SEMI-AUTOMATIC CRIMPING MACHINE SET-UP CYCLE TIME IMPROVEMENT THROUGH STANDARDIZATION OF PARAMETER SELECTION AND KITTING PROCESS

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ABSTRACT

In a very competitive and highly technical business environment the company that introduces in demand product always take the leadership however, there are certain process to follow and to be executed in-time. Any unwanted delay could ruin the customer's trust thus cycle time in a manufacturing is very crucial if success is at stake.

This paper will discuss the significant improvement of cycle time in semi-auto machine set-up using a systematic approach to improve cycle time from 1300 minutes in 2022 data to average 404 minutes plus a significant cost saving amounting to $623.73 in the first half of FY 2023.

1. 0 INTRODUCTION

Timely execution will give a deep impression to stakeholders that delivering on time is essential. Cable assembly encountered huge backlogs in terminal crimping process due to high crimping machine setup cycle time which affect commitment date and delivery schedule. The 2022 Cycle Time (CT) is needed for systematic evaluation of obtaining reduced cable assembly CT by reducing semi-automatic crimping machine set-up time.

Machine set-up CT contributes by ~23% (~1,300minutes) in the overall JEDEC Load Port (JLP) and Pick and Place (PNP) Matrix cable assembly process (5,698 minutes).

	15-Oct	16-Oct	17-Oct	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct	
	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat AM	Sat PM
WIRE/TUBE CUTTING	309			512		493	319	209	22
WIRE STRIPPING	203			174		42	161	172	73
SOLDERING				3		3	3	3	1
TERMINAL CRIMPING	328	NO WORK	QCAMP	536	QCAMP	520	392	304	396
FINAL ASSEMBLY	59			64		53	88	87	149
LABELLING	28			17		15	49	36	0
VISUAL INSPECTION	5			9		72	120	120	13
OQA	11			11		95	122	141	71
FG									
TOTAL QTY	943	0	0	1326	0	1293	1254	1072	725

Figure 1a. Cable Production report update of October 22, 2022. A cable production flow showing an enormous backlog in the terminal crimping process.

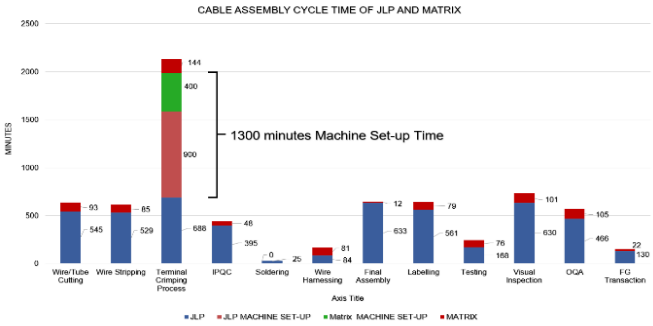

Figure 1b. Cable assembly 2022 cycle time of JLP and Matrix.

1.1 Semi-Automatic Crimping Machine

The semi-automatic crimping machine is a manually loaded machine for crimping. It has an applicator that is made for a specific terminal and is used in all machine types for crimping the terminal on the specific gage of wires.

Figure 2. Semi-auto crimping machine with applicator.

1.2 JLP and PNP Matrix Head

JLP and PNP Matrix Head are some of the ATS mass-production products. JLP is an automated tray handling system that transports JEDEC trays to and from other SMEMA-Equipped process tools. PNP Matrix Head is part of Cohu's MATRiX thermal handler, it is highly flexible test site configuration well suited for analog ICs with short test times and high-throughput, automotive devices requiring accurate thermal control, small pitch wireless-communication products, high parallel microcontroller testing, MEMS device testing, and many other devices market segments with their unique requirements.

Figure 3. ATS mass-pro product. JLP and PNP MATRiX Head

1.3 The Formula

The existing process of machine set-up is too complex, and it needs to be simplified by using the right attitude and the Define, Measure, Analyze, Improve and Control (DMAIC) approach in problem solving. From an average of ~1300 minutes, it was trimmed down to an average of ~404 minutes or >69% improvement in terms of cycle time.

2.0 EXPERIMENTAL SECTION

2.1 Baseline / Historical Performance

A review on the historical data, current machine set-up time is higher than the crimping process.

Figure 1: For the overall cycle time in crimping process including machine set-up time is an average of 2132 minutes.

Figure 6: Machine set-up time = ~61% (1300 minutes)
Crimping process = ~39% (832.31minutes)

Machine set-up is higher than the crimping process cycle time by ~22%.

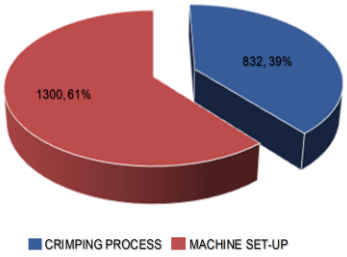

Figure 4. Pie Chart of Crimping Process Versus Machine Set-up Cycle Time.

JLP has 45 numbers of terminals to be set up on different wires and gages while the PNP Matrix has 20 numbers of terminals to be set up on different wires and gages. The number of machine set-ups may be added based on production order arrangement.

PN	DESCRIPTION	MPN	MANUFACTURER	AWG
A0000002284	CONTACT,28-32AWG,GOLD PLATED	1-104481-1	AMP/TE	28
A0000002284	CONTACT,28-32AWG,GOLD PLATED	1-104481-1	AMP/TE	26
4101804	CONT F M M N LOK 3MM 20/24AWG	1-794609-1	AMP	22
4101804	CONT F M M N LOK 3MM 20/24AWG	1-794606-1	AMP	24
4101804	CONT F M M N LOK 3MM 20/24AWG	1-794606-1	AMP	26
4101803	CONT F M M N LOK 3MM 26/30AWG	794607-1	AMP	26
4101659	CONT SOCKET 26-22 AWG	87666-5	AMP	26
2001185	CRIMP,MALE,22-28 ANG	39-00-0048	MOLEX	26
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	22
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	22
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	22
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	24
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	24
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	24
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	26
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	26
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	28
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	18 TEFLON WIRE
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	18
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	22

Figure 5. 20 numbers of PNP MATRiX terminals to be set up on different wires and gage.

PN	DESCRIPTION	MPN	MANUFACTURER	AWG
A0000002284	CONTACT,28-32AWG,GOLD PLATED	1-104481-1	AMP/TE	28
A0000001866	CONTACT,SOCKET,14-18AWG	66598-2	AMP	14
A0000001866	CONTACT,SOCKET,14-18AWG	66598-2	AMP	16
A0000001866	CONTACT,SOCKET,14-18AWG	66598-2	AMP	16
A0000001864	CONTACT,PIN,18-14AWG	66597-2	AMP	16
4102263	CONTACT PIN 26-30AWG	CC79R-2630-01-S	SAMTEC	28
4102015	CONTACTOR,PW SKT 16&12-14 AWG	1-66740-2	AMP	14
4101760	CONTACT PINMATENLOCK 14-20AWG	350218-7	AMP	16
4101760	CONTACT PINMATENLOCK 14-20AWG	350218-7	AMP	16
4101759	CONTACT SKTMATENLOCK 14-20AWG	350536-2	AMP	16
4101660	CONTACT,FEMALE,22-28AWG	39-00-0434	MOLEX	22
4101660	CONTACT,FEMALE,22-28AWG	39-00-0434	MOLEX	24
22-28 (1658670-	CONTACT,PIN,22-28	1658670-3	AMP	22
4100903	CONTACT,PIN,22-28	1658670-3	AMP	24
2001204	CONN,PIN,18-22AWG GOLD CRIMP	745229-2	TE CONN	22
2001185	CRIMP,MALE,22-28 ANG	39-00-0048	MOLEX	22
2001185	CRIMP,MALE,22-28 ANG	39-00-0048	MOLEX	26
2000716	TERMINAL MALE	39-00-0040	MOLEX	16
2000716	TERMINAL MALE	39-00-0040	MOLEX	22
2000716	TERMINAL MALE	39-00-0040	MOLEX	22 - TEFLON
2000716	TERMINAL MALE	39-00-0040	MOLEX	24
2000684	PIN,CONNECTOR D-SUB FEMALE	66504-3	AMP	22
2000684	PIN,CONNECTOR D-SUB FEMALE	66504-3	AMP	24
2000684	PIN,CONNECTOR D-SUB FEMALE	66504-3	AMP	26
2000683	PIN,CONNECTOR D-SUB MALE	1658539-1	TE CONN	26
2000683	PIN,CONNECTOR D-SUB MALE	1658539-1	TE CONN	24
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	22
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	22
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	22
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	24
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	24
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	24
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	26
2000645	CONTACT SOCKET 22-26AWG	104480-2	AMP	26
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	18 TEFLON WIRE
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	18
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	18
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	18
2000637	TERMINAL FEMALE	39-00-0038	MOLEX	22
2000633	CONTACT,RECEPTACLE	87523-5	AMP	26
2000591	CONTACT PIN 16-12	66255-6	AMP	16
2000516	SOCKET,CONN GOLD/NIC	66104-9	AMP	22
2000516	SOCKET,CONN GOLD/NIC	66104-9	AMP	24
2000514	PIN CONN GOLD/NICKEL	66102-9	AMP/TE	22
2000514	PIN CONN GOLD/NICKEL	66102-9	AMP/TE	24

Figure 6. 45 numbers of JLP terminals to be set up on different wires and gage.

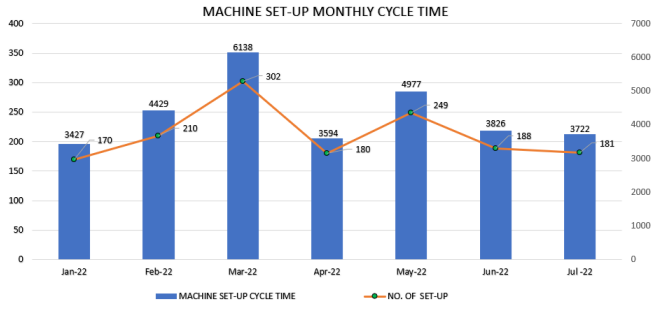

Figure 7. For the period of January 2022 to July 2022, machine set-up time is at peak ~20 minutes per set-up or ~1300 minutes for 65 machine set-up required for JLP and PNP MATRiX.

2.2 Methodology

Initial corrective action done is to identify risk and non-value-added activity classified per priority. In crimping, there are two crimp requirements, in the insulation and conductor area. Conductor crimp height is the priority it is the requirement by customer while insulation crimp height is not tightly measured but it is required to pass the IPC-WHMA-A-620 standard.

1. Identifying the measurement gap of every tuning stroke in the applicator and standardize it in specific terminals defined in figure 5 and figure 6.

After set-up of the applicator to crimping machine, conduct trial and error process to identify good crimping output. Adjustment of the tuning stroke for conductor crimp from 0 to 8 for specific crimp height requirement and adjustment of tuning stroke for insulation crimp from 0 to 8 for of insulation crimp appearance.

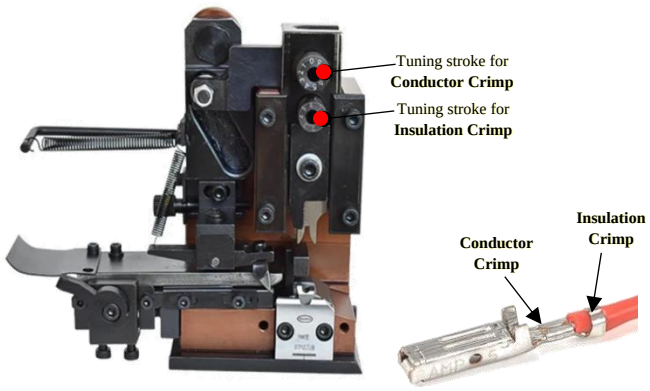

Figure 8. Applicator adjustment for conductor crimp and insulation crimp.

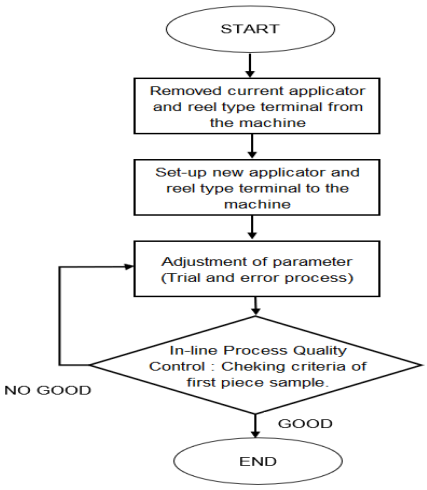

Figure 9. Process flow of crimping machine set-up.

2. Re-structure the arrangement planning of kitting part for cable assembly load. First In First Out (FIFO) arrangement of load from the highest number of terminals with the same wire gage and wire part number in crimping process to lessen number of machine set-up times.

No.	Part No.	DELTA Part No.	Description	Remarks
1	LSCH-CB-8330570001	8330570001	SENSOR ASSY,PM-R24,TRAY LATCH	JLP 1078-1080 TXP assy
2	LSCH-CB-8330570003	8330570003	SENSOR ASSY,PM-R24,TRAY LATCH	JLP 1078-1080 TXP assy
3	LSCH-CB-8330570004	8330570004	SENSOR ASSY,PM-R24,TRAY LATCH	JLP 1078-1080 TXP assy
4	LSCH-CB-8330571001	8330571001	SENSOR ASSY,PM-F24,TRAY LATCH	JLP 1078-1080 TXP assy
5	LSCH-CB-8330571002	8330571002	SENSOR ASSY,PM-F24,TRAY LATCH	JLP 1078-1080 TXP assy
6	LSCH-CB-8330571003	8330571003	SENSOR ASSY,PM-F24,TRAY LATCH	JLP 1078-1080 TXP assy
7	LSCH-CB-8330571004	8330571004	SENSOR ASSY,PM-F24,TRAY LATCH	JLP 1078-1080 TXP assy
8	LSCH-CB-8330572001	8330572001	SENSOR ASSY,THRU,EMITTER,MTE3F	JLP 1078-1080 TXP assy
9	LSCH-CB-8330573001	8330573001	SENSOR ASSY,THRU,RCVR,DO,MTE3F	JLP 1078-1080 TXP assy
10	LSCH-CB-8330570002	8330570002	SENSOR ASSY,PM-R24,TRAY LATCH	JLP 1078-1080 TXP assy
11	LSCH-CB-100081305	100081305	Cable Assy, SNSR EXT, TXP-Y (10008130	JLP 1078-1080 TXP assy
12	LSCH-CB-8333124005	8333124005	SENSOR ASSY,THRU,RCVR,DO,MTE3F	JLP 1078-1080 Assy Conveyor
13	LSCH-CB-8333123005	8333123005	SENSOR ASSY,THRU,EMITTER,MTE3F	JLP 1078-1080 Assy Conveyor
14	LSCH-CB-8333123006	8333123006	SENSOR ASSY,THRU,EMITTER,MTE3F	JLP 1078-1080 Assy Conveyor
15	LSCH-CB-8333131002	8333131002	SENSOR ASSY,REFLECTIVE,30MM,DO	JLP 1078-1080 Assy Conveyor
16	LSCH-CB-8333131001	8333131001	SENSOR ASSY,REFLECTIVE,30MM,DO	JLP 1078-1080 Assy Conveyor
17	LSCH-CB-8333124006	8333124006	SENSOR ASSY,THRU,RCVR,DO,MTE3F	JLP 1078-1080 Assy Conveyor
18	LSCH-CB-8330572004	8330572004	SENSOR ASSY,THRU,EMITTER,MTE3F	JLP 1078-1080 CDM assy
19	LSCH-CB-8330573003	8330573003	SENSOR ASSY,THRU,RCVR,DO,MTE3F	JLP 1078-1080 CDM assy
20	LSCH-CB-8330572002	8330572002	SENSOR ASSY,THRU,EMITTER,MTE3F	JLP 1078-1080 CDM assy

Figure 10. Current Kitting Arrangements

2.3 Action Implementation

Action split into two, one focuses on the actual machine set-up process from the time of removal of applicator and end in approval of IPQC, this will reduce the actual time of machine set-up, second focuses on restructuring of FIFO system of cable assembly kitting process this will reduce the number of machine set-up process.

Action 1 was performed using the trial-and-error process for each machine and applicator parameter setting to set the ideal parameter setting as a standard and meet the ideal output of the product. Trial and error were based on each terminal by wire gage per wire part number.

FROM

NO.	PROCESS	CT Average (minute)
1	Removed Current Applicator and Reel	3.06
2	Set-up New applicator and reel (Trial and Error) MACHINE STANDARD PARAMETERS Parameters / M1 / M2 / M3 / M4 Speed Die Strength	6.58
3	Adjustment of Conductor and Insulation Parameter (Trial and Error Process) Conductor: Top / Bottom / Crimp Hieght; Insulation: Top / Bottom / Crimp Hieght 0 5 — 0 4 1 6 — 1 5 2 7 — 2 6 3 8 — 3 7 4 9 — 4 8 5 0 — 5 0 6 1 — 6 1 7 2 — 7 2 8 3 — 8 3 9 4	8.52
4	IPQC Inspection Criteria / Result Crimp Height Appearance	2.3
	TOTAL	20.46

Figure 11. Average machine set-up time the old machine set-up process with 20.46 minutes average time.

TO		
NO.	**PROCESS**	CT Average (minute)
1	Removed Current Applicator and Reel	3.56
2	Set-up New applicator and reel. **Standardized the parameter per per machine.** MACHINE STANDARD PARAMETERS Parameters: M1 40, M2 40, M3 45, M4 40 Die Strength: M1 15, M2 15, M3 15, M4 11	2.38
3	Adjustment of parameter. **Standardized the Conductor and Insulation parameter each terminal by wire per wire gage.** Conductor: Top 0, Bottom 5; Crimp Height 0.75 Insulation: Top 0, Bottom 4; Crimp Height 0.81	2.13
4	IPQC Inspection Criteria: Crimp Height, Appearance Result	2.3
	TOTAL	10.37

Figure 12. Action 1. Average machine set-up time, Output for the standardization of parameters for machine and applicator settings in machine set-up process with 10.37 minutes average time.

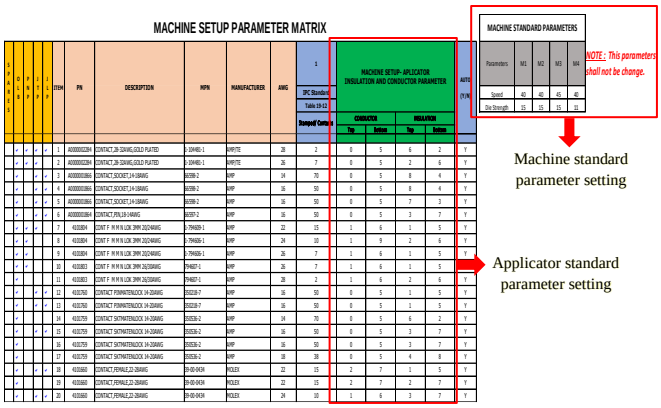

Figure 13. Machine Setup Parameter Matrix with 65 set of parameters for JLP and PNP MATRiX. Indicates standard parameters per Machine for speed and Die Strength, and Applicator for conductor and insulation by terminal per wire gage per wire part number.

Action 2 was performed by arranging the kitting in common terminal by wire gage per wire part number and implement as FIFO from kitting to terminal crimping process.

No.	Part No.	Delta Part No.	Description	COMMON		
				Terminal	Wire Gage	Wire PN
1	LSCH-CB-8330572001	8330572001	SENSOR ASSY,THRU,EMITTER,MTE3F	A0000002284	28AWG	3604152
2	LSCH-CB-8330572004	8330572004	SENSOR ASSY,THRU,EMITTER,MTE3F	A0000002284	28AWG	3604152
3	LSCH-CB-8330572002	8330572002	SENSOR ASSY,THRU,EMITTER,MTE3F	A0000002284	28AWG	3604152
4	LSCH-CB-8330572003	8330572003	SENSOR ASSY,THRU,EMITTER,MTE3F	A0000002284	28AWG	3604152
5	LSCH-CB-8333102001	8333102001	SENSOR ASSY,THRU RECEIVER,MTE3	A0000002284	28AWG	3604152
6	LSCH-CB-8330573001	8330573001	SENSOR ASSY,THRU,RCVR,DO,MTE3F	A0000002284	28AWG	3604156
7	LSCH-CB-8333124005	8333124005	SENSOR ASSY,THRU,RCVR,DO,MTE3F	A0000002284	28AWG	3604156
8	LSCH-CB-8333123005	8333123005	SENSOR ASSY,THRU,EMITTER,MTE3F	A0000002284	28AWG	3604156
9	LSCH-CB-8333123006	8333123006	SENSOR ASSY,THRU,EMITTER,MTE3F	A0000002284	28AWG	3604156
10	LSCH-CB-8333124006	8333124006	SENSOR ASSY,THRU,RCVR,DO,MTE3F	A0000002284	28AWG	3604156
11	LSCH-CB-8330573003	8330573003	SENSOR ASSY,THRU,RCVR,DO,MTE3F	A0000002284	28AWG	3604156
12	LSCH-CB-8330573002	8330573002	SENSOR ASSY,THRU,RCVR,DO,MTE3F	A0000002284	28AWG	3604156
13	LSCH-CB-8330573004	8330573004	SENSOR ASSY,THRU,RCVR,DO,MTE3F	A0000002284	28AWG	3604156
14	LSCH-CB-8333101001	8333101001	SENSOR ASSY,THRU EMITTER,MTE3F	A0000002284	28AWG	3604156
15	LSCH-CB-8330579002	8330579002	SENSOR ASSY,REFLECTIVE,15MM,DO	A0000002284	28AWG	3604166
16	LSCH-CB-8330579003	8330579003	SENSOR ASSY,REFLECTIVE,15MM,DO	A0000002284	28AWG	3604166
17	LSCH-CB-8330579004	8330579004	SENSOR ASSY,REFLECTIVE,15MM,DO	A0000002284	28AWG	3604166
18	LSCH-CB-8330579001	8330579001	SENSOR ASSY,REFLECTIVE,15MM,DO	A0000002284	28AWG	3604166
19	LSCH-CB-8330579005	8330579005	SENSOR ASSY,REFLECTIVE,15MM,DO	A0000002284	28AWG	3604166
20	LSCH-CB-8333131002	8333131002	SENSOR ASSY,REFLECTIVE,30MM,DO	A0000002284	28AWG	3604167

Figure 14. Action 2. Improved FIFO JLP and PNP MATRiX Kitting Arrangements. Arranged common terminal by wire gage per wire part number (PN).

2.4 Project Impact

- Improved overall consistency in machine set-up in JLP and PNP MATRiX
- Lessen idle time of the kitting for auto crimping process.
- Additional time for cable assy to produce more products and generate more revenue.

2.5 Validation of Result

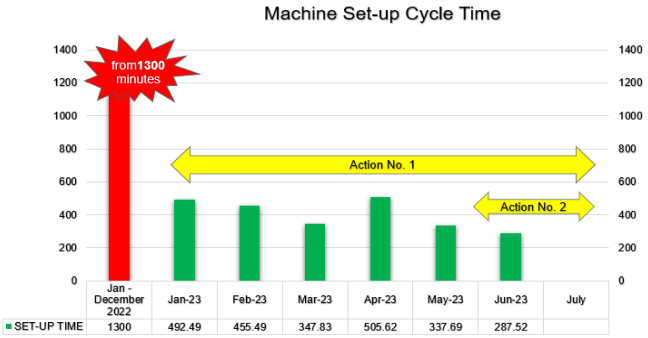

Figure 15. Drastic time improvement realizes from ~1300 minutes to average of 404 minutes in machine set-up time from January to June.

3.0 RESULT AND DISCUSSION

In summary, the contributor for the high crimping machine set-up time for JLP and PNP MATRiX are the following:

1. Multiple trial and error process of machine and applicator parameter setting in each terminal by wire gage per wire part number per machine set-up.
2. There is no proper arrangement of the kitting from the kitting process to the terminal crimping process causing duplicate machine setups with the same terminal, wire gage and wire part number.

NO.	Validated Cause	Permanent Actions
1.	Multiple trial and error process per machine set-up	Standardized the machine and applicator parameter selection settings per terminal, wire gage and wire part number
2.	Repetitive machine set-up with same terminal, wire gage and wire part number.	Developed systematic kitting flow and implemented FIFO system from kitting process to terminal crimping process.

Figure 16. Permanent corrective actions implemented.

3.1 Implementation Result

Realized ~404 minutes machine set-up time with ~69% CT improvement for JLP and PNP MATRiX from ~1300 minutes in 2022 data.

Other support actions implemented for the smooth implementation of permanent action.

- Applicator parameter included in terminal validation form. This is a required document during machine set-up until IPQC process.
- Strict implementation of no change of machine parameter set by the standard.
- Cable assembly strict implementation of FIFO system in kitting process to terminal crimping process.

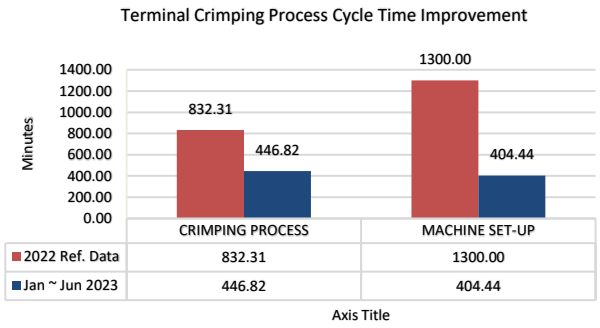

Figure 17. Terminal crimping process cycle time improvement from 2022 data to the 1st half of 2023.

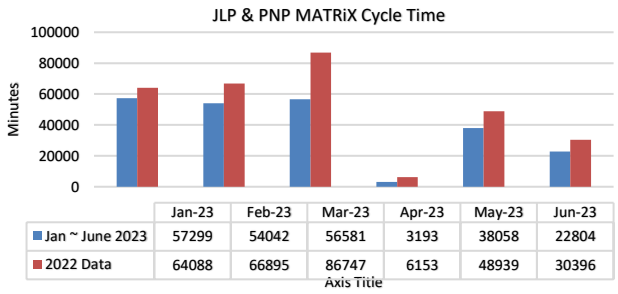

Figure 18. Correlation to Machine set-up time to overall JLP and Matrix cycle time from ~1300 minutes to average of 404 minutes and improved CT in average of 27% in the 1st half of 2023.

As the machine setup and overall JLP and PNP MATRiX cycle time improved a significant cost will be saved.

Month	No. of Set-up	Saved Time		Manhour Cost	Monthly Saving
		Minutes	Hours		
January	190	5554.71	92.58	$2.125	$196.73
February	220	2391.31	39.86	$2.125	$84.69
March	201	5489.30	91.49	$2.125	$194.41
April	49	601.65	10.03	$2.125	$21.31
May	163	1239.84	20.66	$2.125	$43.91
June	111	2334.35	38.91	$2.125	$82.67
2023 Monthly Average Savings					$103.95
2023 Total Savings					**$623.73**

Figure 19. Significant cost saving from the machine set-up cycle time improvement of $623.73 in the 1st half of 2023.

4.0 CONCLUSION

Crimping machine setup cycle time can be improved using the right solution and implementation. Through identification and process elimination, the identified and proper correction were applied. **From the baseline of 1300 minutes it was gradually reduced to 404 minutes machine setup cycle time.**

5.0 RECOMMENDATION

Cycle time is a process related things that can be improved. This project methodology created a window of opportunity for other products in cable assembly. It is highly recommended that this solution should be executed also in OLB and JTP products and upcoming new product/s in cable assembly.

6.0 ACKNOWLEDGMENT

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7.0 REFERENCES

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