamically updating of the quantity 'Q'
- Automated adjustments of production quantities based on rejections and raw material defects



# Solutions

Associated items	Intrest?	Current	Target	Requirements	Technology
Product quality	Yes	80-90%	90-100%	Smart gauging system, automatic sampling plan, smart packaging system	<b>Smart gauges</b> , Standard quality control practices, Cp, Cpk, Cloud computing, Computation devices, AI/ML, algorithms, sensors, <b>Smart HMI</b> , CPS, IoT, Simulation modelling, interoperatability, smart packaging

## Smart HMI

- Data collection,
- alarm notification,
- communication,
- analysis,
- data computation



- Touch panel
- IP65 protection
- Ethernet
- RS-485

## Smart Gauge



- Capable of displaying,
- recording,
- communicate data over Wi-Fi