Cost of Quality Reduction in NEMA Coils Assembly Lines

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Abstract

The Cost of Quality (COQ) is a proactive cost associated with a prevention investment needed to ensure requirements are met to avoid nonconformances (NC). There are two components to ensure companies meet requirements: internal costs and external costs. The internal costs occur prior to delivery of goods and services, and external costs occur after delivery or shipment. In this paper, the focus is on COQ reduction for a production line in a manufacturing facility. The NEMA Coils area is one of the top assembly lines for the company. Improvement projects were needed in order to reduce recent influx in NC and to accommodate high demands at both short-term and long-term horizons. Root cause analyses were carried out and, as a result, the top 5 defects were determined to be associated with incomplete molding, incomplete winding, wrong stamping, wire split, and bad winding. In addition, two of these defects contributed up to 50% of the total non-conformances found at these assembly lines. A time study was performed in NEMA coils and process changes were carried out which resulted in new assembly lines layout. After implementation line capacity increased by 25%, the downtime was reduced by 20%, and the COQ was reduced by 34%.

Introduction

According to the American Society for Quality (ASQ), the Cost of Quality (COQ) is the total of the cost incurred by investing in the prevention of nonconformance to requirements, appraising a product or service for conformance to requirements and failing to meet requirements [1]. The internal failure costs occur prior to delivery of shipments. The external failure occurs after delivery or distribution, which includes processing customer complaints, customer returns, warranty claims and product recalls.

Background

The topic is associated with the reduction in the Cost of Quality in the assembly lines of a manufacturing facility. In order to protect intellectual property of the company and follow its policies, the name of the company will be Electrical YBO. The project was executed in the NEMA Coils area, one of the most demanding lines for the company. The NEMA Coils have different sizes and demand received for both short-term and long-term horizons are very high, thus management would like to ensure this is prioritized. In order to keep the production line with the highest performance, it was important to look for potential areas of improvements.

Problem

After the recent influx in the number of non-conformances coming from these lines, further investigation was required to understand the 'current' state. After investigation, action plans were evaluated and subsequently implemented to meet the objectives. The objectives of this project were to maximize line capacity by 15% in NEMA Coils Assembly Lines by April 2022; minimize downtime by 10% in NEMA Coils Assembly Lines by May 2022; and reduce COQ by 20% in NEMA Coils Assembly Lines by May 2022.

Methodology

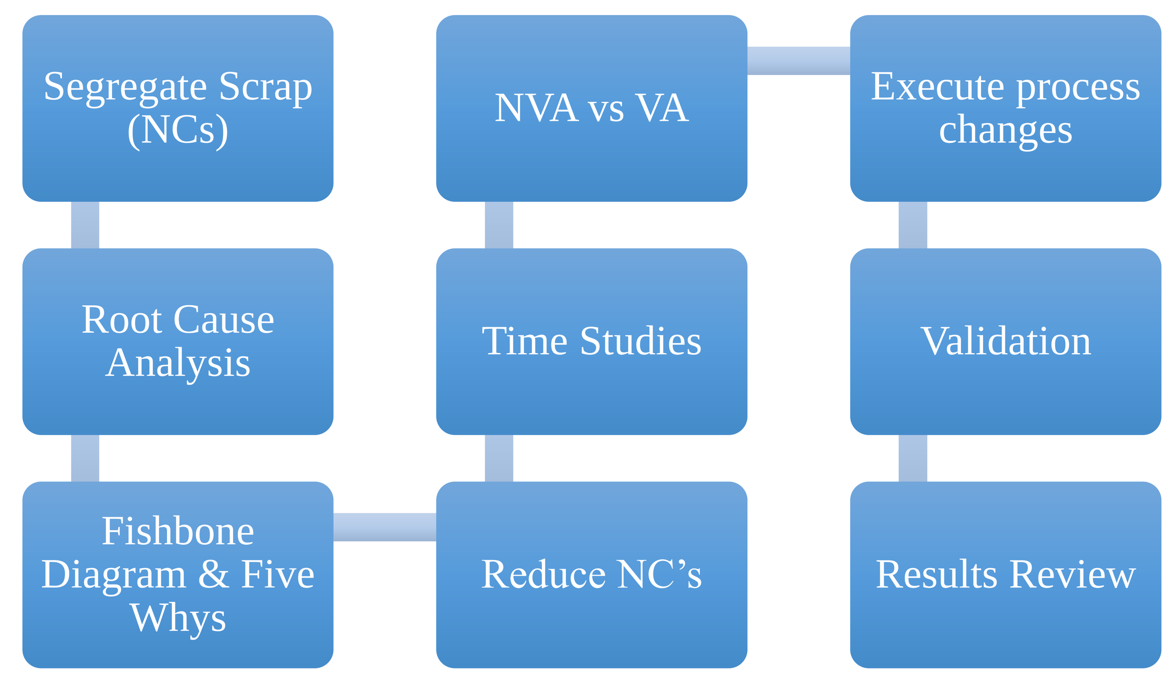

Figure 1 shows the types of defects found in NEMA Coils Assembly lines Sizes 1 & 2. The major contribution to the scrap generation was the incomplete molding and incomplete winding.

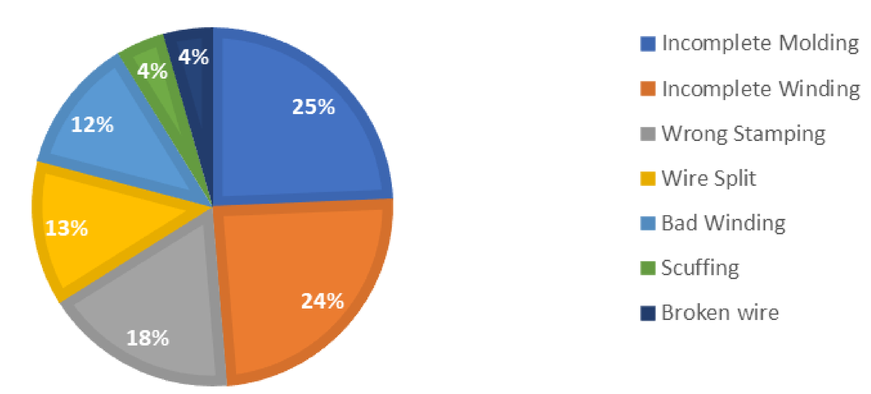

Figure 1
Type of defects found in Nema Coils Size 1 & 2

The fishbone diagram tool was used to determine the root cause of the defects [2]. In Figure 2 and Figure 3 are shown the fishbone diagrams generated for incomplete winding and incomplete molding, respectively.

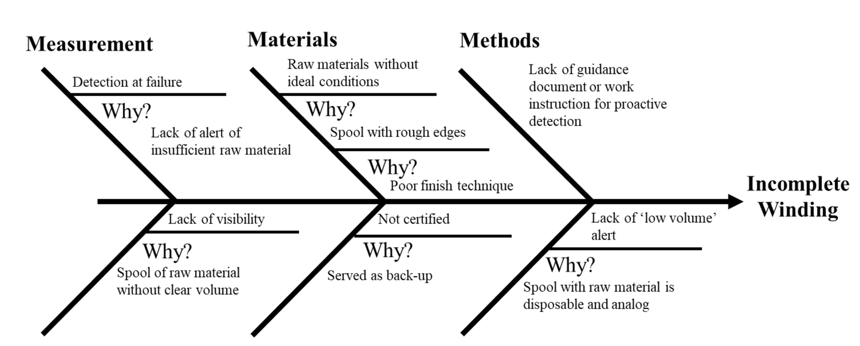

Figure 2
Fishbone for Incomplete Winding

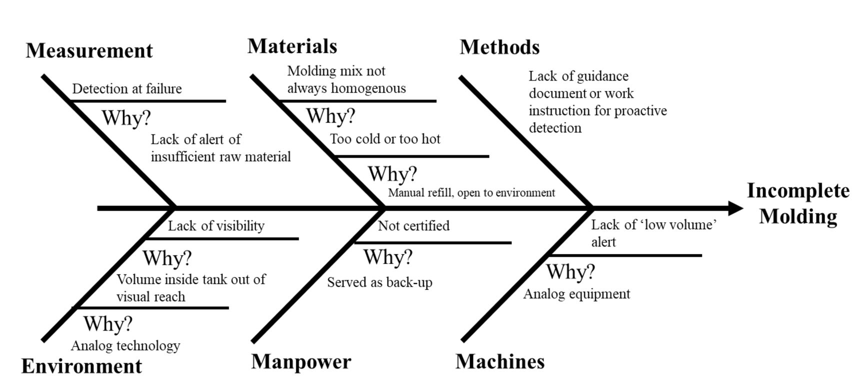

Figure 3
Fishbone for Incomplete Molding

For the incomplete winding defect, it is evident that scraps occur after failure and there is no alert or notice that raw material is running low until it completely fails. The high runners were determined using Pareto Principle also known as 80-20 rule. On this approach, 80% of sales come from 20% of products. In order to implement an effective method to reduce or eliminate the scrap for the Nema Coils Size 1, tables were designed containing roll weight and number of spools that could be made with that amount of wire. These tables that were placed at the station are for operators to have guidance of the number of units to be produced with the quantity of raw material available at the time of running new units.

Root cause analysis for incomplete molding showed that the main contributor for this defect was lack of work instruction for proactive detection and or alert that raw material is running low. After further investigation, the team found a weight sensor that was able to fix the issue and easily detect or show the operator when the tank was running off molding mix, an issue that contributed to incomplete molding. The sensor was installed and now every time the tank is running low on mix, it will display a red light and a beep sound. The new process was documented and validated, and operators are trained and certified to the new process.

Table 1 shows Running Time, Capacity and Downtime before the project and any process improvement effort. The overall available time per assembly line is 480 minutes and current capacity is between 70 to 80 percent, and the daily downtime is up to 28% for Size 5. In Table 2 presents the time study performed in Nema Coils Assembly Line 1. Every step in the procedure is shown below and there are designated columns for Value Added (VA) and Non-Value Added (NVA) activities. There were additional time studies performed on other sizes that provided similar data with VA and NVA activities. The core team evaluated the waste and eliminated the NVA when possible [3]. The approach included new layouts and required to update the work instruction and modification to workstations.

Table 1
Pre-Implementation state of assembly lines size 1 thru 5

Nema Coil Line	Available Time [minutes]	Daily Running Time [minutes]	Current Capacity [%]	Daily Downtime [%]
Size 1	480	390	81%	19%
Size 2	480	375	78%	22%
Size 3	480	375	78%	22%
Size 4	480	360	75%	25%
Size 5	480	345	72%	28%

Table 2
Results of Time Study Performed in Nema Coils Size 1

Step	Cycle Time [seconds]	Value Added [seconds]	Non-Value Added [seconds]
1	0:00:15	0:00:10	0:00:05
2	0:00:06	0:00:06	0:00:00
3	0:00:04	0:00:04	0:00:00
4A	0:00:31	0:00:31	0:00:00
4B	0:00:07	0:00:02	0:00:05
5	0:00:05	0:00:00	0:00:05
6	0:00:04	0:00:00	0:00:04
7A	0:00:10	0:00:10	0:00:00
7B	0:00:05	0:00:02	0:00:03
8	0:00:03	0:00:00	0:00:03
9	0:00:11	0:00:07	0:00:04
10	0:00:04	0:00:00	0:00:04
11	0:00:02	0:00:00	0:00:02

Results and Discussion

The updated work instruction for the winding process and the implementation of binders with tables at the workstations resulted in drastic improvement and the reduction of NC due to incomplete winding. Before process improvement and pre-implementation, the NEMA Coil Assembly Line Size 1 and 2, was generating 24% of scraps, the AP went from implementation to EM phase and during this phase the count of nonconformances due to this defect is down to 0%. For incomplete molding defects, the work instruction was updated, and a new sensor was installed at the workstation. Pre-implementation, the number of scraps due to this defect was 25%, the AP is now in EM phase and the number of nonconformances due to incomplete molding reduced by 15%. Combining both process changes the COQ for NEMA Coils assembly lines was reduced by 34%, which is 14% more than its initial target. The line capacity before process changes was approximately 70% and the downtime was up to 25% depending on the assembly line size. After process improvements, which included the new layout, updated work instructions, and reduction in nonconformances, all of this contributed to a line capacity increased up to 95%, and the downtime was reduced on average to 5%. The daily output has increased which has increased coverage, days of supplies (DOS) and the stock equation.

Conclusions

The objectives of this project were accomplished. The NEMA Coils Assembly Lines COQ was reduced by 34% ($15K/annually). The line capacity was increased by 25%. The downtime was reduced by 20%. For root cause analysis, lean six sigma tools like the fishbone diagram and the Five Whys were helpful to determine the root cause for defects. In addition, time studies were supportive to determine VA and NVA activities. Also, the use of pareto principle supported the focus for selecting the high moving catalogs.

Future Work

These assembly lines are the high runners with high demand at both short-term and long-term horizons. There are similarities between the core lines like sizes 1 to 5, but also with larger sizes like size 29, the work done for this project can be leveraged for future projects and to implement similar improvement ideas.

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References

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