LEAN SIX SIGMA IMPLEMENTATION IN CABLE HARNESS MANUFACTURING

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Abstract—The cable harness manufacturing industry has been growing in a fast pace during the recent years in India. Cable harnesses are used to link together all the electrical components scattered throughout any electrical equipment. Cable harness manufacturing involves a series of operations which are to be carried out in a proper sequence to make a good quality harness. In real time scenario, high volume production of cable harness with consistent good quality is a difficult target to achieve. This paper is directed at the efforts intended to improve the quality of cable harness manufacturing using six sigma methodologies. It includes collection of defects data, analysis of the defects data using FMEA methodology, determining the causes and taking corrective actions to eliminate the defects. Process flow chart and manufacturing lead time are also determined and lean tools such as one-piece flow and job instruction are also used.

Keywords: Cable Harness Manufacturing; Failure Mode and Effect Analysis; Risk Priority Number(RPN); defects.; one piece flow.

I. INTRODUCTION

Cable harness manufacturing is one of the fast growing industries in today’s world. The good quality industrial grade cable harness acts as the central nervous system to many device and vehicle electronics designs, particularly in the automobile and military aerospace segments. As applications become increasingly complex, innovations in cable harness design and manufacturing techniques become more and more critical. Manufacturing cable harnesses with good quality is the need of the hour. Six sigma promises good quality when properly applied to cable harness manufacturing.

II. CABLE HARNESS PRODUCTION

Cable harness is often designed according to geometric and electrical requirements. A diagram is then provided (either on paper or on a monitor) for the assembly preparation and assembly.

The wires are first cut manually or using a special wire-cutting machine. After this, the ends of the wires are stripped to expose the metal (or core) of the wires, which are soldered or crimped to terminals or connector housings. The cables are assembled and clamped together on a special workbench, or onto a pin board (assembly board), according to the design specification to form the cable harness. After fitting any protective sleeves, conduit, or extruded yarn, the harness is either fitted directly in the vehicle or shipped.

In spite of increasing automation in general cable harnesses continue to be manufactured by hand, and this likely is the case for the foreseeable future. In part, this is due to the many different processes involved, such as,

- routing wires through sleeves
- taping with fabric tape, in particular on branch-outs from wire strands,
- crimping terminals onto wires, particularly for so-called multiple crimps (more than one wire into one terminal),
- inserting one sleeve into another
- fastening strands with tape, clamps or cable ties.

The picture of a cable harness is shown in Fig.1 below.

![Fig. 1.1 Cable Harness](image-url)
over machine, since he can change over to the different variants (no reprogramming required).

Pre-production, however, can be automated in part. The following processes can be automated.

- Cutting individual wires (cutting machine)
- Stripping the outer individual jacket (stripping machine)
- Crimping terminals onto one or more sides of the wire,
- Partial plugging of wires prefit with terminals into connector housings,
- Soldering of wire ends (solder machine), and
- Twisting wires.

Manufacturing high volume of cable harnesses with consistent good quality is a tough task. Cable harness manufacturing involves much complexity. To produce quality we depend on the six sigma methodology.

III. LEAN SIX SIGMA FRAMEWORK

The activities that cause the customer’s critical to quality issue and creates the longest time delays in any process offer the greatest opportunity for improvement in cost, quality, capital and lead time. It is the synergy of lean and sig sigma that has helped companies to reduce manufacturing overhead and quality costs by 20% and inventory by 50% in less than 2 years. The fundamental principle of six sigma is to take an organization to an improved level of sigma capability through the rigorous application of statistical tools and techniques. Six Sigma simply means to reduce variation in product and process characteristics.

IV. FMEA METHODOLOGY

Whenever any industry is going to design or redesign its manufacturing process, measuring its reliability is an essential part of TQM. The ability of measuring the new process or new products reliability is the strength of TQM. One of the important tools for measuring the reliability of the product or process is FMEA. Failure Mode Effect Analysis (FMEA) is utilized to identify the various failure modes of the products or processes or systems. It also analyses the causes of these failures and identify the failure causes. With a prioritization method, it tries to eliminate the failure modes at the design stage of the product or process. Therefore, the FMEA is classified as Design FMEA and Process FMEA. FMEA is an analytical technique that combines the technology and experience of people in identifying failure modes of a product or process and planning for its elimination [3]. Each potential type of failure of a product or process is assessed relative to three criteria on a scale of 1 to 10.

- The likelihood that something will go wrong (1=not likely; 10=almost certain).
- The detect ability of failure (1=likely to detect; 10=very unlikely to detect).
- The severity of a failure (1=little impact; 10= extreme impact, such as personal injury or high financial loss).

The three scores for each potential failure are multiplied together to produce a combined rating known as the Risk Priority Number (RPN); those with the highest RPNs provide the focus for further process/redesign efforts.

V. DATA COLLECTION AND ANALYSIS

A. Defects Data

The defects that have occurred in the manufacturing of cable harness are collected over a period of three months and are tabulated here. The defects are plotted in a histogram to get a visual idea of their occurrence and frequencies as shown in Fig. 1.2. The defect values are also represented in the form of a histogram as shown in Fig. 1.3.

The defects have occurred in 11 different parts of the cable harness and therefore the FMEA was carried out for all the 11 items to determine the causes and therefore the Risk Priority Number (RPN). The corrective actions were taken for all of these defects and the improvement achieved were denoted in the form of improved RPN values.

The eleven different items which are causing defects in the cable harness are (1) heat shrink sleeves, (2) Soldering, (3) Connector, (4)ID-Plates, (5)Wire locking, (6)Bush and ring soldered Braid, (7) Sleeve Elaster, (8)Braid, (9)Wire termination, (10) Endnut screw and (11)Cables.
There are two heat shrink sleeves (inner and outer) available over the lug. Fig. 1 shows the picture of heat shrink sleeve on lug.
Fig. 1.9 Connector with RTV filled up.

Fig. 1.10 FMEA for connector

Fig. 1.11 Cable with ID-Plates

Fig. 1.12 FMEA for ID-Plates

Fig. 1.13 FMEA for Wire-locking

Fig. 1.14 FMEA for Bush and Ring soldering

Fig. 1.15 FMEA for Sleeve Elaster

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Fig. 1.16 FMEA for Braids

Fig. 1.17 Wire Termination

Fig. 1.18 FMEA for Wire Termination

Fig. 1.19 FMEA for End Nut Screw

Fig. 1.20 FMEA for Cables

Fig. 1.21 RPN values before and after corrective actions

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<th>RPN After Corrective Action</th>
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Fig. 1.22 Bar chart showing RPN values for problems before and after improvements.

The process flow charts and the checklist which have brought these improvements are listed below.

Fig. 1.23 Process Flowchart for procuring new items.

Fig. 1.24 Process Flowchart for handling new job.

Fig. 1.25 Checklist for Cables

VI. LEAN IMPLEMENTATION

The first towards speeding up the process is to determine the process flow chart. The next step is to determine the manufacturing lead time. Then studying the data will reveal the delay in the process. Lean tools such as one piece flow and Job instruction (training within industry) were applied to reduce the wastage of time and increase the speed of the process.
So, from the above table it is noticed that the manufacturing lead time is 241 minutes or 4 hours, with a maximum braid cutting and bush soldering time of 55 minutes.

B. One Piece Flow

The total time for making one set is 54 minutes. The current batch size is 5 and it was consuming 270 minutes. The shield preparation and braid insertion process was waiting to receive material from bush soldering process. So, this wastage was reduced by decreasing the batch size from 5 to 2.

C. Job Instruction

The testing department had only one technician to do the process of testing the test equipment HP network analyzer 8714ET. Therefore, two more people were given training so that the process will not get delayed due to the absence or non-availability of one of them.

CONCLUSION

The defect analysis and corrective actions have improved the processes by eliminating the defect causing elements. The improvement is easily sustainable and so quality has improved permanently. The FMEA methodology has helped in determining the reliability and finally in ensuring the good reliability of the system. The process flow chart is
drawn and the manufacturing lead time is determined as 4 hours. A lean tool such as one-piece flow was applied to reduce wastage of time. Training within industry was also provided to eliminate unwanted delays in processes.

REFERENCES


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