IMTMA-ACE MICROMATIC

Productivity Championship Award 2022

1.Brief Description of the Project

Mekhos is a project-based company that provides assembly and testing solutions to customer for their industrialization needs. The solution that we provide are completely crafted based on customer requirement and are custom designed to suit the product quality and productivity requirements of the customer.

In the presented case study, the customer is producing Cabin Latch unit for different OEMs at global locations, there are different variants of latch that need to be produced specific to customer requirement, the core function of the product remains same but there are dimensional variances in the component across variants.

Machinery that the customer was using in production was 20 years old and was lagging in the latest technological development.

The Requirement floated to us for the project was to provide an assembly and testing solution for the latch meeting the quality and productivity requirements. Another challenge in the production line was to accommodate all the variants of the latch keeping the change over time minimum.

The Old line also didn’t have any provision for data collection, handling and processing which had to be incorporated in our proposal.

Product details:

A cabin latch unit is used to secure the front cabin of a commercial truck to its chassis. During maintenance and repair of the engine, the entire cabin has to be tilted by approximately 130 degrees. The latch supports the entire weight (1500Kg) of the cabin during the closure.

The latch unit is manufactured by our customer M/s. Centre Motion. They have 13 different variants of latch units. These variants differ in terms of mechanical design, child parts, assembly and process parameters. The latch unit consists of 17 child parts (varies depending on the variant).

Latch Assembly

Child Parts.

Machine Introduction:

The objective was to create an assembly and testing line, which would use only 8 operators to assemble the latch unit against 28 which are used currently. The existing line had its well share of limitation, a few being, incapability of handling newer variants within existing machines, high rejection rate, missing Poka-Yoke and inability to collect and process data. A new and improved set of machines were need of the hour to overcome these issues. Since each variant had different set of child parts, assembly parameters & operations, the mammoth task was to design a single assembly line which could take care of the assembly of all variants, since having separate machines for each variant was not a feasible option.

An in-depth study of the component (all 13 variants) was undertaken to understand the assembly requirements. In order to completely assemble a single latch unit, 8 individual semi-automatic stations had to be designed. The stations were

1. Back plate riveting
2. Hook and trigger riveting
3. Latch unit assembly
4. Top plate riveting
5. Silent block pressing
6. End of Line testing
7. Hydraulic Cylinder Poka Yoke Station
8. Hydraulic Cylinder Assembly and Testing Machine

The Assembly Line consists of 3 Sets of Latch Assembly Machine and 1 Set of Hydraulic Cylinder assembly Machines.

The Line also had process level traceability capturing the process data which was stored against the unique barcode laser printed on the component.

The major innovation which was brought with the use of compact tooling dies with single minute exchange of dies concept. The machines were designed with generic parameters to suit all the variants of latches and the specific tooling were designed for each variant. This also gives the feasibility of adding further variants in the machines with minimum effort. Line balancing and process optimisation was done to come up with a process flow that followed single piece flow, optimizing the manpower and space requirements. The customer was using heavy presses (80 Ton Capacity) which was optimized to smaller presses (30 Tons) that reduced the overall energy consumption of per unit production thereby lowering the carbon footprint of the product. Furthermore, these machines had to follow the European union's standards of safety and regulations

2. Trigger for the project

1. The previous assembly line required 28 operators. The steep rise in labour costs across Europe meant that the total profit generated per unit was on the steady decline. A new line which utilised fewer operators was one of the main triggers for the project
2. There were 13 separate end of line testing machines in the previous line, as its design was such that it could only run a single variant. Furthermore, any new variants added in the future would require an additional end of line testing station. This was a massive setback in terms of investment cost.
3. The design of the existing machine was such that the required process parameters were sometimes not being met. This meant that the rejection rate of quite high.
4. As the annual requirement for latch units grew around 6,37,000 units/annum were required at peak capacity, which was not feasible with the existing setup.
5. The overall equipment effectiveness (OEE) was at 80 percent. Productive manufacturing time had to be increased to at least 95 percent.
6. In the previous machine, the assembly of child parts required the complete involvement of the operator. Greater the involvement of the operator, greater the chance of defective component. This had to be taken care of with a new semi-automatic solution.

7. There was no traceability on the production line, which made it very difficult to back-trace any rejection and perform a root cause analysis.
8. There was WIP accumulation in the existing line which had to be removed.
9. Energy consumption and layout requirement of the line was high.
10. Change over time from one variant to other was 60 mins which resulted in reduced actual production time.

3. Solution Generation, Innovation & Complexity

Problem Definition:

Current Scenario:

Three main assembly line for latch and one offline assembly line for hydraulic cylinder is running at a cycle time of 72 Secs/ per line, three shifts in a day to produce the required output at an estimated OEE of 85%. The total number of operators used in the line are 28 Nos.

Problems faced:

- Rejection rates are high because of the lacking poka-yoke and process control, which is increasing the per piece cost of output.
- Running the line is 3rd shift is expensive because if the extra wages that needs to be paid to night shift workers and other overheads.
- Change over time from variant to variants is high, around 30 mins which is impacting the productivity.
- Hook and trigger sub-assembly are outsourced, this is an added cost to the process.
- Since all parameters are not tested in the EOL, thus rejection occurs at customer site, leading to the decreased brand value.
- Traceability in the line is absent, thus backtracking of errors is not feasible.

Problem Statement:

- An assembly line needs to be designed, with decreased manpower requirement which will run for two shifts only to fulfil the required output.
- The new line must have all the required poka-yoke and end of line checks to reduce the rejections faced to minimum level.
- The riveting process should be improved to increase the process control with a closed loop system. The new line should have relevant traceability thus enabling the firm to backtrack the rejections and perform root cause analysis.
- The change over time should be made less than 5 mins with minimum setting requirement thus low skilled manpower should be able to perform the changeover.

Solution generation:

Multiple solutions were tried and process failure mode analysis, cycle time analysis, risk analysis, man machine movement analysis was performed. Based on the data, final solution was accepted.

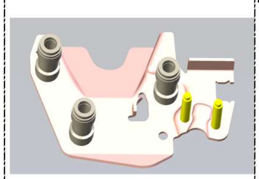
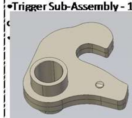
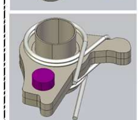
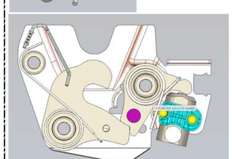
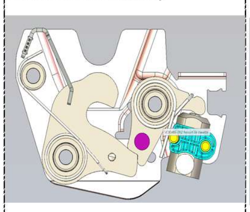
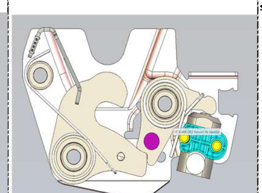
The analysis of the accepted solution is presented below.

Process Mapping:

Process Mapping for each variant was performed to study how a common process can be developed across all variant.

A Section of the study is presented for the visualization:

Each Variant was analyzed individually for the process specific details and the child parts involved in it, marking the important process parameters to be achieved:

S.NO	Operation.	Program	Input Components.	Output Components	Material Feeding Details.	Poka Yoke.
1.3	OP20 Back Plate Crimping Machine.	Scania / V28	• Axel 1 - 2 Nos. • Axel 2 - 3 Nos, • Back Plate - 1 Nos.	•Back Plate Sub-Assembly - 1Nos. 	• Axel 1 - Side Chutes • Axel 2 - Side Chutes • Back Plate - Side Chutes	• Axel 1 & 2- LVDT and Loadcell. • Back Plate - Flat Proximity.
2.3	OP10 Hook and Trigger Crimping. & Assembly Station	Scania / V28	•Axel 1 -1 Nos. •Spacer Pipe-1 Nos. •Hook Plate - 2 Nos. •Axel 3 -1 Nos. •Trigger Plate -2 Nos. •Trigger Spring - 1 Nos. •Spacer Pipe -1 Nos. • Hook Sub-Assembly -1 Nos. •Trigger Sub Assembly -1 Nos. •Hydraulic Jack Sub-Assembly - 1 Nos.	•Hook Sub-Assembly - 1 Nos. (intermediate output) •Trigger Sub-Assembly - 1 Nos. (intermediate o[illegible] •[illegible]embly.   	•Axel 1 -1 Nos. •Spacer Pipe-1 Nos. •Hook Plate - 2 Nos. •Axel 3 -1 Nos. •Trigger Plate -2 Nos. •Trigger Spring - 1 Nos. •Spacer Pipe -1 Nos. • Hook Sub-Assembly -from previous process , machine fixture. •Trigger Sub Assembly -from previous process , machine fixture. •Hydraulic Jack Sub-Assembly - Conveyor from Other Station.	•Axel 1 -LVDT and Loadcell. •Spacer Pipe-LVDT and Loadcell. •Hook Plate - Bottom Plate - Flat Proximity. Top Plate - Laser Sensor. •Axel 3 -LVDT and Loadcell. •Trigger Plate - Bottom Plate - Flat Proximity. Top Plate - Laser Sensor. •Trigger Spring - Flat Proximity. •Spacer Pipe -LVDT and Loadcell. •Trigger Spring - Flat Proximity. • Hook Sub-Assembly -Camera in Next Stage. •Trigger Sub Assembly -Camera in Next Stage. •Hydraulic Jack Sub-Assembly -Camera in Next Stage.
3.3	OP30 Camera Checking.	Scania / V28	• Latch Back Plate Sub Assembly. 	• Latch Back Plate Sub Assembly. 	• Latch Back Plate Sub Assembly - From previous station on conveyor (Automatic) F12	Latch Back Plate Sub Assembly - Through Beam Sensor, Mechanical PY.

Upon analysis of each variant, the data was assimilated and all the processes across all variants was mapped, the elements distinguishing in each variant and points of similarity was drawn to analysis how an smooth flow of man and material across variants can be achieved.

A Snap shot of the mapping is shown below:

S.NO.	Family	Tooling	Model	Number of Axels	Hydraulic Cylinde	OP20 Back Plate Crimping		OP10 Hook and Trigger Crimping		Greasing		Latch Assembly Station		Camera Checking		OP40 Top Plate Crimping		Switch Assembly	
1	V15	1	V15.0700	7	Tightening Type Torque : 24 N.m (+4 -0)	✔	7 Axels. 2 BackPlates	✔	3 Hook Plate. 1 Rivet. 3 Trigger Plate. 1 Rivet. 1 Top Plate. 1 Guide Plate. 1 Small Rivet	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly.	✔	Sub Assembly	✔	6 Axels. 1 Top Plate Sub Assembly	✖	
2	V15	1	V15.0701	7	Tightening Type Torque : 24 N.m (+4 -0)	✔	7 Axels. 2 BackPlates	✔	3 Hook Plate. 1 Rivet. 3 Trigger Plate. 1 Rivet. 1 Top Plate. 1 Guide Plate. 1 Small Rivet	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly.	✔	Sub Assembly	✔	6 Axels. 1 Top Plate Sub Assembly	✖	
3	V15	1	V15.0800	7	Tightening Type Torque : 24 N.m (+4 -0)	✔	7 Axels. 2 BackPlates	✔	3 Hook Plate. 1 Rivet. 3 Trigger Plate. 1 Rivet. 1 Top Plate. 1 Guide Plate. 1 Small Rivet	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly.	✔	Sub Assembly	✔	6 Axels. 1 Top Plate Sub Assembly	✖	
5	V29	2	VCB054D.000	3	Tightening Type Torque : 23 Nm Minimum	✔	3 Axels. 1 Back Plate.	✔	2 Hook Plate. 2 Trigger Plate. 1 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly.	✔	Sub Assembly	✔	3 Axels. 1 Top plate	✖	
6	V29	2	VCB054D.100																
7	V28	3	V28.000D	5	NA	✔	5 Axels. 1 Back Plate	✔	2 Hook Plate. 2 Trigger Plate. 1 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly.	✔	Sub Assembly	✔	5 Axels. 1 Top Plate	✖	
9	V07	3	V07.0200	2	Pending	✔	2 Axels. 1 Back Plate	✔	2 Hook Plate. 2 Trigger Plate. 1 Switch Sub Assembly. 1 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly. Tightening of Hydraulic Cylinder to	✔	Sub Assembly	✔	2 Axels 1 Top Plate	✔	1 Switch Bracket. 1 Switch + Self Locking Link. 2 Hollow Rivet
10	V07	3	V07.0300	2	Pending	✔	2 Axels. 1 Back Plate	✔	2 Hook Plate. 2 Trigger Plate. 1 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly. Tightening of Hydraulic Cylinder to	✔	Sub Assembly	✔	2 Axels 1 Top Plate	✖	
11	565	4	565.03	4	Tightening torque = 31 Nm. ±3 Nm	✔	4 Axels. 1 Back Plate	✔	3 Hook Plate. 3 Trigger Plate. 1 Spring. 2 Rivets. 1 Guide Pin.	✔	Hook & Trigger Assembly.	✔	Hydraulic Cylinder Tightening to Plate. Hook Trigger	✔	Sub Assembly	✔	4 Axels. 1 Top Plate	✖	
13	V08	5	V08.0000	5	Tightening torque = 20 Nm	✔	6 Axels. 1 Back Plate	✔	3 Hook Plate. 3 Trigger Plate. 1 Spring. 2 Rivets. 1 Guide Pin.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Assembly.	✔	Sub Assembly	✔	6 Axels. 1 Top Plate	✔	1 Switch Bracket. 1 Switch + Self Locking Link. 2 Hollow Rivet
15	V11	6	V11.0100	3	Clamping torque : 38 N.m (+10 ; 0)	✔	3 Axels. 1 Back Plate.	✔	3 Hook Plate. 3 Trigger Plate. 1 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Asssembly.	✔	Sub Assembly	✔	3 Axels. 1 Top plate	✖	
16	V10	7	V10.0200	4	Clamping torque = 22 N.m mini	✔	4 Axels. 1 Back Plate	✔	3 Hook Plate. 3 Trigger Plate. 1 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Assembly.	✔	Sub Assembly	✔	4 Axels. 1 Top Plate	✖	
18	V12		V12.0200																
19	V12		V12.0300																
20	V06	8	V06.0300	8	NA	✔	8 Axels 1 Back Plate	✔	3 Hook Plate. 3 Trigger Plate. 2 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Assembly.	✔	Sub Assembly	✔	8 Axels. 1 Top Plate	✖	
27	V13	9	V13.0000	5	NA	✔	4 Axel. 1 Lever with Axel. 1 Back Plate.	✔	3 Hook Plate. 3 Trigger Plate. 2 Spring. 2 Spacer 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Assembly.	✔	Sub Assembly	✔	4 Axel. 1 Top Plate.	✖	Different Switch Type Crimping not required only tightening. Can be done in hydraulic bracket crimping machine.
30	V20 - NE	10	V20.0000	6	NA	✔	6 Axels 1 Back Plate	✔	3 Hook Plate. 3 Trigger Plate. 1 Spring. 2 Rivets.	✔	Hook & Trigger Assembly.	✔	Hook Trigger Spring Hydraulic Cylinder Assembly.	✔	Sub Assembly	✔	6 Axels 1 Top Plate		

Based on this study the single piece flow concept was stabilized by balancing the line for each model which is used for the detailed cycle time study across all variants. This study also highlights the difference in the process for each variant which was further used during design to stabilize relevant poka-yoke in the line specific the variants.

Poka-Yoke analysis:

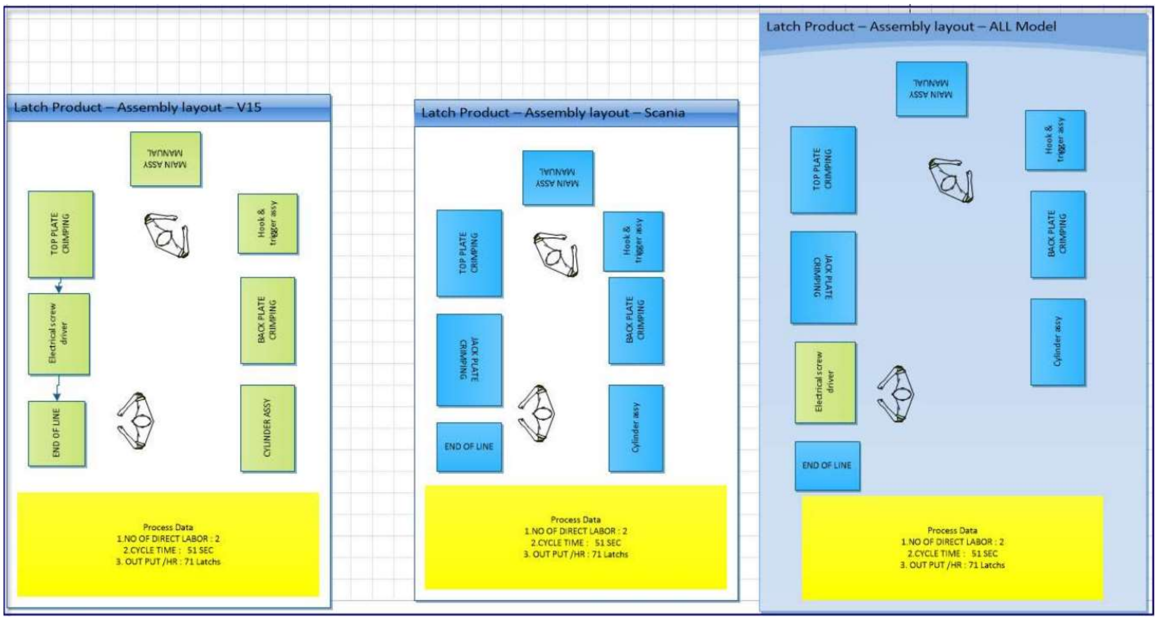
Based on the identified failure mode from the PFMEA of the customer poka-yoke was stabilized in the line, a snapshot of the analysis is presented for better understanding.

Poka Yoke List Station Wise						
Station Name	**S.No**	**Process**	**Details**	**Possible Effects of stated problems**	**Action Plan**	**Occurance Possiblity**
OP 10 Hook and Trigger Crimping		Hook, Rivet & Pipe Presence	Operator to load the component into fixture and press cycle start, machine to verify the component presence & Orientation into the fixture before crimping	Process Worng- Non Detectable	•Mechanical Poka-Yoke with Spring loaded probes to check the presence of component (Rivet & Pipe)into the fixture. •Hook Presence to be ensured by Flat	✓
		Trigger, Rivet, Pipe and Springs	Operator to load the component into fixture and press cycle start, machine to verify the component presence & Orientation into the fixture before crimping	Process Worng- Non Detectable	•Mechanical Poka-Yoke with Spring loaded probes to check the presence of component (Rivet, Pipe, Top Spring)into the fixture. •Trigger Presence to be ensured by Flat Proximity. •Bottom Spring Presence Checking using Flat Proximity.	✓
		Riveting Pressing Depth Checking	While Riveting, Pressing Depth to be checked	Process Worng- Non Detectable	LVDT is used for monitoring the riveting depth	✓
		Riveting Pressing Load Checking	While Riveting, Pressing Load to be checked	Process Worng- Non Detectable	Load Cell is used for monitoring the riveting load	✓
		Tool Change Over Presence Checking	Correct Tool to be checked before riveting, after tool change-over	Process Wrong- Detectable by machine	Proximity Sensor to ensure the correct tool presence.	✓
OP 20 Back Plate Crimping		Axle & Spacer Presence Checking	Operator to load the component into fixture and press cycle start, machine to verify the component presence & Orientation into the fixture before crimping	Process Worng- Non Detectable	•Mechanical Poka-Yoke with Spring loaded probes to check the presence of component (Rivet & Pipe)into the fixture. •If the Component will be placed into the fixture in correct orientation, spring loaded probes will check the presence if loaded in correct orientation.	✓
		Plate Presence Checking	Operator to load the component into fixture and press cycle start, machine to verify the component presence & Orientation into the fixture before crimping	Process Worng- Non Detectable	• Flat Proximity Sensor will be used for sensing the plate if loaded in correct orientation.	✓
		Riveting Pressing Depth Checking	While Riveting, Pressing Depth to be checked	Process Worng- Non Detectable	LVDT is used for monitoring the riveting depth	✓
		Riveting Pressing Load Checking	While Riveting, Pressing Load to be checked	Process Worng- Non Detectable	Load Cell is used for monitoring the riveting load	✓
		Tool Change Over Presence Checking	Correct Tool to be checked before riveting, after tool change-over	Process Wrong- Detectable by machine	Proximity Sensor to ensure the correct tool presence.	✓
OP 30 Back Plate, Hook, Trigger & Hydraulic Jack Assembly		Back Plate, Hook, Trigger & Hydraulic Jack Presence Check	When cycle start is pressed, Part Presence to be checked before process starts	Process Wrong- Detectable by machine	Image Discrimination Sensor, Keyence to be used for checking the presence of all components.	✓
		Greasing Presence	grease dispensing checking	Process Worng- Non Detectable	Grease Pressure Regulator and Valve Actuation Feedback will ensure the dispensing of the grease.	✓
		Hydraulic Jack Assembly Torque Monitoring	Tightening torque for the hydraulic jack to be monitored	Process Worng- Non Detectable	Electrical Spindle is used for tightening, torque and angle monitoring will be used.	✓
		Component Presence Checking in Leak Testing Fixture	Component Presence to be ensured	Process Worng- Non Detectable	Mechanical Poka-Yoke and Component presence checking.	×
		Leak Testing				×
OP 40 Back plate assembly with Hook & Trigger. (Riveting)		Hook, Trigger & Hydraulic Jack Presence Checking	Operator to load the component into fixture and press cycle start, machine to verify the component presence & Orientation into the fixture before crimping	Process Worng- Non Detectable	•Mechanical Poka-Yoke with Spring loaded probes to check the presence of component (Rivet & Pipe)into the fixture. •If the Component will be placed into the fixture in correct orientation, spring loaded probes will check the presence if loaded in correct orientation.	✓
		Top Plate Presence Checking	Operator to load the component into fixture and press cycle start, machine to verify the component presence & Orientation into the fixture before crimping	Process Worng- Non Detectable	• Flat Proximity Sensor will be used for sensing the plate if loaded in correct orientation.	✓
		Riveting Pressing Depth Checking	While Riveting, Pressing Depth to be checked	Process Worng- Non Detectable	LVDT is used for monitoring the riveting depth	✓
		Riveting Pressing Load Checking	While Riveting, Pressing Load to be checked	Process Worng- Non Detectable	Load Cell is used for monitoring the riveting load	✓
		Tool Change Over Presence Checking	Correct Tool to be checked before riveting, after tool change-over	Process Wrong- Detectable by machine	Proximity Sensor to ensure the correct tool presence.	✓
OP50 Hydraulic Bracket Crimping		Component presence Checking	Presence of Hydraulic Bracket to be ensured before crimping	Process Stop	Fixture with Mechanical Poka Yoke Component Presence Sensor, Photo-Electric Sensor	✓
		Pressing Depth Checking	While Pressing, Pressing Depth to be checked	Process Worng- Non Detectable	LVDT is used for monitoring the pressing depth	✓
		Pressing Load Checking	While Pressing, Pressing Load to be checked	Process Worng- Non Detectable	Load Cell is used for monitoring the pressing load	✓
OP50 Hydraulic Bracket Crimping		Component presence Checking	Presence ofLatch to be ensured before Testing	Process Stop	Fixture with Mechanical Poka Yoke Component Presence Sensor, Photo-Electric Sensor	✓
		Latch Lock Feedback	When Pneumatic Cylinder is actuated, latch locking feedback to be taken	Process Worng- Non Detectable	Position of cylinder ensured by reed switch will ensure latch closing	✓
		Latch should not open when pulled	After locking Latch will be pulled using same cylinder, latch not opening should be confirmed	Process Worng- Non Detectable	Same pneumatic cylinder which is used for locking will pull and try to open the latch, position of the cylinder ensured by reed switch will confirm of latch not opening while pulling	✓
		2D Marking	Data will be marked on the component	Process Worng- Non Detectable	as per the captured data 2D matrix will be marked using Laser marking head, but readablity of the same is not confirmed	×

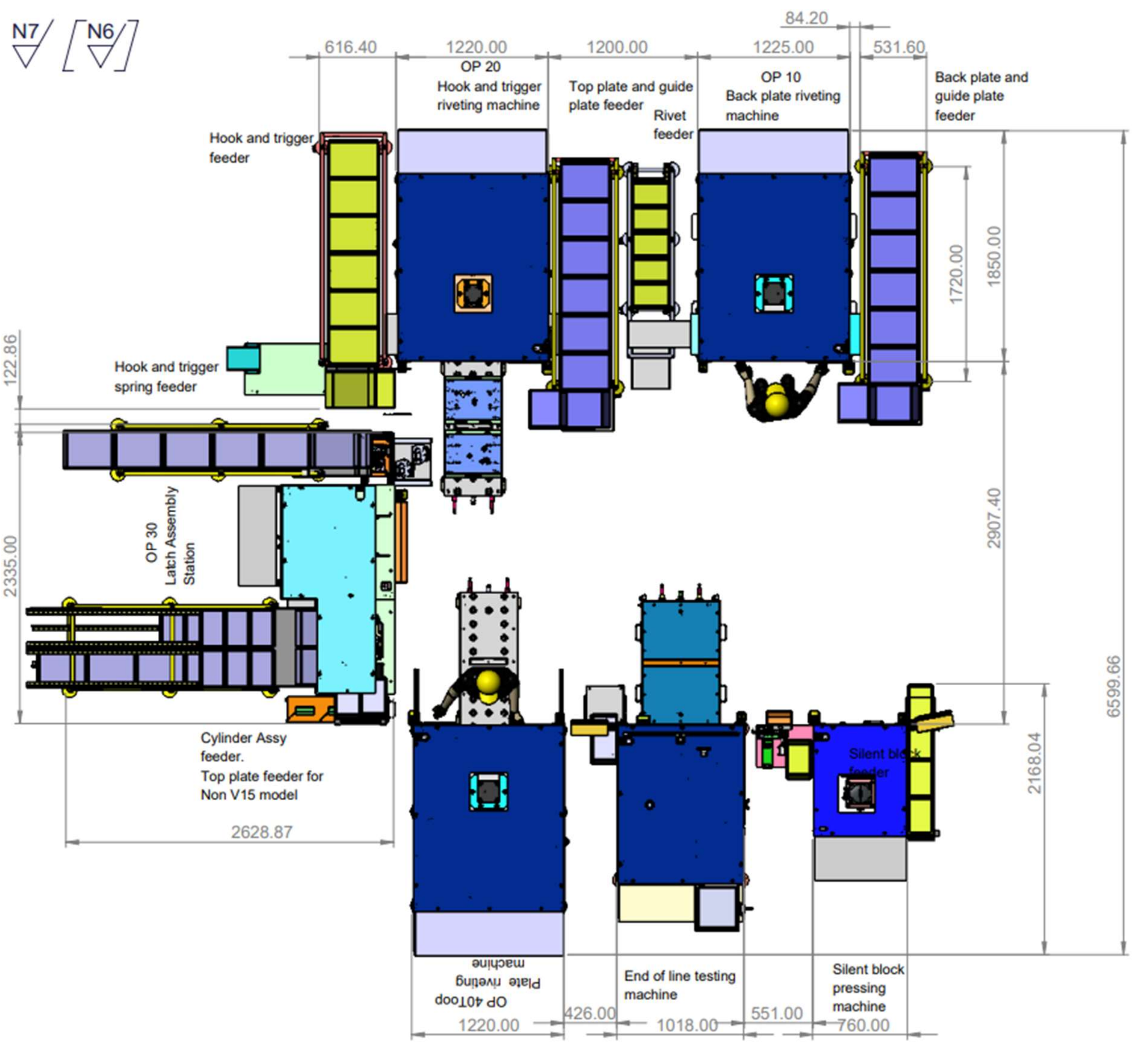
Layout generation.

Different layouts were tried analysis using software was done to arrive at the most optimum layout.

Screenshot of some layouts used for analysis is attached below:



The finalized layout for the line was:



The automatic part of the machine was simulated using software and mathematical calculations to arrive at the cycle time of each section, along with software analysis, physical model of the machines was developed and manual time was simulated to confirm the presented cycle time of each variant.

Cycle Time Study:

Available time:

S.No.	Particulars	Data	UOM	Remarks
1	Number of shifts available	2	Nos.	
2	Time per Shift	7.5	Hrs	
3	Time available per Day	15	Hrs	
4	Time required for Other than production activities	1.59	Hrs	(Details Confidential)
5	Net Time available	13.41	Hrs	
6	Number of Days in a Year	250.00	Days	
7	**Net Production Time available**	**12072000.00**	**Secs**	

Extensive Cycle time study was performed for each activity for each variant per station:

An example of the study is presented below:

Cycle Time Chart

Project Name: Latch Assembly Machine — Touch Number

Prepared By: Anurag

Step Value 1.00

Stn.Name	Operation Description	Method of Operation	Time in secs Start	End	Total
OP 30 Back Plate, Hook, Trigger & Hydraulic Jack Assembly	Component Unload and Place it on Camera Checking Fixture	Manual	0	2	2
	Take Trigger Assembly from greasing Fixture, Spring and Load into the fixture with rivet	Manual	2	6	4
	Take Switch Sub Assembly and Assemble	Manual	6	11	5
	Manually Pull the Trigger back to using Lever	Manual	11	12	1
	Load the Hook with Spring into the Fixture	Manual	12	16	4
	Assemble the Hydraulic Jack	Manual	16	36	20
	Press Cycle Start.	Manual	36	37	1
	Index the Conveyor	Automatic	37	39	2
	Camera Checking	Automatic	39	43	4
		∑Manual			37
		∑Automatic			6
		Cycle Time			43

Man- Machine diagram was plotted across variants.

An example of man machine diagram for one variant is presented below:

Operation Name	Program.		Time →
OP20 Back Plate Crimping	V15/Volvo.	M	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
OP20 Back Plate Crimping	V15/Volvo.	A	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Walking	V15/Volvo.	M	19 20
OP10 Hook and Trigger Crimping	V15/Volvo.	M	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
OP10 Hook and Trigger Crimping	V15/Volvo.	A	12 13 14 15 16 … 1 2 … 1 2 3 4 5 6 7 8 9 10 11
Walking	V15/Volvo.	M	47 48
OP 30 Back Plate, Hook, Trigger & Hydraulic Ja	V15/Volvo.	M	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
OP 30 Back Plate, Hook, Trigger & Hydraulic Ja	V15/Volvo.	A	1 2 3 4 5 6
Walking	V15/Volvo.	M	21 22
OP40 Top Plate Crimping	V15/Volvo.	M	23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
OP40 Top Plate Crimping	V15/Volvo.	A	16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 … 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Walking	V15/Volvo.	M	40 41
OP60 EOL	V15/Volvo.	M	42 43 44 45 46 47
OP60 EOL	V15/Volvo.	A	4 5 6 7 8 9 10 11 12 13 14 … 1 2 3
Walking	V15/Volvo.	M	48 49

Manual	
Automatic	

Based on the output generated the productivity planning for full line is generated.

S.No.	Model	Part Number	Customer	Annual Projected Volume Cycle time (calculated)	(Customer Data)	Overall OEE	Cycle Time After OEE Consideration	Time (Secs) required to meet production Volume	% utilization by each model of total lines % Occupany in Avilaible Machine Time
				sec			85% OEE		
1	V15	V15.0700	VOLVO	48	1,20,000	85%	56	67,76,470.59	19%
2		V15.0800	VOLVO	48	90,000	85%	56	50,82,352.94	14%
3	V29	VCB054D.000	DAF New, replace V16	46	1,00,000	85%	54	54,11,764.71	15%
4	V28	V28.000D	SCANIA New	40	1,80,000	85%	47	84,70,588.24	23%
5	V07	V07.0200	DAF T	60	15,000	85%	71	10,58,823.53	3%
6		V07.0300	DAF T	60	15,000	85%	71	10,58,823.53	3%
7	565	565.0300	IVECO	52	25,000	85%	61	15,29,411.76	4%
8	V08	V08.0000	IVECO	69	20,000	85%	81	16,23,529.41	4%
9	V11	V11.0100	VOLVO	58	14,000	85%	68	9,55,294.12	3%
10	V10	V10.0200	RENAULT	52	20,000	85%	61	12,23,529.41	3%
11	V06	V06.0300	VOLVO	55	10,000	85%	65	6,47,058.82	2%
12	V13	V13.0000	KAMAZ	65	16,000	85%	76	12,23,529.41	3%
13	V20 - NEW	V20.0000	KAMAZ	65	12,000	85%	76	9,17,647.06	3%
					6,37,000		% Utilization of Line		99%
								3,59,78,823.53	

98%	Machine OEE
90%	Manual OEE
96%	Child Parts OEE
85%	Overall OEE

Total Time Avialable in full year (Secs) for Single Line	12072000	per Year
Total Number of Lines	3	
Total Time Avialable (Secs) For All Lines	36216000	per Year

Number of Lines require	2.98

With the above analysis, the cycle time for each variant was generated against the requirement. Along with the mathematical calculations physical model of the machine was generated and manual time simulation was carried out to support the study.

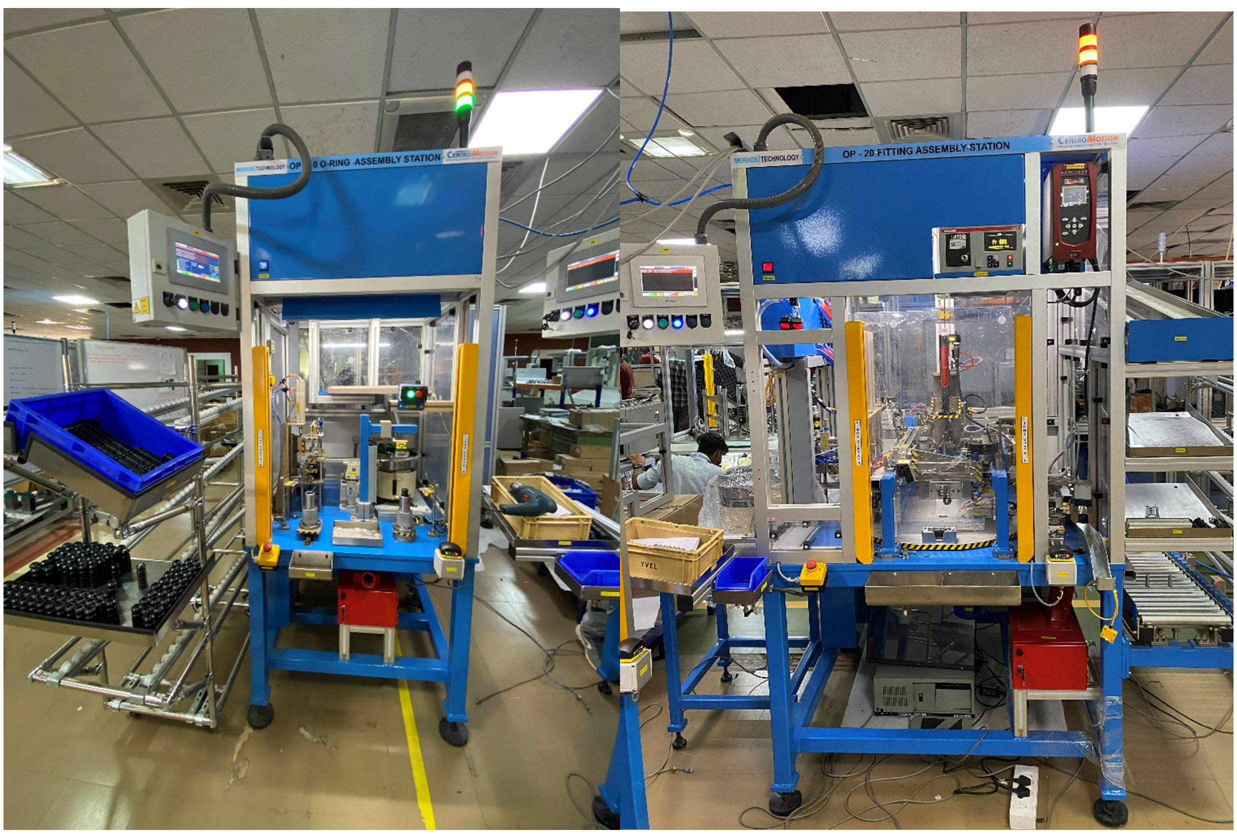
4. Implementation

The complete product and quality requirements were extensively studied and based on a concept was developed for the production line. Some major innovative concepts with comparison with the old production line are drawn out here

S.No.	Pointers	Old Concept	New Concept
1	Mode of Riveting in Latch: There are a total of 8 rivets (Changes based on the variant selected) that needs to be installed on top and bottom plate	All the riveting on the plate were done in single stroke using an 80-ton press.	Servo Gantry system is used to move the fixture to required location and one riveting is done at a time
2	Process input parameters for riveting	There was no dedicated process input parameter control	For each rivet the pressing load and stroke is controlled.
3	Process output control parameter measurement	There was no measurement system for process output parameters	Load Cell and LVDT was installed and each process output parameter were recorded and stored against unique part code
4	Die Design	Separate Top and Bottom Die design was there which needs to be fixed separately on the bottom and top tool of the machines	Die is designed as a set, thus full die can be change over and after change over alignment setting is not required
5	Die Design	Screw Fixing	Quick Change over design

6	Grease Dispensing	Manual greasing was done	Volumetric controlled automatic greasing design is implemented so that quantity can be controlled and also grease dispensing feedback is possible
7	Child part presence before final riveting If the final riveting is performed and any child part is missing, the full latch has to be scarped leading to greater loss	No Poka yoke system available	Camera checking done for every component before final riveting
8	Change over of Die	Using Manual forklift	Using specially designed Die carriage, changeover is performed on each machine adding to the ease of the operator
9	Rivet Presence Checking before riveting If one of the rivet is missing is the riveting process, the full part needs to be scarped	Since all riveting is done in single stroke and there is not poka-yoke for presence of rivets, the parts gets rejected in case of rivet missing and needs to be scraped	Rivet presence is ensured before riveting using load cell and LVDT
10	Plate Presence before riveting process. If plate is absent, and riveting process is carried out, the rivets will get damaged	No poka-yoke system available	Child part is ensured before the start of riveting process using camera
11	WIP	Batch production concept is used in the machine, thus there is WIP is every station	Single Piece Flow is used
12	Line Balancing	Cycle time of each machine is not matched; thus, the line is not fully balanced	Moving operator concept is used and cycle time of each machine is designed for line balancing
13	Screw tightening	Basic Electrical Screwdriver was used	Electric Outrunner with torque and angle control is used
14	gauge checking	standard mechanical gauges with no interlock system used manually by operator	pneumatically actuated gauges with interlock mechanism
15	Traceability	No poke yoke system available	Laser marking machine inscribes data matrix code with all process parameters
16	modular fixture concept	Individual end of line stations used for each variant	single end of line station with modular fixtures
17	Functionality check	Manual Checking of Functionality by operator	automatic locking functionality check of latch using pneumatic cylinder

LATCH Assembly line (Three Lines Made)



Hydraulic Cylinder Assembly Line (One Line that feeds to all three main lines)

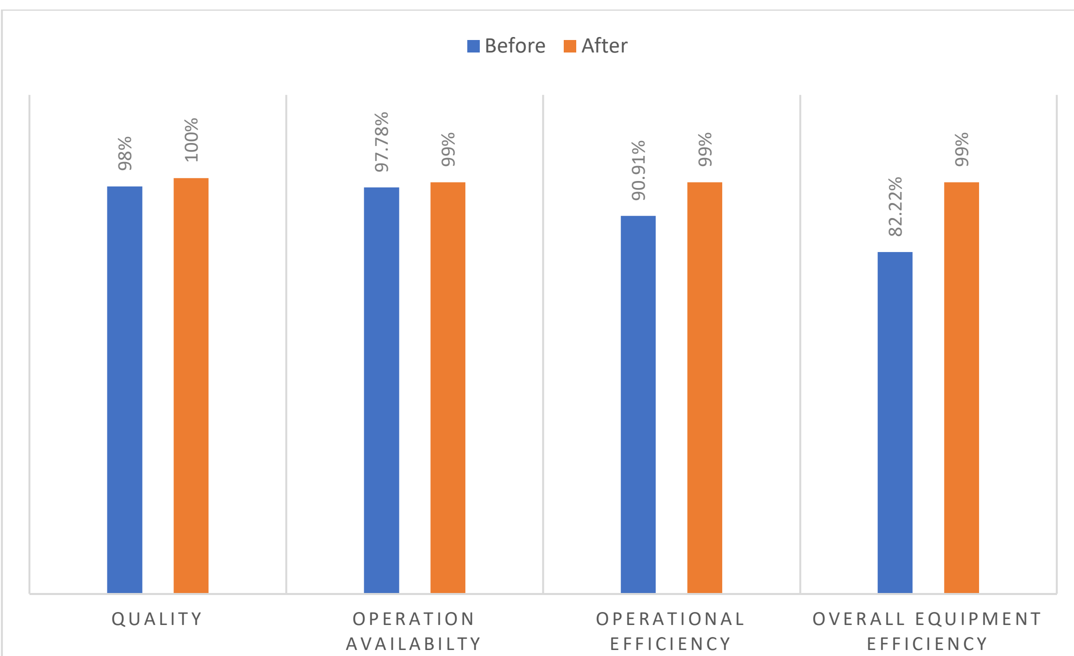
Video Link : https://youtu.be/w8uuYEFwnYg

5. Results/Impact

Machine was designed and made in India and shipped to Netherlands in Europe, after commissioning, the customer started using the machinery in regular production.

Based on the production data, results drawn are presented here.

Parameters	Before	After	Unit of Measurement
Finished Goods	5	3	Days
Intermediate products	20	NIL	Nos
Scrap Generation (loss)	Rs. 17,000	NIL	Per shift
Quality	98%	100%	
Manpower used	28	8	No
Overtime hours	NIL	NIL	Hours
Process capability	<1.67	>1.67	
Safety	No Safety Standards Implemented	CE Certified Machines	
Floor space utilization	75	51.84	Square meters
Cycle time	72	48	Seconds
Variant to variant changeover time	30	5	Minutes
Number of shifts per day	3	2	Nos.
Tool Life	10,000	50,000	hours
Operational Availability	97.78%	99%	
Operation Efficiency	90.91%	99%	
Overall Equipment Efficiency	82.22%	99%	



6. Resource Impact

With improved machine process capability and overall equipment efficiency, the total output was drastically increased. This meant that, what once took 3 shifts to manufacture, took only 2. This had a direct impact on the energy consumption and carbon footprint. Further, since the process was optimized using automation, consumable waste was also significantly reduced. Here are some of the highlights

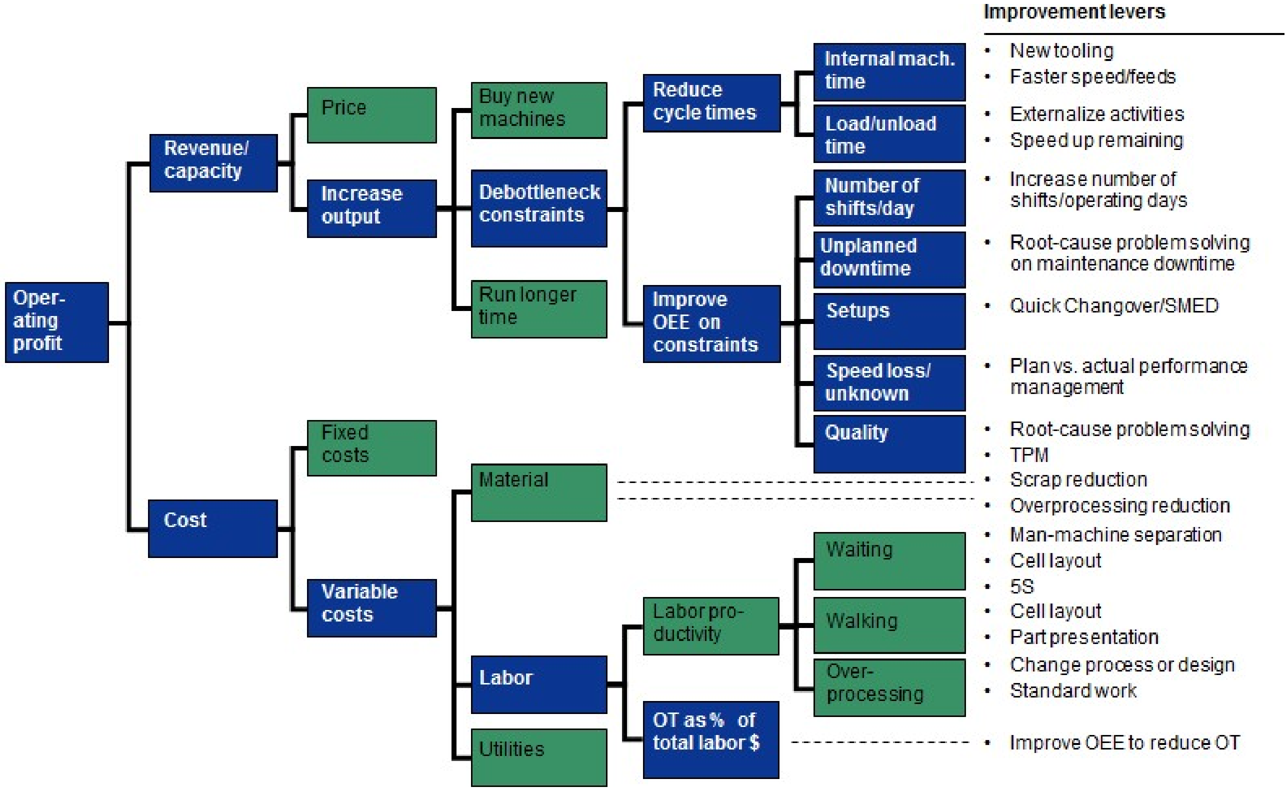
1. The previous line made use of standard 80-ton hydraulic presses. These machines consumed large amounts of space, power and hydraulic oil for its working. The new custom-built machines were 30-ton hydro-pneumatic presses. These utilized significantly less electricity for running, and only used a tiny fraction of hydraulic oil compared to the previous machines which is inbuilt in the cylinders, the frequency to change these oils is much lesser than that of a hydraulic system, It also eliminates the spillage and contamination caused by hydraulic system
2. The pressing tools that were used in the old riveting machines had a service life of 10,000 hours. With improvements in design and materials used, the new pressing tools have a service life of 50, 000 hours. A 500% increase in tool life reduced material consumption and had a direct impact on financial resources as well
3. The lubrication of the child parts using grease was done manually by an operator in the previous line. There was no control on the amount of grease applied per unit. This may seem insignificant for just one latch unit, but when you take into account the production rate per year, this adds up to a significant amount. The new line introduced automatic grease dispensing. Using a grease pump and a metering system, controlled quantity of grease is dispensed. This eliminated unnecessary amounts of grease wastage resulting in direct material saving for the customer.
4. Reducing the shifts from 3 to 2 had a direct impact on electricity consumption. On a yearly basis, this equated to a reduction of 240 shifts per annum from 720 to 480. Furthermore, the previous line used machines that consumed more power per hour. Improvements in the new set of machines reduced the pow er consumption per machine, per hour by x.
5. In terms of floor space utilization, the new line used 7.2m X 7.2m, a considerable reduction compared to the previous line which took up 10 m X 7.5 m.

Parameters	Before	After	Unit of Measurement
Hydraulic Oil	Used for running presses	External Filling once in two years	Litres
Pressing tool service life	10,000	50,000	Hours
Scrap Generation per year	1.27 Cr.	0	INR
Electricity consumption per day	1009	560.69	KWH
Grease usage per component	10	5	grams
Floor space utilization per line	75	51.84	Square meter
Manpower	28	8	No.

7. Business Metrics

In order to raise operating profits, either revenue/ capacity had to be increased, or costs had to be reduced or both. The purpose of implementing the new line was to bring in changes in both aspects.

The methodology followed for cost reduction is:



The main idea behind this program was about improving the bottom line at the given revenue, to achieve the same we have reduced the following:

- Direct manpower in the production line was reduced by 71.4 % which resulted in direct saving of 12.8 Cr.
- Rejection rate in the line was improved in the line which resulted in a direct saving of INR 1.275 Cr. Annually.
- Direct material consumption in the line was reduced in terms of grease which resulted in the saving of 0.6370 Cr.
- Tool life increased by five folds which reduced the running cost of the line.
- Down time of the machine was reduced which resulted in better machine availability, this increased in the confidence of the management on the production process, after running the line for 3 months they reduced the finished goods inventory from 5 days to 3 days.
- The new set of machines are able to produce the same production output in two shift which old machine was producing in three shifts, this provides the end customer with a buffer shift, which can be utilized to increase the revenue with added capacity.

Parameters (Annually)	Values	Unit of Measurement
Manpower Saving	₹ 12,80,00,000.00	INR
Saving because of rejection rate reduction	₹ 1,27,50,000.00	INR
Direct material cost saving	₹ 63,70,000	INR

Total Yearly Saving: **₹ 14,71,20,000.00**

Return on investment

The client was able to generate substantial saving through the implementation of the assembly line and was able to recover the investment made on the project in mere 8 months.

8. Customer Recognitions

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CENTROMOTION
Advancing Actuation and Control Solutions

To
M/S Mekhos Technology Services Pvt. Ltd.
#183, 3rd Phase, Bommasandra Industrial Area,
Bengaluru, Karnataka, 560099

Dear Mohan
I would like to take this opportunity to express my sincere appreciation for the development of the new latch assembly project. Your attention to details and innovative approach have created tangible benefits for our organization. The quality of the machine is matching our standards and have shown promising outputs.

We would like to congratulate the working team at Mekhos for their continuous and dedicated support.

I hope the relationship we have developed through this project will continue to benefit both our organization in the future as well.

Looking forward to collaborate with you on future programs.

Regards,

05/04/22
Senthilvelan
Director Manufacturing

controlcontrol GBS MFG CO. maximatecc POWER-PACKER Weasler

9. Scope for Horizontal Deployment

Due to the success of the latch unit assembly line which is evident from the data presented, our customer has deployed 2 more lines, one in France and other in India. These lines are already implemented in The Netherlands, France & India. They have a new proposal for 2 more lines, one in China and the other in Brazil.

The technologies & solutions that were thought of and implemented in the latch unit assembly line has a possibility of being implemented in other product families, some of them is under discussion with the customer, other than that some major concepts developed for latch line are deployed for other projects as well, a few are presented below:

- The changeover die setup with individual tools for pressing which are part of the die, increased the process accuracy which increased process capability. This solution could be implemented across projects which have multiple variants which require individual pressing control.
- The changeover of the die which was done whenever a new variant had to be manufactured, took around 30 mins in the previous line. The die weighed around 250 Kg. A manual forklift was used for the unloading and loading of the die. For the new line, a trolley arrangement concept was implemented. The trolley would be docked into the machine and an operator would have to only push the die into the fixture. Roller Balls on the fixture reduced the coefficient of friction. The total time for die changeover was reduced to 5 mins. The design of the trolley was also such that it was impossible for the die to fall down during changeover. Safety was ensured with this design.
- In the end of line testing station, the fixture setup included not only the component fixture, but also the pneumatic cylinders and sensors. All the wires of the cylinders and sensors were routed to the male quick connector. What this allowed was, whenever the changeover was performed, the only thing that was required after loading the fixture was the connection of the male quick connector to its counterpart. This design was deployed in another projects
- In the riveting stations, the riveting points are in different location within the component for a single variant. Furthermore, the riveting positions were different for all 13 variants. A combination of 2 servo motors with ball screw mechanism, was used for moving the die to each individual rivet position with 20-micron accuracy. This design was deployed to a ball pressing machine for another customer, where the metal balls had to be pressed into different location on the component.
- In order to prevent the LM guideways and ball screws from absorbing the load that is applied during riveting, a 4-pillar structure was built. The structure consisted of 4 pillars, a top and bottom plate, and screws. This structure absorbed the load on the bottom plate and from there, transferred the load to the top plate through the pillars. This design was deployed to multiple machines including the ball pressing machine.

Note: The data presented here are only screenshot of the work-out done, the full data presentation regarding the project will become very lengthy and also Mekhos Technology is bond by NDA, thus some sensitive data regarding the product and line development is withheld from the scope of this presentation. If jury members want to validate the data presented here, we can review and present the same on case-to-case basis.