A Project Report

on

Implementation & Modification in Navigation System Wiring Harness

Submitted in partial fulfillment of the requirements of
the degree of

Bachelor of Technology

In

Electrical Engineering

Affiliated to

Dr.Babasaheb Ambedkar Technological University, Lonere

Submitted by

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Jaywant College of Engineering and Polytechnic

(Approved by AICTE, New Delhi, DTE, Govt. of Maharashtra, Affiliated to BATU,Lonere)

Academic Year 2021-22

July 2022

Certificate

This is to certify that the project report entitled **Implementation & Modification In Navigation System- Wiring Harness** submitted by **Ms. Aishwarya Vijay Chougule, Ms. Anushka Sanjay Kale, Mr. Nilesh Narayan Chalke, Mr. Prashant Kumar Hake.** is a bonafide record of the work carried out by him towards the partial fulfillment of the requirements of Dr. Babasaheb Ambedkar Technological University, for the award of the degree of **Bachelor of Technology (Electrical Engineering)**,in Academic Year 2021-22.

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The project report hereto entitled **Implementation & Modification In Navigation System- Wiring Harness** submitted by **Ms. Aishwarya Vijay Chougule, Ms. Anushka Sanjay Kale, Mr. Nilesh Narayan Chalke, Mr. Prashant Kumar Hake** in partial fulfillment of the requirements for the degree of **Bachelor of Technology**, (Electrical Engineering) has been Examined and is recommended for acceptance and approval.

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External Examiner
Name and Signature

Date:

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Signature of the Student

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Acknowledgement

It takes thousand voices to tell a story and similarly it takes the help encouragement of numerous people for the completion of any project. We express gratitude for all who look to be especially acknowledged for their support and assistance to us through each stage of study.We take immense pleasure in expressing our deep sense of gratitude to Dr. U. S. Sutar (Principal), M. J. Deshmukh (HOD- Electrical Engineering) & Prof. V.P Mohite for his excellent guidance and constant encouragement

Abstract

Wire Harness is the interconnecting wiring in the vehicle for the transmitting electrical power and signals in the electrical system. Over the years the number of components to be connected and hence the number of circuits has increased many folds. As harness complexity increases, these legacy methods will come under increasing strain, and eventually may fail completely.” You can arguably already seeing this happen in markets such as automotive. And all that is in addition to the risks long posed by late-stage change orders. This has made the wire-harness design as the most complicated task in the vehicle design and wire harness (electrical system) integration with the other aggregates a difficult job. Many CAD tools and design software have evolved from computer companies. But they have not resolved major issues faced by vehicle OEM's and the wire-harness manufacturers. In fact, the requirements of vehicle manufacturers are not clear to the other agencies and this results in wire-harness development as a major bottleneck in any vehicle development program. An overview is given on the importance of the wire-harness design and the impact it will have on the success or failure of the final product ' VEHICLE ' when it reaches the customer.

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Date: 16th June 2022

To whomsoever it may concern

Subject: Industrial project completion letter

This is certify that below mentioned students of B. Tech - Electrical Engineering Final Year from **Jaywant College Of Engineering And Polytechnic, KM, Sangli,** have undergone & successfully completed the project work in the company on "**Implementation & Modification in Navigation System- Wiring Harness"** towards the fulfillment of award of "B. Tech - Electrical Engineering" during academic year 2021-22.The final outcome of this project is the proprietary of **"TE Connectivity India Pvt., Ltd., Shirwal, Satara"**

1. Aishwarya Vijay Chougule.
2. Anushka Sanjay Kale.
3. Prashant Kumar Hake.
4. Nilesh Narayan Chalke.

We found all of them sincere and hardworking and wish them good luck for their future endeavors

For TE Connectivity India Private Limited,

Sanjay Hon
Senior Manager – HR & ER

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Chapter 1

Introduction

The wiring harness is the biggest and heaviest bought-in part and connects all electrical and electronic (E/E) components in the automotive vehicle, like sensors, electronic control units, batteries, and actuators. As a connecting element, the wiring harness is responsible for the energy and information flow within the E/E system to fullfill primary car functions such as steering and braking as well as secondary car functions such as ventilation and infotainment.

The increase in the electrical and electronic content in the automobiles has resulted in the wire harness design

becoming more and more complex. From the simple function of electrical power distribution and transmitting signals, it has become a networking of multiple controllers with a vast range of sensors , actuators and their interfaces. Many luxury features used only in high-end vehicles for safety and comfort have now become standard across all makes and models. With the availability of more electronic components suitable for automobile applications the gadgets on the vehicles are multiplying with every new model introduced in the market.

1. Manufacturing Of Automotive Wiring Harness

The wiring harness consists of thousands of components comprising wires with terminals and seals, connectors, fuses, relay boxes, switching units, fixing components, sensor and protecting component.

1.1. Wiring harness manufacturing process flow

The wiring harness manufacturing is divided into three main areas, the cutting-crimping area & USW area, pre- assembly area, and final assembly area. The manufacturing process starts from the cutting area, in which automated machines cut wires with different cross-sections into predefined lengths(as per customer drawing), strip the cable isolation, and add seals (as per requirement) and crimps.Then spliced wires are welded as per customer requirement and design with the help of Ultra Sonic Welding (USW). In the sub manufacturing area, workers execute special process steps, like twisting, splicing, and heat tube shrinking, either with semi-automated machines or manually.

Furthermore,they prepare small wire harness sub-assemblies. The last manufacturing area consists of multiple final assembly lines, in which workers sequentially add wire harness components or prepared modules to a large assembly board. By performing final assembly tasks, like wire routing wire insertion into connector cavities, and bundling multiple wires with tape, the workers realize the desired tree-like structure of the wiring harness. Finally, the wiring harness is tested regarding electrical functionality, hardware completeness and leakage. Then, the final product is either packaged for -in sequence delivery to the automotive original equipment manufacturer (OEM), where it is installed into the vehicle, or sent to rework in case of a failed test.

1.2. Wiring Harness Components

Wire harnesses are collections of electrical wires, cables, and sub assemblies covered by exterior defined tape & that are used to connect devices to their power source.There are several types of wire harness components, each of which is available in multiple variations to suit different applications. These components include:

- Wires
- Connectors
- Terminal
- Tapes- outer covering
- Ties
- Grommets

1. Wire:

The wire carries the current or signal that powers a device. The wire's capacity needs to meet or exceed the voltage or bandwidth & it's expected to transmit. Most wires are copper and can have a specially chosen coating.

2. Connectors:

Wire connectors are available in several varieties and sizes to connect different types of wires. While they are usually plastic they can be made from a variety of elements.

3. Terminals:

Terminals are the metal parts that are attached to the end of the wire to be inserted into the connector or to be attached to a point on the connecting equipment.Terminal are made up with using stamping process.

4. Tapes:

Tapes are used in wiring harness to bundle all wires together in desired tree-like structure of the wiring harness

5. Ties:

Cable ties and clamps keep the wires inside of the harness attached to from a stream of wires to a particular direction. It can also be used to attach to a structure at fixed points to minimize movement.

6. Grommets:

Grommets are insulators to keep moisture out of the connector. A grommet can be attached with the terminal or can be a part of the connector.Outer coverings/Insulators: Also referred to as tubes and sleeves, insulators provide some degree of abrasion resistance, environmental protection, and protection from electrical shock. They can be made of various materials such as nylon

When choosing a wire harness, some of the component qualities to consider include:

- Type of wire (including material & gauge)
- Insulation Material
- Environment Capabilities

- Voltage & current capacity

Wire harnesses play an essential role in almost every industry. Some of the most common industries that use wire harnesses include:

- Automotive wiring Harness
- Aerospace wiring Harness
- Electronic wiring Harness

1.3 Wire harness manufacturing terms and definitions

7. **American Wire Gage (AWG):** A standard system for designating wire diameter. Primarily used in the U.S
8. **Bell-mouth:** The raised portion at the front and/or back of the wire barrel crimp that provides a gradual entrance and exit for the wire strands without causing damage.
9. **Cable:** A group of individually insulated conductors in the twisted or parallel configuration under a common sheath.
10. **Cable Assembly:** A cable with plugs or connectors attached.
11. **Connector:** A device used to physically and electrically join two or more conductors.
12. **Crimp:** Final configuration of a terminal barrel formed by the compression of terminal barrel and wire.
13. **Crimp Height:** The measurement of the overall wire barrel height after crimping the terminal.

14. **Continuity:** A continuous path for the flow of current in an electrical circuit.

15. **Double Crimp:** The process of two or more mechanical crimping operations on the same location in a single terminal.

16. **Harness:** A group of wire and cables, usually made with breakouts. Furthermore, with a rubber or plastic sheath tie them together. A harness also provides interconnection of an electric circuit.

17. **Insulation:** A material that offers high electrical resistance making it suitable for covering components, terminals, and wires. This material also helps to prevent the possible future contact of adjacent conductors and a resulting short circuit.

18. **Insulation Crimp:** Area of a terminal, splice or contact formed around the insulation of the wire.

2. Manual Wiring Harness Process:

As we observe there are same process of cutting ,Crimping, Welding, sub-assembly, Taping, Visual Inspection, CKT ,FG. The wire harness manufacturing process is time consuming, difficult, and task oriented. Nonetheless, as the demand for wire harnesses ad cable assemblies grow, manufacturing of these components continues to expand. That's because the wire harness is one of the most indispensable electronic and electrical components in the modern world

Step 1: Design

Whether hidden behind a glove box in an automobile or within the back panel of a washing machine, the wire harness A delivers power and transmits information in a streamlined, uniform way. In electronic product research and development, engineers must confront and overcome electrical issues daily to successfully bring a product to market. An integral part of this challenge entails a custom design for each products electronic part and a step by

step wire harness manufacturing process to complete the assembly. This is also the stage at which engineers must choose harness components and decide on other use specifications

Step 2: Prototyping

If necessary, wire harness prototyping enables an engineer or product designer to get their hands on a real-life version of their final product. They can then test the harness in its intended application before beginning the first production run, ensuring optimal performance.In wire harness manufacturing, design specifications must be met and high quality standards with sector, wire harness manufacturing processes still rely in no small part on manual assembly. Though some automation can be incorporated into the process, hand manufacturing of wire harnesses and cable assemblies are necessary due to the many intricate and time consuming steps involved in completing the process. Even though building a wire harness can be difficult and task oriented, manual production remains more cost effective.

Another reason manual production remains the primary method of manufacturing for wire harnesses and cable assemblies is that each must be customized for each application. Wire harnesses are very specific components designed for specific larger parts. They are necessitated to resolve geometric and electrical issues in manufacturing products and to provide solutions to particular problems inherent in the overall process. Geometrically, wire harnesses are designed to fit a specific space within a much larger or alongside a greater network of electrical components and wiring. Wire harnesses also must ground and protect wires from potential internal and external damages related to electrical issues such as crossed wires, chemicals or moisture

Step 3: Wire Cutting

Broadly speaking, the initial step in building a wire harness is make sure the wires are cut to the right length, which is done by a wire-cutting machine.

Fig no: 1

Step 4: Assembly

Lastly, the wires are gathered into a harness utilizing a workbench or assembly board to meet the design specifications. Hand manufacturing of wire harness production is necessary to route wires through sleeves and to apply fabric tape where needed, such as on branch outs from wire strands. Terminals need to be crimped onto wires, and where more than one wire needs to be attached to one terminal, multiple crimping will be

necessary.

Also, the insertion of one sleeve into another is done manually, and so is fastening any strands with tape, clamps or cable ties. Hand production does not exclude the use of automation and machinery in wire harness manufacturing.

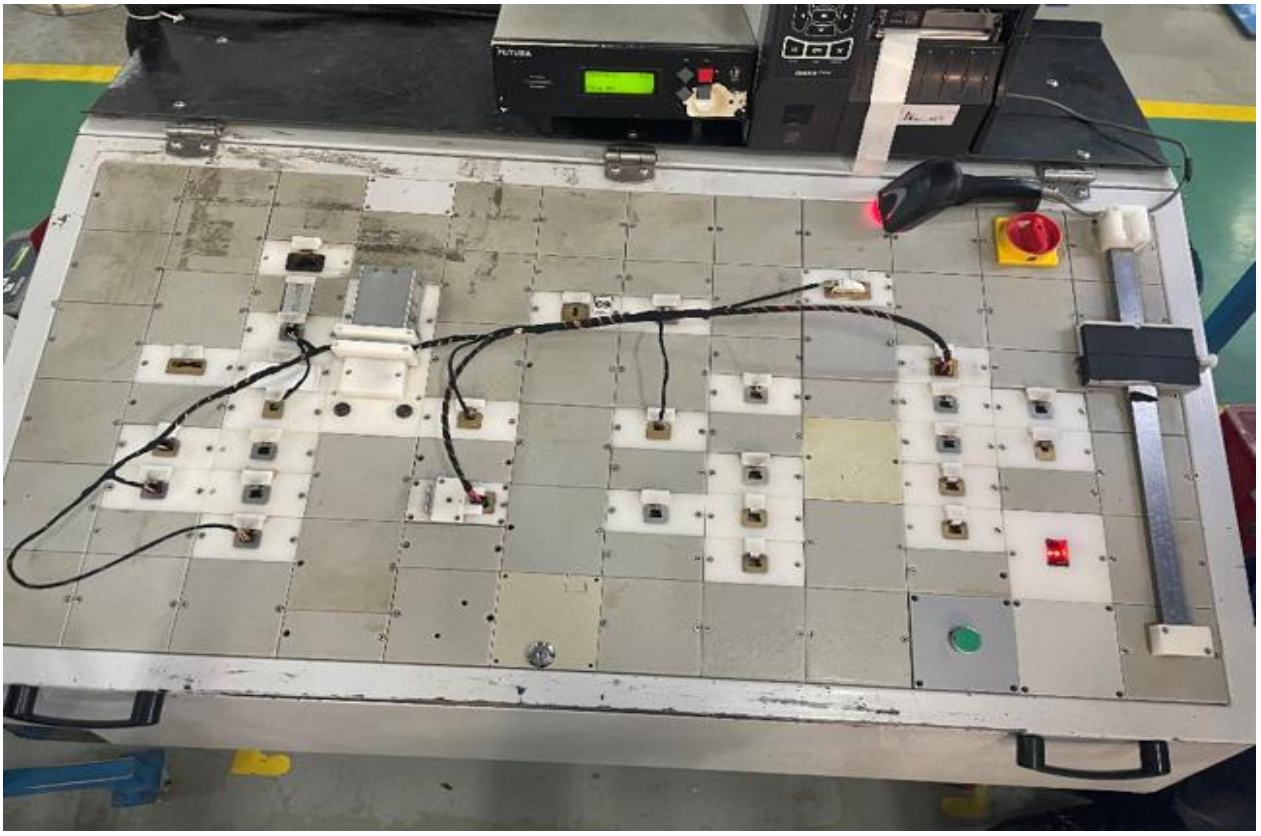
Fig no: 2

Cutting machines are used to uniformly cut wires to specified lengths, machines are used to crimp terminals or to partially plug wires with fitted terminals into connector modules. Solder machines are necessary for sealing wire ends as are tools to twist the wire.

Step 5: Testing

Once production is complete, each individual wire harness must undergo electrical safety testing for any specifications it may be subject to in real-world operation. This step is crucial in ensuring the final product performs 100% reliably.

Wire harness manufacturing is a process. Design and assembly from the drawing board to finished wire harness requires step by step planning and a good amount of manual production. Each wire harness has a specific purpose to integrate into a larger electronic network, which, in the modern world, truly does make wire harnesses indispensable.



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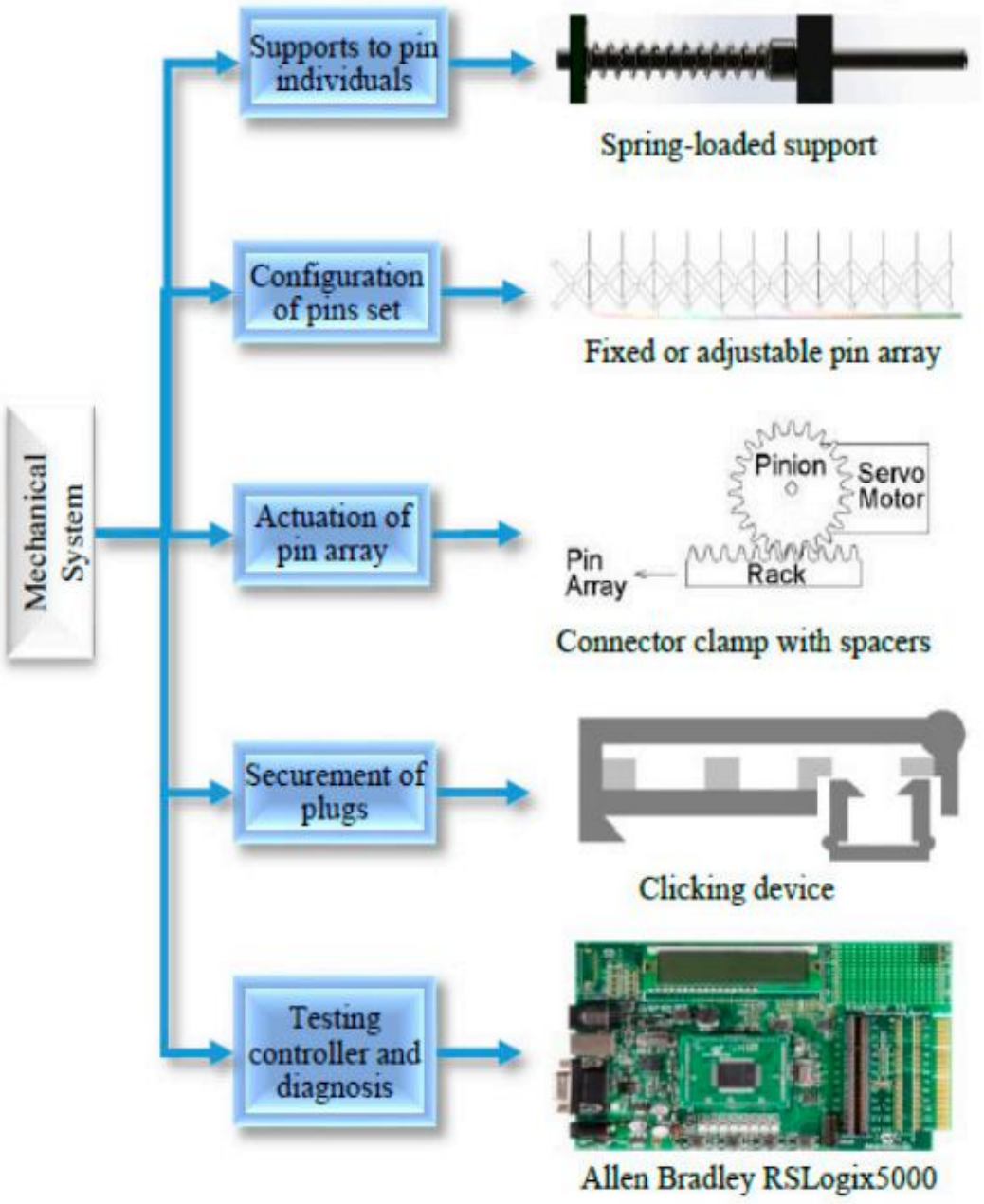


Figure 4. Five functional modules of the mechanical system.

Fig no:4

Chapter 2

Implementation of Navigation System

As discussed in point no 6. is total manual process of making final product (wire harness).It consist of below processes with some manual & automation process

- **Cutting Crimping:** It is fully automated process where operator need to load & unload the applicators, wires & terminals as per requirement. And need to set required parameters as per specification given in catalogue.Cutting Crimping process is fully Automated Process

- **USW - Ultra-Sonic Welding:** Ultrasonic Welding machine is used to welding multiple wire gauges as per requirement. It is also automated system where operator need to select program as per gauge size. Wires get welded automatically with the help of Sonutrode.

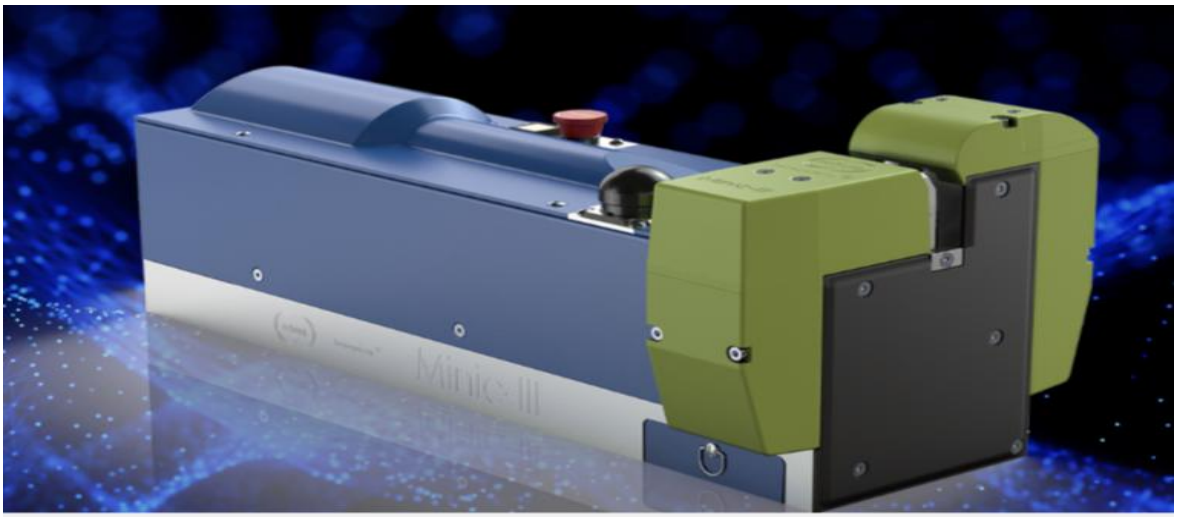


Fig no:5

- **Sub-Assembly process:** It is fully manual process where operator picks single wire manually and insert into a desired connector manually. It is time consuming process also frequency of interchanging of wires is more. It may increase Cost of Poor Quality.

- **Assembly Process:** Assembly process consist of multiple final assembly lines, in which workers sequentially add wire harness components or prepared modules to a large assembly board. Specified wires, when there is more than one wire going into one terminal, requires conducting multiple crimps that have to be done by hand. So does taping the harness with fabric tape at all the branch outs. Finally, the various components need to be bound or "harnessed" by hand with tape, clamps, or cable ties By performing final assembly tasks, like wire routing wire insertion into connector cavities, and bundling multiple wires with tape, the workers realize the desired tree-like structure of the wiring harness and prepares a Final Product which is called as FG - Finished Goods. It is fully Manual Process.

- **Circuit Testing:** Once production is complete, each individual wire harness must undergo electrical safety testing for any specifications it may be subject to in real-world operation. This step is crucial in ensuring the final product performs 100% reliably.It is Semi- Automated process. It requires operators help for laying each harness on test bench.

Implementation Of Navigation System with Auto-Taping Machine:

Process is same except auto sub-assembly & auto taping. As compared to manual process there are less chances of mistake .So this process is better than manual process. In sub-assembly process is semi-automatic based on automation program.

3.1 Introduction to Navigation System:

Navigation system is nothing but conversion of all manual process of sub assembly to automation.That is, as in manual system we need to insert wire with the help of SWI (Standard Work Instructions) which colour of wire need to be inserted in which cavity. This is all manual process which includes manual errors , possibilities of wrong insertion & behaviour Issue.To overcome form those errors we analyzed whole manual process and set one automated process call Navigation.

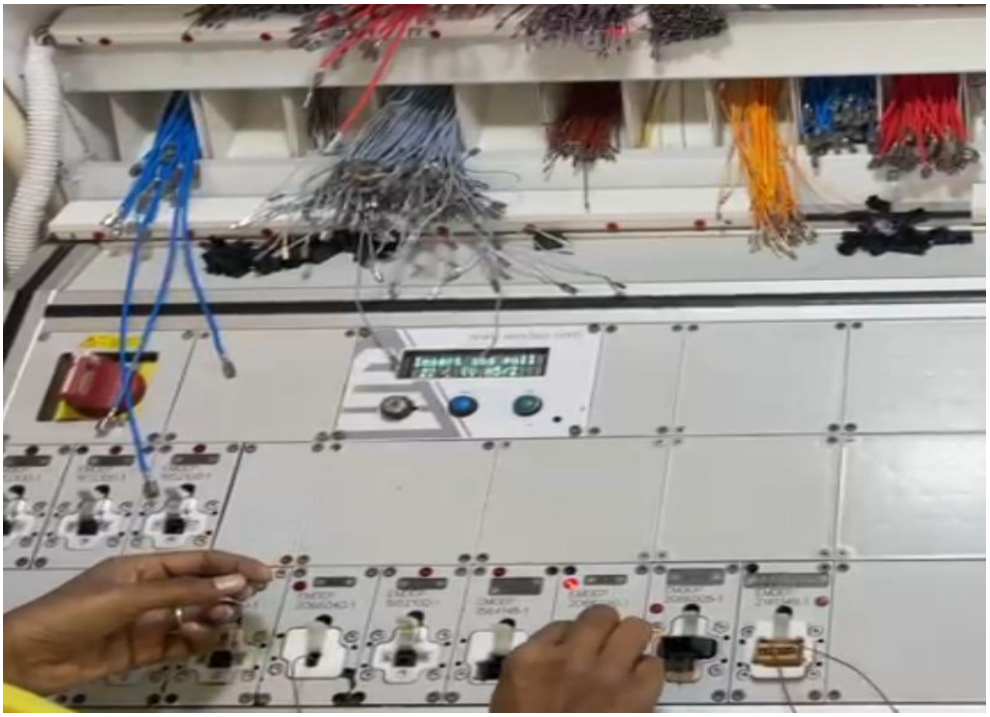


Fig no: 6

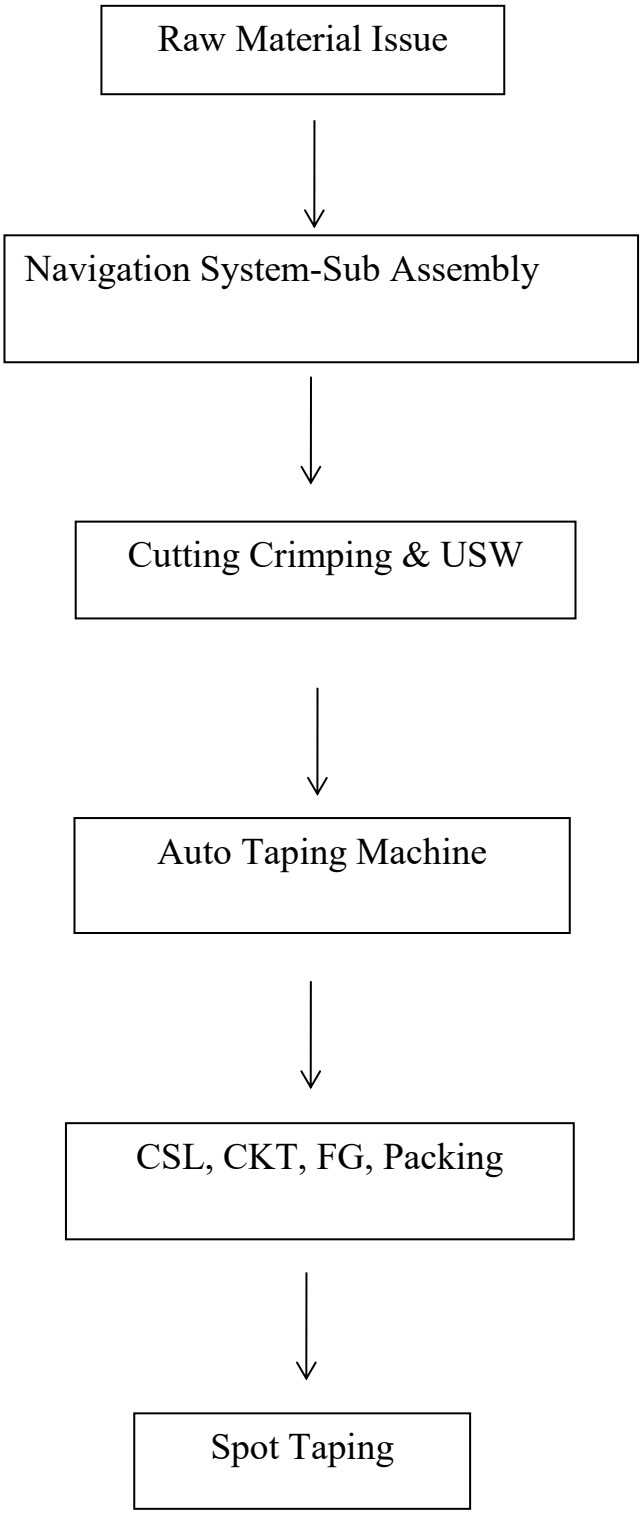
Advantages of Navigation System:

- Elimination of wrong insertion and loose insertion occurrence rate.
- Headcount Reduction
- ROI (Return on Investment) is minimum.
- Cost Saving (Cost Of Labour).
- COPQ - Cost Of Poor Quality improvement.

3.2 Material required for building Navigation System:

- Fixtures, LED for indication, trays, Navigation wire insertion bench.

3.3 Navigation Process Flow



Above flow shows overall process flow of Navigation System with Auto Taping Machine

Fig no: 7

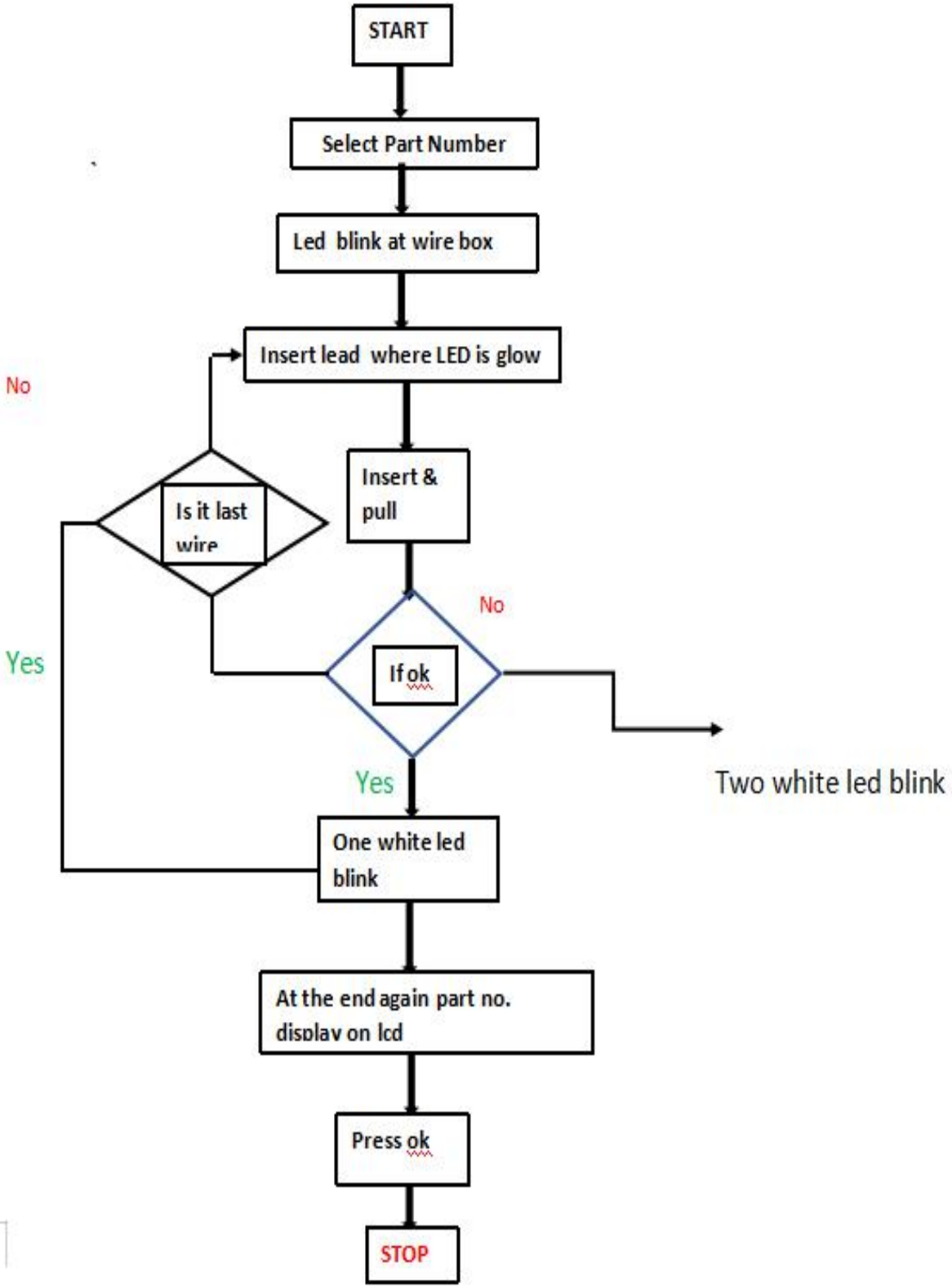
Chapter 3

Modification In Navigation System-

4.1 Current Method –

- Navigation helps for correct insertion of wires
- Operator need to arrange all required wires and required connectors.
- Connectors are inserted as per standard work.
- And for correct insertion wires navigation helps which wire is to be inserted in which connector and which cavity of respective connector.
- Currently there is no provision for locking of connector in fixture when wrong insertion is detected. Person who has done wrong insertion can easily remove that connector and can do rework independently.
- So that employee has no fear of any wrong insertion on Navigation Board because there is no any for escalation for wrong insertion.
- There is no use if they are doing wrong insertion even all information and guidance is given with the help of LED bulbs which gives next insertion of respective wire.

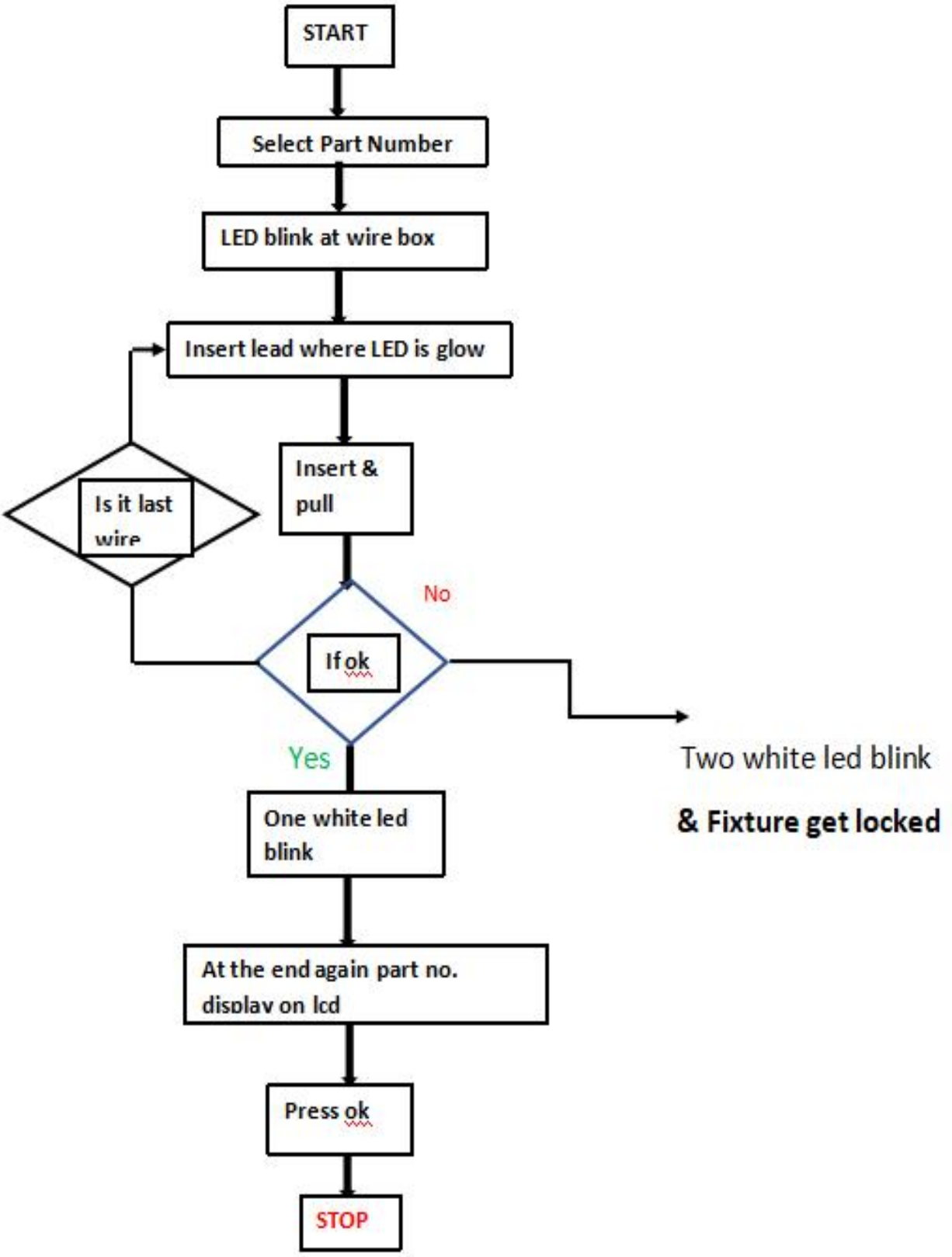
Flow Chart of Sub-Assembly processes

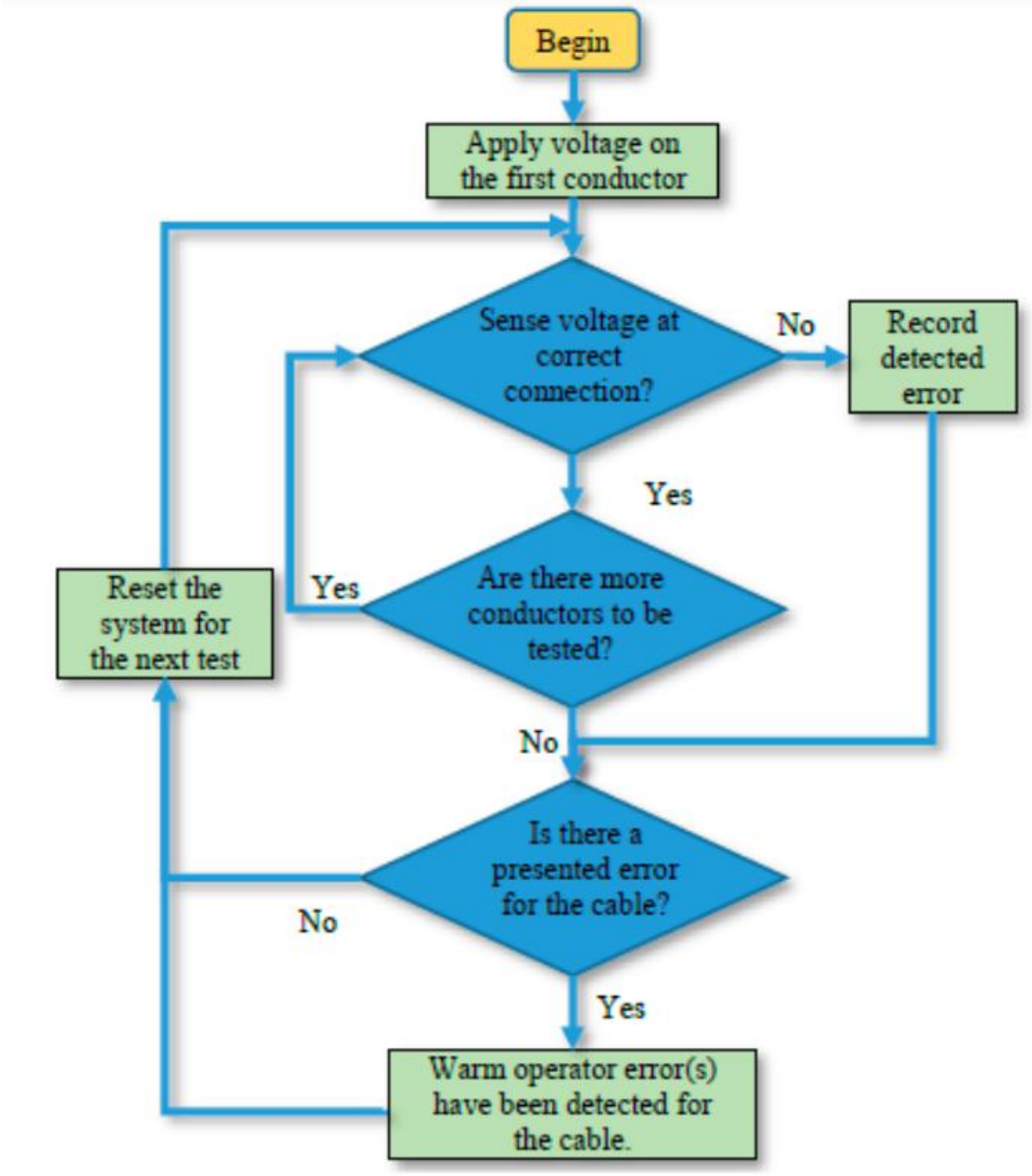


Proposed Method –

- During analysis of current method we found some bottlenecks in Navigation System.
- If any wrong insertion detected in navigation fixture isn't getting locked.
- Employee is used to rework by himself/herself which may create defect in wiring harness.
- Rework can damage lance, terminal which will not get locked in MQS (Micro Quad-lok Series) connector.
- To avoid such concerns from customers, modification is done in navigation system.
- Whenever wrong insertion is detected through navigation system, fixtures will get locked as harness gets locked when error is detected on EOL tester.
- Fixtures remains locked unless and until a figure print scanner doesn't scan for Authorized person.
- This will help to reduce wrong insertion frequency and if any wrong insertion is detected, it will be reworked by skilled rework operator.

Flow Chart of Sub-Assembly processes




Begin
Apply voltage on the first conductor
Sense voltage at correct connection?
No
Record detected error
Yes
Are there more conductors to be tested?
Yes
Reset the system for the next test
No
Is there a presented error for the cable?
No
Yes
Warm operator error(s) have been detected for the cable.

5. Program Structure for Navigation:

Programs are developed with Company's registered Supplier named EMDEP,Pune.

To maintain smooth flow in whole process, maintenance and further development a programmable structure is developed with them.

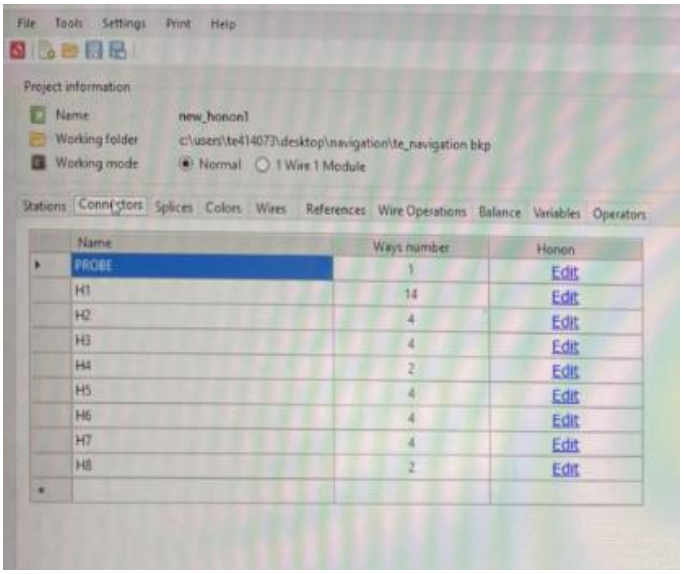
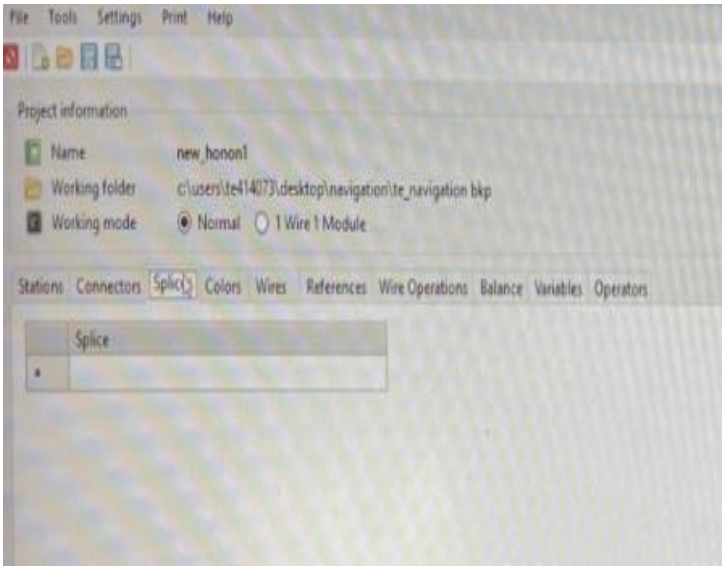


Fig no: 10



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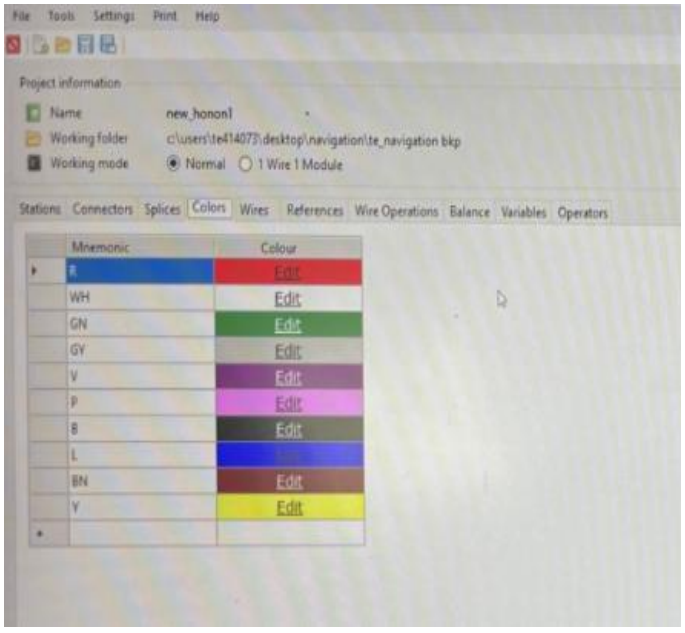

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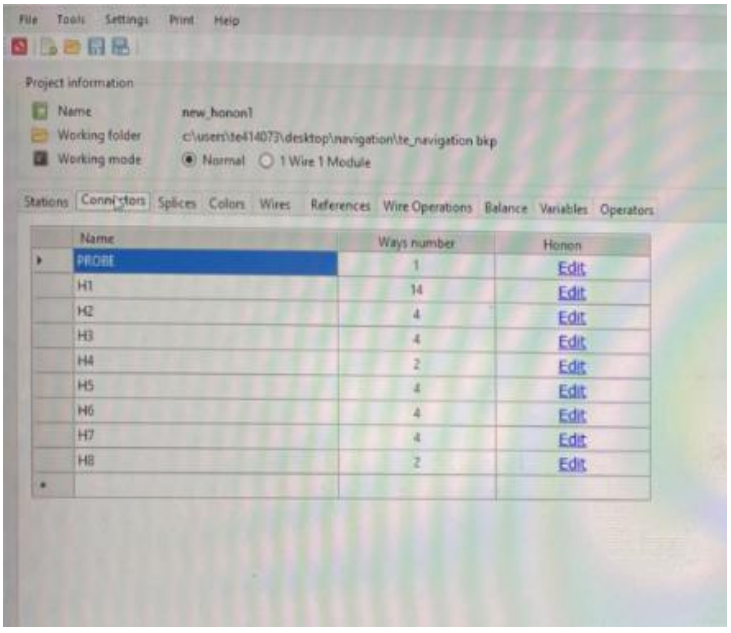

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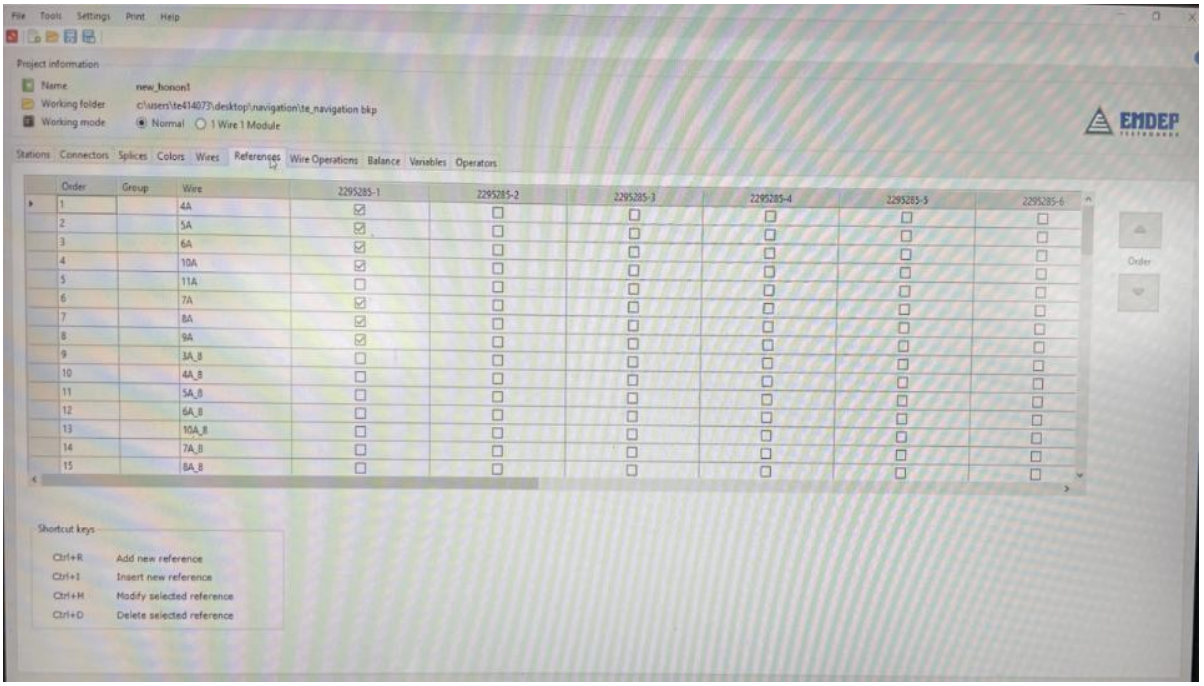

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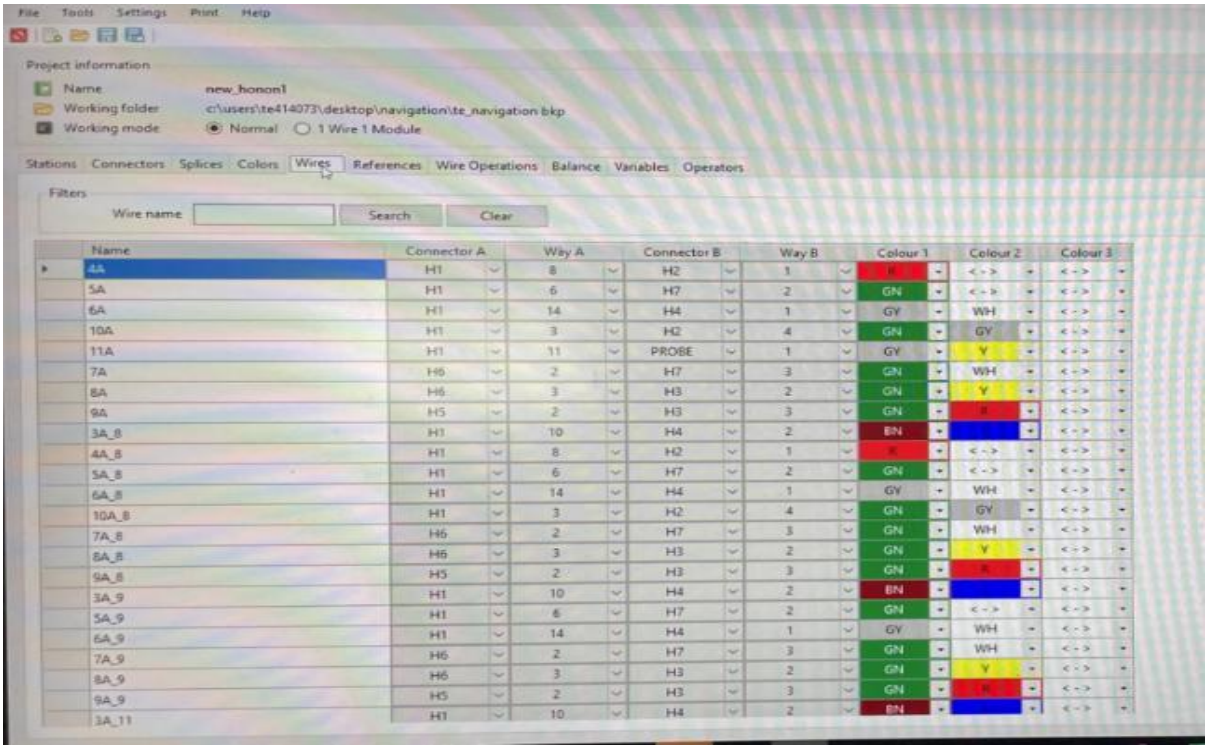


Fig no: 15

6. Headcount Allocation

Existing Method					
Procedure	Head-Count per Exit	Production Per Shift	Number Of Exits	Total Hradcount	Total Production
Manual Sub Assembly	3	660	1	3	660
Splice Insertion	5			5	
Manual Taping	7			7	

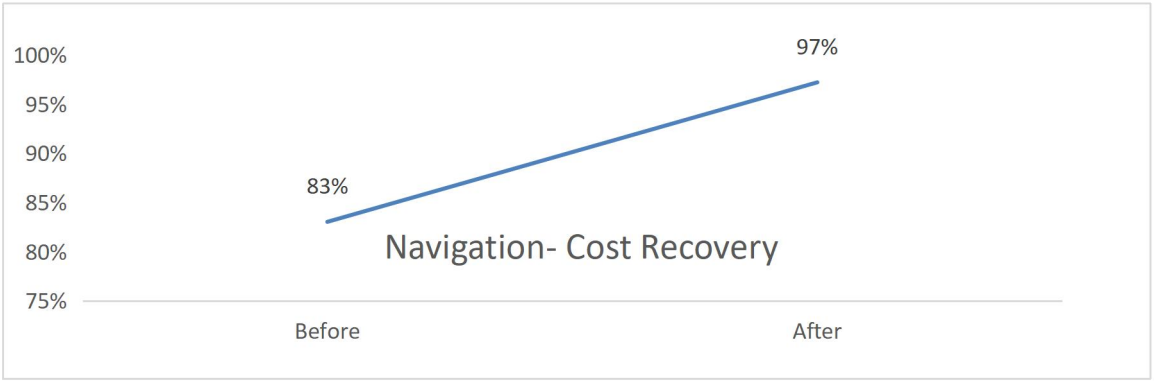
Preposed Method					
Procedure	Head-Count per Exit	Production Per Shift	Number Of Exits	Total Hradcount	Total Production
Sub Assembly on Navigation	2	660	1	2	660
Splice Insertion	1			1	
Manual Taping	4			4	
Auto Taping Machine	2			2	

7. Navigation Predicted Plan-

Part No.	VSM	Project		SCM Plan	Month Planned C	Difference	Actual		Daily	SHE/Part	COGS	TCW	SCCOP
2292114-1	HVAC-1 Automation-Navigation	MQB A0						-					
2292114-3	HVAC-1 Automation-Navigation	MQB A0						-					
2292114-4	HVAC-1 Automation-Navigation	MQB A0						-					
2292115-1	HVAC-1 Automation-Navigation	MQB A0						-					
2292115-2	HVAC-1 Automation-Navigation	MQB A0						-					
2292115-3	HVAC-1 Automation-Navigation	MQB A0						-					
2292115-4	HVAC-1 Automation-Navigation	MQB A0						-					
2292115-5	HVAC-1 Automation-Navigation	MQB A0						-					
2292115-6	HVAC-1 Automation-Navigation	MQB A0						-					
2295285-1	HVAC-1 Automation-Navigation	Hanon		-	-	-	-	-		0	203	593	49
2295285-2	HVAC-1 Automation-Navigation	Hanon		-	-	-	-	-		0	215	591	50
2295285-3	HVAC-1 Automation-Navigation	Hanon		-	-	-	-	-		0.16	109	475	39
2295285-4	HVAC-1 Automation-Navigation	Hanon		-	-	-	-	-		0.18	205	548	47
2295285-5	HVAC-1 Automation-Navigation	Hanon		-	-	-	-	-		0.14	98	415	35
2295285-6	HVAC-1 Automation-Navigation	Hanon		-	-	-	-	-		0.14	99	472	36
2295285-7	HVAC-1 Automation-Navigation	Hanon		-	-	-	-	-		0.18	195	550	46
2383523-2	HVAC-1 Automation-Navigation	Hanon		5,024	5,024	-	-	-		0.18	195	459	42
2383523-1	HVAC-1 Automation-Navigation	Hanon		8,000	8,000	-	1,305	58,634		0.19	203	424	45
2383544-1	HVAC-1 Automation-Navigation	Hanon		2,000	2,000	-	915	42,026		0.2	215	474	46
2383544-2	HVAC-1 Automation-Navigation	Hanon		2,000	2,000	-	2,388	1,03,209		0.18	205	429	43
2295285-8	HVAC-1 Automation-Navigation	Hanon		8,000	8,000	-	2,100	69,336		0.13	91	451	33
2321202-1	HVAC-1 Automation-Navigation	NHMR		-	-	-	-	-			-	527	68
2321202-2	HVAC-1 Automation-Navigation	NHMR		600	600	-	950	42,617		0.29	-	578	45
2321202-3	HVAC-1 Automation-Navigation	NHMR		-	-	-	-	-			-	661	68
2321202-4	HVAC-1 Automation-Navigation	NHMR		3,600	3,600	-	3,456	2,35,907		0.29	-	803	68

8. Navigation predicted Cost Recovery Graph:

Working days	24	Before	After
Current Output		660	600
Agency HC		15	9
Total		15	9
Agency Salary	15000	7500	4500
Energy		16667	16667
Transport + Canteen	50000	2083	1250
		26250	22417
SCCOP Recovery		21793	21793
% Recovery		83%	97%



9. Cost Saving With Head-Count

	No Of Days	Head-Count Deployed	Compensation Provided	Total / Month
Before	30	15	15000	225000
After	30	9	15000	135000
			Total Saving	**90000**

From above calculations it is clear that total saving for company is near about 90K per Month.

10. Total Costing And Saving

	Project	Hanon System
	No Of Parts in Projects	12
Volume per project	Volume/month	32,000
	Day Demand (A+B Shift)	1,333
Assets per project	Taping Machine Required	1
	Capacity	600
	No of Navigation Considered	1
Investment in INR	Navigation System	2,54,700
	Point Taping Station	55,556
	Taping Machine	6,98,800
	CSL Station	11,111
	Tester	4,67,000
	Total Modification Cost - INR	5,33,667
Headcount Details	Existing Headcount/ Day	15
	Proposed Hed-Count/ Day	9
	Total Headcount saving/ Day	6
Saving in $	Total Monthly Saving (INR)	90,000
15.65	Total Annual Saving (INR)	10,80,000
	Average time for ROI - in years	0.49
	MOP Impact	100%

11. Result

- Elimination of wrong insertion & loose insertion occurrence **rate is reduced to zero**
- Headcount **saving of 6contractual Employees**
- Cost Of Poor Quality (COPQ) improvement (2% of **Cost Of Goods Produced** (COGS) - produced)
- **Productivity increased**

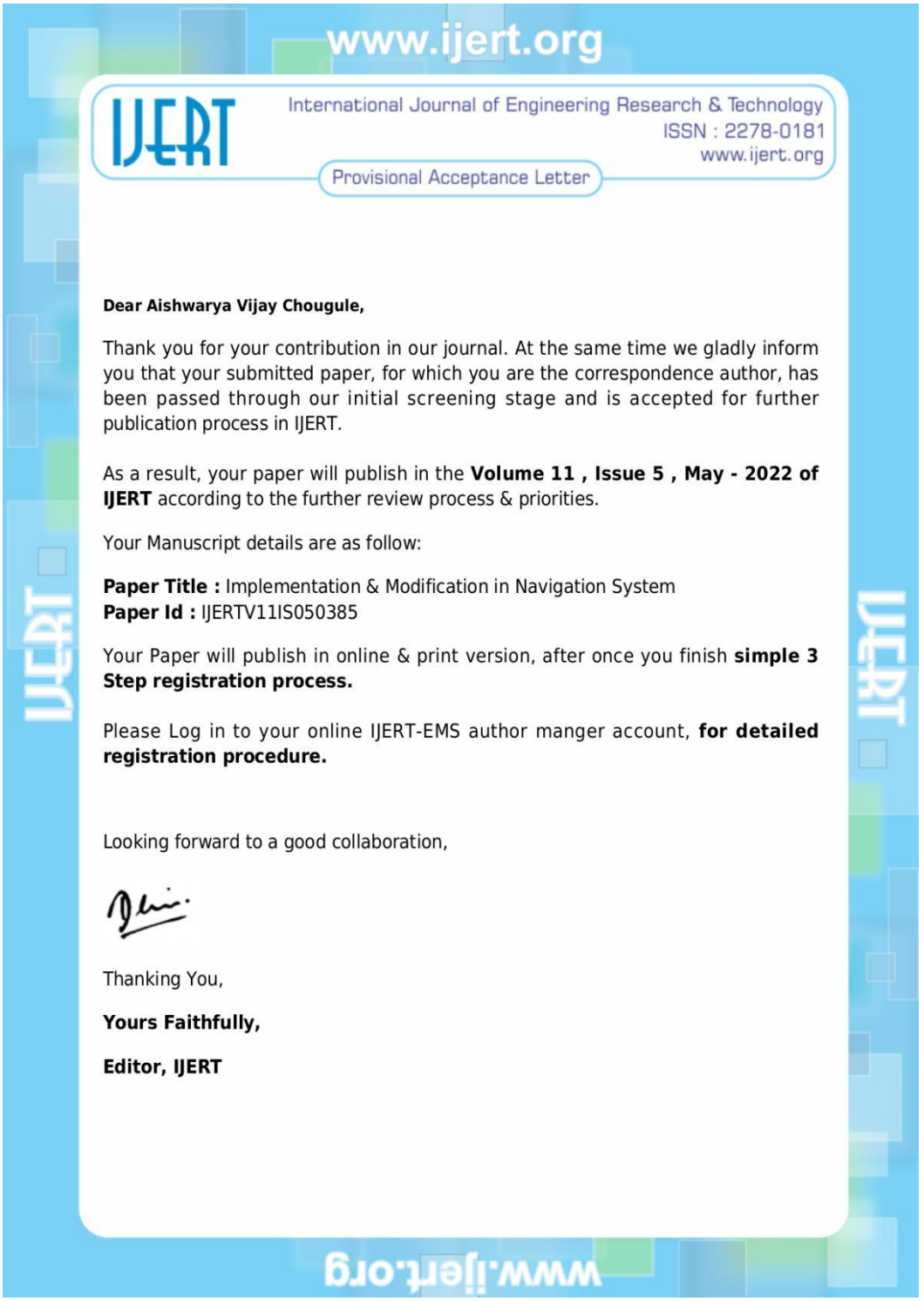
12. Conclusion

The reliability of the electrical system can be gauged from the robustness of the wire harness layout and the consistency of the supplies received from the wire harness manufacturer.If the controls on the assembly of wire harness ensure that the fitment is exactly identical as per the fitment drawing specified by the designer, the electrical faults due to wire connections get totally eliminated.

To overcome all possibilities of production defective product automation in wiring harness became an essential past.Similarly, if the quality checks at wire harness manufacturer are enabling an error free and zero defect wire harness, the vehicle assembly clearance for electrical system faults will be almost nil on assembly line with automation in wiring harness .As world is growing faster and faster with automation in every aspect wherever possible is must

Chapter 3

13. IJERT Published Paper



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As a result, your paper will publish in the **Volume 11 , Issue 5 , May - 2022 of IJERT** according to the further review process & priorities.

Your Manuscript details are as follow:

Paper Title : Implementation & Modification in Navigation System
Paper Id : IJERTV11IS050385

Your Paper will publish in online & print version, after once you finish **simple 3 Step registration process.**

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Yours Faithfully,

Editor, IJERT

14. IJERT Published Paper

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Implementation & Modification in Navigation System

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***Abstract*—Wire Harness is the interconnecting wiring in the vehicle for the transmitting electrical power and signals in the electrical system. Over the years the number of components to be connected and hence the number of circuits has increased many folds. As harness complexity increases, these legacy methods will come under increasing strain, and eventually may fail completely." You can arguably already seeing this happen in markets such as automotive. And all that is in addition to the risks long posed by late-stage change orders. This has made the wire-harness design as the most complicated task in the vehicle design and wire harness (electrical system) integration with the other aggregates a difficult job. Many CAD tools and design software have evolved from computer companies. But they have not resolved major issues faced by vehicle OEM's and the wire-harness manufacturers. In fact, the requirements of vehicle manufacturers are not clear to the other agencies and this results in wire-harness development as a major bottleneck in any vehicle development program. An overview is given on the importance of the wire-harness design and the impact it will have on the success or failure of the final product ' VEHICLE ' when it reaches the customer)**

Keywords—Implementation of Navigation System, Manufacturing Automation, Automotive wiring harness, Cutting Crimping, Assembly, Final FG

I. INTRODUCTION

The wiring harness is the biggest and heaviest bought-in part and connects all electrical and electronic (E/E) components in the automotive vehicle, like sensors, electronic control units, batteries, and actuators. As a connecting element, the wiring harness is responsible for the energy and information flow within the E/E system to fullfill primary car functions such as steering and braking as well as secondary car functions such as ventilation and infotainment.

The increase in the electrical and electronic content in the automobiles has resulted in the wire harness design becoming more and more complex. From the simple function of electrical power distribution and transmitting signals, it has become a networking of multiple controllers with a vast range of sensors , actuators and their interfaces. Many luxury features used only in high-end vehicles for safety and comfort have now become standard across all makes and models. With the availability of more electronic components suitable for automobile applications the gadgets on the vehicles are multiplying with every new model introduced in the market.

II. MANUFACTURING OF AUTOMOTIVE WIRING HARNESS

The wiring harness consists of thousands of components comprising wires with terminals and seals, connectors, fuses, relay boxes, switching units, fixing components, sensor and protecting component.

A. Wiring harness manufacturing process flow

The wiring harness manufacturing is divided into three main areas, the cutting-crimping area & USW area, pre- assembly area, and final assembly area. The manufacturing process starts from the cutting area, in which automated machines cut wires with different cross-sections into predefined lengths(as per customer drawing), strip the cable isolation, and add seals (as per requirement) and crimps.Then spliced wires are welded as per customer requirement and design with the help of Ultra Sonic Welding (USW). In the sub manufacturing area, workers execute special process steps, like twisting, splicing, and heat tube shrinking, either with semi-automated machines or manually.

Furthermore,they prepare small wire harness sub-assemblies. The last manufacturing area consists of multiple final assembly lines, in which workers sequentially add wire harness components or prepared modules to a large assembly board. By performing final assembly tasks, like wire routing wire insertion into connector cavities, and bundling multiple wires with tape, the workers realize the desired tree-like structure of the wiring harness. Finally, the wiring harness is tested regarding electrical functionality, hardware completeness and leakage. Then, the final product is either packaged for -in sequence delivery to the automotive original equipment manufacturer (OEM), where it is installed into the vehicle, or sent to rework in case of a failed test.

B. Wiring Harness Components

Wire harnesses are collections of electrical wires, cables, and sub assemblies covered by exterior defined tape & that are used to connect devices to their power source.There are several types of wire harness components, each of which is

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available in multiple variations to suit different applications. These components include:

- Wires
- Connectors
- Terminal
- Tapes- outer covering
- Ties
- Grommets

Wire:
The wire carries the current or signal that powers a device. The wire's capacity needs to meet or exceed the voltage or bandwidth & it's expected to transmit. Most wires are copper and can have a specially chosen coating.

Connectors:
Wire connectors are available in several varieties and sizes to connect different types of wires. While they are usually plastic they can be made from a variety of elements.

Terminals:
Terminals are the metal parts that are attached to the end of the wire to be inserted into the connector or to be attached to a point on the connecting equipment.Terminal are made up with using stamping process.

Tapes:
Tapes are used in wiring harness to bundle all wires together in desired tree-like structure of the wiring harness

Ties:
Cable ties and clamps keep the wires inside of the harness attached to from a stream of wires to a particular direction. It can also be used to attach to a structure at fixed points to minimize movement.

Grommets:
Grommets are insulators to keep moisture out of the connector. A grommet can be attached with the terminal or can be a part of the connector.Outer coverings/Insulators: Also referred to as tubes and sleeves, insulators provide some degree of abrasion resistance, environmental protection, and protection from electrical shock. They can be made of various materials such as nylon

III. WHEN CHOOSING A WIRE HARNESS, SOME OF THE COMPONENT QUALITIES TO CONSIDER INCLUDE:

- Type of wire (including material & gauge)
- Insulation Material
- Environment Capabilities
- Voltage & current capacity

Wire harnesses play an essential role in almost every industry. Some of the most common industries that use wire harnesses include:

- Automotive wiring Harness
- Aerospace wiring Harness
- Electronic wiring Harness

A. Wire harness manufacturing terms and definitions

American Wire Gage (AWG):
A standard system for designating wire diameter. Primarily used in the U.S

*Bell-mouth:*The raised portion at the front and/or back of the wire barrel crimp that provides a gradual entrance and exit for the wire strands without causing damage.

Cable: A group of individually insulated conductors in the twisted or parallel configuration under a common sheath.

Cable Assembly: A cable with plugs or connectors attached.

Connector: A device used to physically and electrically join two or more conductors.

Crimp: Final configuration of a terminal barrel formed by the compression of terminal barrel and wire.

Crimp Height: The measurement of the overall wire barrel height after crimping the terminal.

Continuity: A continuous path for the flow of current in an electrical circuit.

Double Crimp: The process of two or more mechanical crimping operations on the same location in a single terminal.

Harness: A group of wire and cables, usually made with breakouts. Furthermore, with a rubber or plastic sheath tie them together. A harness also provides interconnection of an electric circuit.

Insulation: A material that offers high electrical resistance making it suitable for covering components, terminals, and wires. This material also helps to prevent the possible future contact of adjacent conductors and a resulting short circuit.

Insulation Crimp: Area of a terminal, splice or contact formed around the insulation of the wire.

IV. MANUAL WIRING HARNESS PROCESS:

As we observe there are same process of cutting ,Crimping, Welding, sub-assembly, Taping, Visual Inspection, CKT ,FG. The wire harness manufacturing process is time consuming, difficult, and task oriented. Nonetheless, as the demand for wire harnesses ad cable assemblies grow, manufacturing of these components continues to expand. That's because the wire harness is one of the most indispensable electronic and electrical components in the modern world

Step 1: Design

Whether hidden behind a glove box in an automobile or within the back panel of a washing machine, the wire harness A delivers power and transmits information in a streamlined, uniform way. In electronic product research and development, engineers must confront and overcome electrical issues daily to successfully bring a product to market. An integral part of

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this challenge entails a custom design for each products electronic part and a step by step wire harness manufacturing process to complete the assembly. This is also the stage at which engineers must choose harness components and decide on other use specifications

Step 2: Prototyping

If necessary, wire harness prototyping enables an engineer or product designer to get their hands on a real-life version of their final product. They can then test the harness in its intended application before beginning the first production run, ensuring optimal performance.In wire harness manufacturing, design specifications must be met and high quality standards with sector, wire harness manufacturing processes still rely in no small part on manual assembly. Though some automation can be incorporated into the process, hand manufacturing of wire harnesses and cable assemblies are necessary due to the many intricate and time consuming steps involved in completing the process. Even though building a wire harness can be difficult and task oriented, manual production remains more cost effective.

Another reason manual production remains the primary method of manufacturing for wire harnesses and cable assemblies is that each must be customized for each application. Wire harnesses are very specific components designed for specific larger parts. They are necessitated to resolve geometric and electrical issues in manufacturing products and to provide solutions to particular problems inherent in the overall process. Geometrically, wire harnesses are designed to fit a specific space within a much larger or alongside a greater network of electrical components and wiring. Wire harnesses also must ground and protect wires from potential internal and external damages related to electrical issues such as crossed wires, chemicals or moisture

Step 3: Wire Cutting

Broadly speaking, the initial step in building a wire harness is make sure the wires are cut to the right length, which is done by a wire-cutting machine.

Fig no: 1

Step 4: Assembly

Lastly, the wires are gathered into a harness utilizing a workbench or assembly board to meet the design specifications. Hand manufacturing of wire harness production is necessary to route wires through sleeves and to apply fabric tape where needed, such as on branch outs from wire strands. Terminals need to be crimped onto wires, and where more than one wire needs to be attached to one terminal, multiple crimping will be necessary.
Also, the insertion of one sleeve into another is done manually, and so is fastening any strands with tape, clamps or cable ties. Hand production does not exclude the use of automation and machinery in wire harness manufacturing.

Fig no: 2

Cutting machines are used to uniformly cut wires to specified lengths, machines are used to crimp terminals or to partially plug wires with fitted terminals into connector modules. Solder machines are necessary for sealing wire ends as are tools to twist the wire.

Step 5: Testing

Once production is complete, each individual wire harness must undergo electrical safety testing for any specifications it may be subject to in real-world operation. This step is crucial in ensuring the final product performs 100% reliably.

Wire harness manufacturing is a process. Design and assembly from the drawing board to finished wire harness requires step by step planning and a good amount of manual production. Each wire harness has a specific purpose to integrate into a larger electronic network, which, in the modern world, truly does make wire harnesses indispensable.

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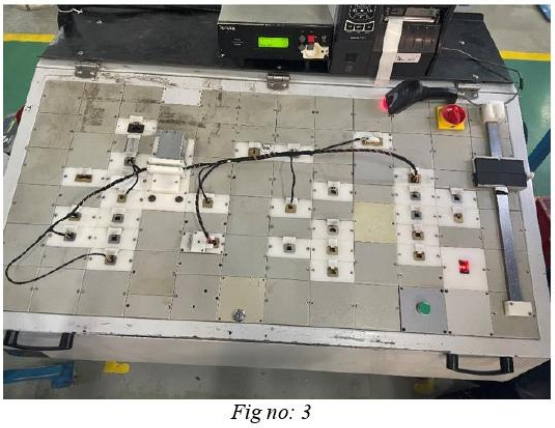

Fig no: 3

V. IMPLEMENTATION OF NAVIGATION SYSTEM

As discussed in point no 6. is total manual process of making final product (wire harness).It consist of below processes with some manual & automation process

- *Cutting Crimping:* It is fully automated process where operator need to load & unload the applicators, wires & terminals as per requirement. And need to set required parameters as per specification given in catalogue.Cutting Crimping process is fully Automated Process
- *USW - Ultra-Sonic Welding:* Ultrasonic Welding machine is used to welding multiple wire gauges as per requirement. It is also automated system where operator need to select program as per gauge size. Wires get welded automatically with the help of Sonutrode.

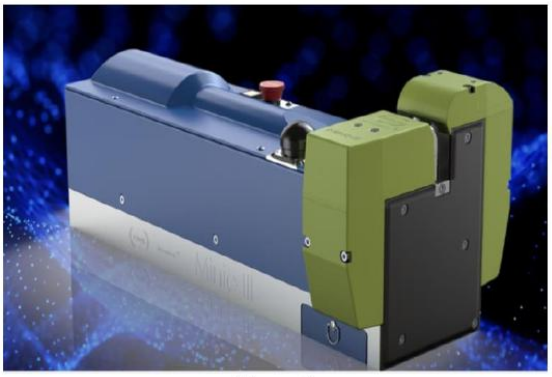

Fig no:4

- *Sub-Assembly process:* It is fully manual process where operator picks single wire manually and insert into a desired connector manually. It is time consuming process also frequency of interchanging of wires is more. It may increase Cost of Poor Quality.
- *Assembly Process:* Assembly process consist of multiple final assembly lines, in which workers sequentially add wire harness components or prepared modules to a large assembly board. Specified wires, when there is more than one wire going into one terminal, requires conducting multiple crimps that have to be done by hand. So does taping the harness with fabric tape at all the branch outs. Finally, the various components need to be bound or "harnessed" by hand with tape, clamps, or cable ties By performing final assembly tasks, like wire routing wire insertion into connector cavities, and bundling multiple wires with tape, the workers realize the desired tree-like structure of the wiring harness and prepares a Final Product which is called as FG - Finished Goods. It is fully Manual Process.
- *Circuit Testing:* Once production is complete, each individual wire harness must undergo electrical safety testing for any specifications it may be subject to in real-world operation. This step is crucial in ensuring the final product performs 100% reliably.It is Semi- Automated process. It requires operators help for laying each harness on test bench.

VI. IMPLEMENTATION OF NAVIGATION SYSTEM WITH AUTO-TAPING MACHINE:

Process is same except auto sub-assembly & auto taping. As compared to manual process there are less chances of mistake .So this process is better than manual process. In sub-assembly process is semi-automatic based on automation program.

A. Introduction to Navigation System:

Navigation system is nothing but conversion of all manual process of sub assembly to automation.That is, as in manual system we need to insert wire with the help of SWI (Standard Work Instructions) which colour of wire need to be inserted in which cavity. This is all manual process which includes manual errors , possibilities of wrong insertion & behaviour Issue.To overcome form those errors we analyzed whole manual process and set one automated process call Navigation.

Fig no: 5

B. Advantages of Navigation System:

- Elimination of wrong insertion and loose insertion occurrence rate.
- Headcount Reduction
- ROI (Return on Investment) is minimum.
- Cost Saving (Cost Of Labour).

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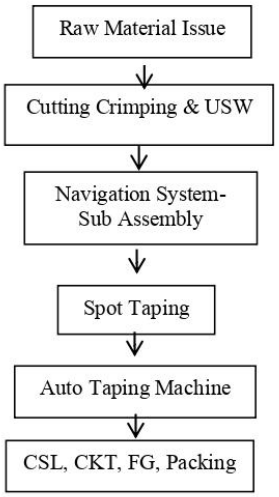
- COPQ - Cost Of Poor Quality improvement.

C. Material required for building Navigation System:

Fixtures, LED for indication, trays, Navigation wire insertion bench.

D. Navigation Process Flow:



Flow Chart

Above flow shows overall process flow of Navigation System with Auto Taping Machine

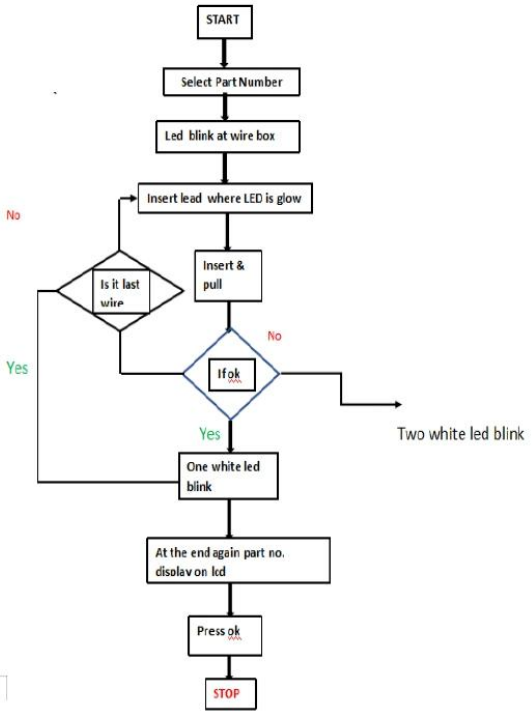
Fig no: 6

VII. MODIFICATION IN NAVIGATION SYSTEM-

Current Method –

- Navigation helps for correct insertion of wires
- Operator need to arrange all required wires and required connectors.
- Connectors are inserted as per standard work.
- And for correct insertion wires navigation helps which wire is to be inserted in which connector and which cavity of respective connector.
- Currently there is no provision for locking of connector in fixture when wrong insertion is detected. Person who has done wrong insertion can easily remove that connector and can do rework independently.
- So that employee has no fear of any wrong insertion on Navigation Board because there is no any for escalation for wrong insertion.
- There is no use if they are doing wrong insertion even all information and guidance is given with the help of LED bulbs which gives next insertion of respective wire.
- There is chance of terminal damage

Flow Chart of Sub-Assembly processes



Proposed Method –

- During analysis of current method we found some bottlenecks in Navigation System.
- If any wrong insertion detected in navigation fixture isn't getting locked.
- Employee is used to rework by himself/herself which may create defect in wiring harness.
- Rework can damage lance, terminal which will not get locked in MQS (Micro Quad-lok Series) connector.
- To avoid such concerns from customers, modification is done in navigation system.
- Whenever wrong insertion is detected through navigation system, fixtures will get locked as harness gets locked when error is detected on EOL tester.

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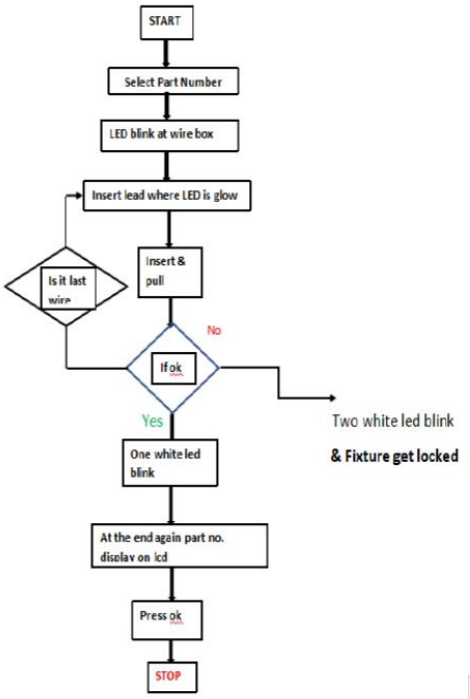
- Fixtures remains locked unless and until a figure print scanner doesn't scan for Authorized person.
- This will help to reduce wrong insertion frequency and if any wrong insertion is detected, it will be reworked by skilled rework operator.

Flow Chart of Sub-Assembly processes



CONCLUSION

The reliability of the electrical system can be gauged from the robustness of the wire harness layout and the consistency of the supplies received from the wire harness manufacturer.If the controls on the assembly of wire harness ensure that the fitment is exactly identical as per the fitment drawing specified by the designer, the electrical faults due to wire connections get totally eliminated.

To overcome all possibilities of production defective product automation in wiring harness became an essential past.Similarly, if the quality checks at wire harness manufacturer are enabling an error free and zero defect wire harness, the vehicle assembly clearance for electrical system faults will be almost nil on assembly line with automation in wiring harness .As world is growing faster and faster with automation in every aspect wherever is possible.

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It takes thousand voices to tell a story and similarly it takes the help encouragement of numerous people for the completion of any project. We express gratitude for all who look to be especially acknowledged for their support and assistance to us through each stage of study.We take immense pleasure in expressing our deep sense of gratitude to Prof. Udaysinh Sutar (Principal), M. J. Deshmukh (HOD- Electrical Engg) & Prof. V.P Mohite for his excellent guidance and constant encouragement.

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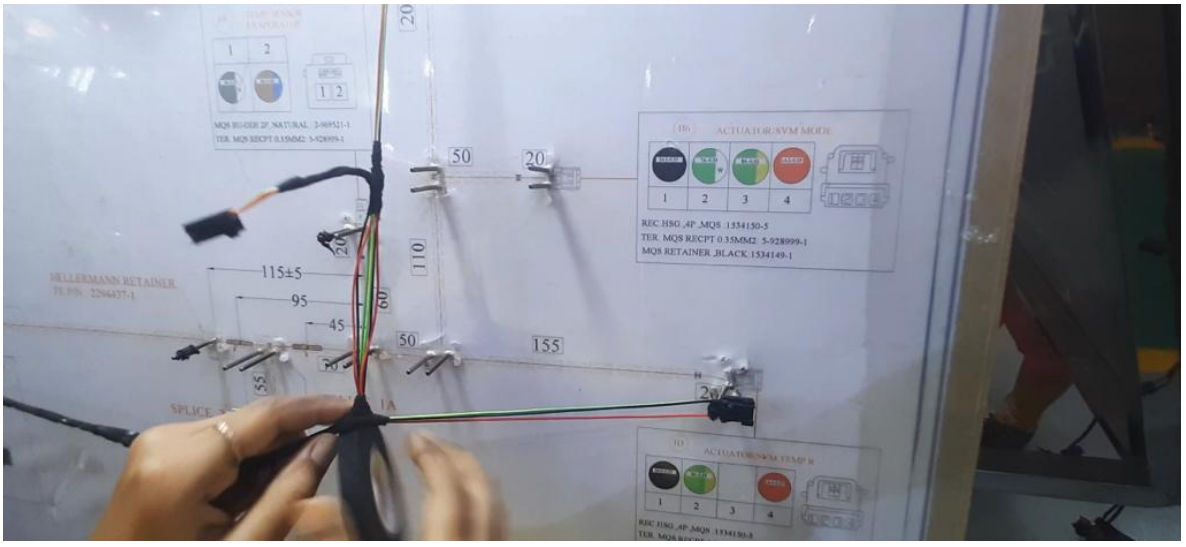
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