8D Problem Solving Methodology: Continuous Improvement in Automation Organization

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Abstract. The Eight Disciplines (8D) is a problem-solving technique methodology to identify the root cause of a problem, devise a short-term fix and implement a long-term solution to prevent recurring problems. 8D is a remarkable first step to enhancing Quality and Reliability when the product is defective or not satisfying the customer. The study was conducted in a manufacturing company producing and assembly wire harness. The data was collected for a period of Three months from July 2020 to September 2020, to identify defective percentage of wire harness and they were found to be high at the average rate of 51.39%. In this work the objective was set to investigates quality issues and provides a solution to reduce the rejection of wiring harness mainly in crimping process. In order to achieve this, 8D problem solving technique was used to analyze and solve the problem. Then, Pareto analysis was done to identify vital causes contributing defectives. From the Pareto analysis, it was found that functioning contact crimp condition with percentage 66.67% is the major cause for rejection. Further brainstorming sessions was held to identify the root causes. After the brainstorming session, cause and effect diagram was constructed and it was found to be variation in the that the connector near cable chain is moving area. Thus, the wire assembly with too high radius may caused external force to the wires when machine running with speed and the end of wire may break off when the wire stretched. The suggestions to reduce the rejection percentage were to install mounting bracket prevent wires shaking when machine running and use proper crimp tools. After implementing the suggestion, the total rejection for wire harness particularly contact crimp condition was reduced to 0.93% in December 2020, from average rejection of 66.67%. (3 months data).

1. Introduction

SMEs play a vital role in both developing and developed economies. They are regarded as the backbone of the economy, and they are said to be the leading employer. Their prolonged powers and strengths play an important role in the way to the improvement of a steady and strong private sector-led financial system. The World Bank reported that about 90% of business entities are SMEs. Whereas there could be without a doubt in which the huge companies are embracing and embarking total quality in their trades and businesses, the same could not be regarded of the SMEs. As said by a survey on SMEs, just 20% are
intending for the total quality and in which only one single company has been performing total quality for 5 years, a mainstream of those reviewed supposed that it is simply for large firms and companies [1]. There is a remarkable requirement to tackle such misconception with the intention that they could execute total quality in the activity and their operation. On the other hand, this is easier understood than done as there are a vast range of quality management practices and initiatives which may be complex to implement even for large organizations.

Generally, among the most vital concerns for the SMEs in the automation industry is the elimination of the critical quality defects. Manufacturing Company X is a producer and assembler of wire harness. A concern was raised of defects in the form of wiring harness for the Insulation Resistance JKL Corporation (IRJ) breaking off from its connector due to defective contact crimps. This defect will lead to the manufacturer wasting its resources and time to re-manufacture or rework the products, but it will also contribute to the loss of customers’ satisfaction and trust. Thus, this problem needs to be addressed. Among quality improvement methods that are popular in the automotive industry is the 8 disciplines (8D) problem-solving framework [2]. Under this method, few statistical and quality improvement tools such as fishbone diagram, and Pareto chart are also used. Thus, this a study on how to solve the problem of wiring harness breaking off will be conducted using the 8D methodology of problem solving. For the case study purpose, the wiring harness was selected because the issue was live and occurred many times. There were maximum customer complaints about this part and thus, the problem needs to be addressed quickly.

2. 8D Problem Solving

The 8D model is a problem-solving approach originated during the Second World War by the US Government to address nonconforming materials and later applied by the Ford Motor Company [3]. The 8D process is defined as a structured problem-solving methodology designed to find out the root causes of a problem, devise a short-term fix and implement a long-term solution to prevent recurring problems using a team-oriented approach [4]. In addition to that, the key goal of the 8D methodology is to define the root cause of the issue and to develop containment measures to defend consumers from the problem and to take appropriate steps to protect similar issues in the future. Structure, discipline and operations are the core strengths of the 8D methodology. The methodology is also widely used as a complaint handling mechanism for the variations of the automation industry and other industries [5]. The method begins with the plan step and proceeds through the other steps in the clockwise direction. Figure 1 depicts the 8D problem solving methodology processes.
3. Production Steps of Cable Harnesses

Generally, a harness refers to a set of bonded wires which are used to transmit signals or electrical power in electric and electronic systems. While a wire harness is an assembly of electrical cables which is used in automation connects electronic components, control units, sensors and actuators to meet the quality standards of products, harnesses must be tested accordingly. The production and testing methods for wiring harness is as per Figure 2.

**Step 1: Wire Cutting and Terminal crimping**
The first step of this process is the wires are first cut to the desired length, the ends of the wires are trimmed to expose the metal (or core) of the wires that are fitted with the specified terminals.

**Step 2: Subassembly**
In this phase, all manual operations are delivered like the crimping of more than one wire in the same terminal, twisting, soldering, shrinking, thermal tube cutting, double crimping, and splicing.
Step 3: Module Assembly
In this process, the cables are assembled and clamped together on a special workbench, a terminal block (assembly board) or a conveyor, according to the design requirements from customers, to form a cable harness.

Step 4: Electrical Testing
The principle of this step is electrical functionality of the cable harness is tested by means of continuity test on which is the checking of an electric circuit to see if current flows. Continuity checking is done by positioning a small voltage over the selected path. After electrical testing, the wiring harnesses are subject to final dimensional inspection, passed harnesses fitted in secure sleeves, conduit and assemble on automation machines and thus to be ready for shipment.

4. Methodology
The overall aim of the research study was to elimination of the critical quality defects such as wiring of IRJ break off from connector at customer end due to the weak contact crimp during the manufacturing and assembly process of a wiring harness. As immediate protection to the customers and quick resolution of the problem was required, the 8D framework was estimated most appropriate.

4.1 Recognize that a Problem Exists (D0)
The first step of this methodology is to make plan to solve the problem and determine its basics. Besides, the 8D is a fact-based problem-solving process involving specialized skills and a culture that favors continuous improvement.

4.2 Form the Cross-Functional Team (D1)
In this step, a team of selected members with adequate knowledge about the process and product is established. This is because, the team members know about where the problem occurred, why the problem occurred, and they have experience in the technical disciplines needed to solve the problem and taking the action. Therefore, the team have been 4-10 members with all the necessary knowledge and experience.

4.3 Describe the Problem (D2)
In this step, the problem to be solved was defined and the specifications of the problem with all the necessary parameters are clarified to the team. The team member first analyzed the problem and how long it has been. It was established that the problem is occurs in the wiring harness assembly. The problem is wiring of IRJ break off from connector at customer end as the IR terminal motor alarm during setup.

4.4 Implement and Verify Short-Term Corrective Actions (D3)
The objective of this step is to identify an interim containment action (ICA) or interim solution while the subsequent steps of root cause analysis and problem solution formulation are carried out. The ICA is a temporary action to protect the customer from the problems on the spot when the problem has been occurred. This interim action will be removed once a permanent action is put in place. Here we know that the wiring of IRJ break off from connector when they setup. The short-term action is where the team inform the customer to set aside the defective pieces while waiting for replacement pieces.

4.5 Identify the Root Causes (D4)
Even though the short-term action, that is to recall and replace the defective pieces has been implemented, the root cause of the problem must be identified so that permanent action to eliminate the problem can be
formulated. A few methods were employed such as root case identification through brainstorming technique and fishbone diagram analysis. The findings were then verified against data collected. In this study, it was found that the machine assembly method with too high radius caused external force to the crimp cable when the machine was running with speed. This is the root cause to the problem that was discovered using the 8D process.

4.6 Address the Corrective Actions (D5)
The main objective of this step is to select the best permanent corrective action to exclude the root cause and remove the leak permanently by applying best cure. The corrective action proposed is to stabilize the crimp cable during production to minimize shaking. The designer designs and installs mounting bracket to prevent wires shaking when machine was run.

4.7 Implementation of Corrective Actions (D6)
In this step, the main purpose is to plan, implement and validate the selected permanent corrective actions. Before, the implementation and validation of the permanent corrective action, the implemented interim corrective action or temporary actions, namely recalling and replacing the defective items, were removed from the whole production process.

4.8 Prevent the Reoccurrence of the Problem (D7)
This step involves update all the necessary documents, systems, operations and procedures involved with the new permanent corrective action to prevent recurrence for future similar problems.

4.9 Congratulate the Team (D8)
Lastly, is the completion of the project and the relevant documentations in the 8D quality improvement process report and congratulate team for a job well done.

5. Finding and Discussions

5.1 Data Collection and Data Analysis
For preliminary analysis, the data for quarter three, namely rejection data for wiring harness from July 2020 until September 2020 was collected as per Table 1. To identify the major defect, Pareto analysis was performed. Based on Table 1, the total quantity for wiring harness produced for the period is 216 unit, and for each month have 72 units. Table 2 also shows the acceptance and rejection data of wiring harness.

| Month     | Q3       | 2020 Year End |
|-----------|----------|---------------|
|           | Jul | Aug | Sep | End  |
| Total Unit|    72|    72|    72|   216|
| Accepted  |    40|    28|    37|    105|
| Rejected  |    32|    44|    35|     111|
| Rejected Unit | 32 | 44 | 35 | 111 |
| Acceptance | 55.56%| 38.89%| 51.39%| 48.61%|
| Reject     | 44.44%| 61.11%| 48.61%| 51.39%|
Based on the lot acceptance rate and rejection rate of data analysis for wiring harness, in Figure 3 shows that the highest rejection unit was in month August which is 44 unit (61.11%), following with September is 35 unit (48.61%) and July is 32 unit (44.44%). The total rejection unit for quarter three is 111 unit (51.39%).

![Figure 3. Acceptance Rate and Rejection Rate Pareto Analysis](image)

The rejection data was further analyzed based on the types of defects which are parts’ crimp condition, wiring, wire pull, and lug orientation. Data of the types of defects is as per Table 2. The total number of defects for part crimp condition are 74 units, wiring is 24 units, wire pull is 8 units, and lug orientation is 8 units. Therefore, part crimp condition was chosen for the improvement plan as the part have the highest open defect compared to others.

Table 2. Rejection data and Defect wise rejection data for Wiring Harness

| Type of Defect     | No. of Parts Rejected |
|-------------------|-----------------------|
| Crimp Condition   | 74                    |
| Wiring            | 24                    |
| Wire Pull         | 8                     |
| Lug Orientation   | 5                     |
| Total rejected    | 111                   |
5.2 Problem Description
The average percentage of rejection was about 51.39% and 111 wiring harness have defects and 74 defects (66.67%) which was mainly due to crimp condition no good where defect is observed at production. The problem occurred when wiring of IRJ break off from connector at customer end after the IR terminal motor alarm during setup as shown in Figure 5.

Figure 5. Wiring of IRJ Break Off from Connector
5.3 Short-Term Corrective Actions
All the parts potentially affected by this problem were identified and their locations were pinpointed. All the parts at customer side as well as at supplier side were put on hold. Lots already on the line were called back to the stores.

5.4 Identify the Root Causes
To identify the root causes of occurrence of defect and to get deeper understanding of probable causes for the occurrence of problem brainstorming technique and fishbone diagram analysis is used [7-9]. The causes identified for the occurrence of problem are as per Figure 6. While based on the discussion, descriptions of the problems are further analyzed as per Table 3.

![Fishbone Diagram](image)

**Figure 6.** Fish bone diagram for the root causes of defect

| Description                                |
|--------------------------------------------|
| **Material**                              |
| • Wires and connectors confirmed to be using the correct specifications. |
| **Man**                                   |
| • All wiring technicians are certified and qualified for the wiring job. |
| **Methods**                               |
| • Wiring technician perform pull test after crimping. |
| • Machine assembly method with too high radius may caused external force to the crimp cable when machine running with speed. |
| **Working environment**                   |
| • Machine assembly area are well lighted up for all technicians to perform their job accordingly. |
| • Wire at moving area do not have guide to prevent force to the wires. |
| **Tool**                                  |
| • Wrong crimping tools used.              |

Based on Table 3, the summary is that the connector near cable chain is moving area. Thus, the wire assembly with too high radius may have caused external force to the wires when machine running with speed and the end of wire may break off when the wire stretched. Visual checking performed after wire break off and crimp condition not stronger found as shown in Figure 7 below.
5.5 Corrective Actions
Following Table 4 are corrective actions recommended in order to avoid the occurrence of defects.

Table 4. Description of corrective actions

| Corrective Action Taken                                                                 | Responsibility                                                                 |
|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| 1. To install mounting brackets to prevent wires being shaken when machine is running  | Production Manager and Section Head from Control Manufacturing Department     |
| 2. Make sure all the wire crimp's are in good condition. (Visual Inspection)           |                                                                               |
| 3. Briefing the wiring team for the wires harnessing tidiness.                         |                                                                               |
| 4. Use proper AMP crimp tool (exclusive for small pin) instead Pro’s Kits small crimp tool for better crimping. |                                                                               |

5.6 Implementation of Corrective Actions
Based on analysis, an upper specification by install mounting bracket and proper AMP crimp tool (exclusive for small pin) was applied to the wiring harness assembly as a permanent corrective action. A significant reduction in shut-off failures from 66.67% to 0.93% which decreased from 2 defects in October to 0 defects in December by Quarter 4 was observed after the improved condition, as shown in Figure 8.

Figure 8. Pareto Analysis after Improved Condition
5.7 Prevent the Reoccurrence of the Problem
Following preventive actions were recommended and implemented to avoid the reoccurrence of defects. The new methods become standardized in practice and lessons learned are documented through:
i. Designer update new connector and new mounting bracket in the latest design file (Figure 9).
ii. Training of cable-crimping technician on the new used tools and on the new revised WI.
iii. Training of maintenance technicians on the new revised processes and tool release process.

![Figure 9. Updated new mounting bracket](image)

6. Conclusion
The 8D methodology used in this paper is an excellent tool for solving the problem as well as for preventing defects from reoccurring. The results of the case study show that the methodology is effective and it provides systematic guidelines to the suppliers to reduce internal as well as external rejections. After implementing 8D methodology the rejection level for the issue of wiring harness and total rejection percentage reduces to 0.93% from 66.67%. After consistent monitoring the supply of wiring harness for next 3 months, no quality issues were observed for wiring harness. So, the company declares that the 8D activity is closed for the wiring harness issue.

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Acknowledgments: The authors wish to thank the Ministry of Higher Education (MOHE), Malaysia, for their financial support of this study through Fully Integrated Students Entrepreneurial Mapping & Entrepreneurial Knowledge Management System (FISEM) Grant, 9007-00039.