Potting Process Improvement for Inductors

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Abstract — *During the last 20 years, X Aerospace Company has produced enormous gains due to a relentless focus on process in manufacturing, engineering and research and development. These margin increases came from many incremental and continuous improvements in all aspects of its business [1]. Continuous improvement has important benefits for corporate capital and cash flow requirements. The main goal for this project was to identify the main problem-taking place during potting operation, for an inductor that was not able to meet dimensional specifications. This project will use tools and methods adapted from lean, quality and statistical process control practices. The project led to a reduction of potting dimension out of specification condition by 100% and increased manufacturing yield by 13%. This huge opportunity was developed under the Define, Investigate, Verify, and Ensure (DIVE) cycle methodology, to identify real root causes affecting process yield and leading to unnecessary scrap and rework expenses.*

Key Terms — *DIVE, Lean Six Sigma, Opportunity, Process Improvement, Quality, Yield.*

PROBLEM STATEMENT

During the process conducted for inductors in X Aerospace Company, associates performing potting operation had problems meeting dimensional specifications for several inductors, causing critical to quality issues.

Research Description

This project has been outlined with the purpose of analyzing current potting process for inductors, in order to determine key factors negatively affecting the operation; thus increasing potting operation yield and reducing scrap and rework expenses.

Research Objectives

The objectives of this design project are stated below:

- Reduce potting dimension out of specification condition by 50%.
- Establish Cost avoidance strategy with new fixture implementation.
- Minimize internal defects (SRR).

Research Contribution

As a corporation, X Aerospace Company is focused on identifying every opportunity to improve processes. The company believes continuous improvement has important benefits for cash flow and corporate capital requirements [2]. Upon improving tool design on the actual tool used during potting operation, the process will increase its yield, minimize internal defects and will avoid cost associated with rework and scrap metrics.

LITERATURE REVIEW

Manufacturing companies are focusing on implementing those tools and methods that are easily grasped, learned and applied, it is the development of an appropriate context in which the tools are used that is vital to the organization success. An organization's leader creates through their ongoing support and consistency on applying continuous improvement tools. Leadership creates a culture that embraces learning and continuous improvement to the company associates [3]. Continuous improvement has important benefits for corporate capital and cash flow requirements.

The opportunity analyzed on this project was effectively achieved under the Define, Investigate, Verify, and Ensure (DIVE) cycle methodology, to identify real root causes affecting process yield and leading to unnecessary scrap and rework expenses.

DMAIC and PDCA are similar to DIVE method; examples of team based problem-solving methods. These methods define a cycle of detective and corrective actions to solve problems. Methods mentioned, tend to differ in their focus from other quality methods, which drive their main focus into continuous improvement rather than reactive problem solving. However, many of these methods use similar tools. The importance is that all methods are documented and taught so they become a common method used by a group of people that allow associates to contribute into improvements or problem solving activities.

During DIVE cycle methodology, the first step is to define. This phase consists of validating the problem and really understanding the problem before any action is taken. The second step is to investigate and it consists on strictly focusing on the problem at hand and search for the point of occurrence and real root causes. Third step is to verify, consisting of performing tests into selected root causes and testing potential solutions after performing robust group brainstorming. The last step for DIVE problem solving method is ensuring. This step implements solutions, track products and process performance in order to monitor improvements, as well identifying new opportunities. This tool guides the setting for strategic priorities and establishes processes to translate strategies into actions. Also sets up a feedback mechanism for assessing improvement and performance [4].

METHODOLOGY

In order to successfully implement the proposed goals, project methodology section will identify and describe each metric. Being ACE the operating system of X Aerospace Company, the problem solving method used for this project was D.I.V.E, which is an acronym for Define, Investigate, Verify and Ensure phases. These problem-solving are used to drive relentless root cause analysis and mistake proofing to prevent recurrence.

Define

Defining phase consists of validating the problem with gathered customer data or process data, information discussed through quality clinic process charts in order to understand the problem before any action is taken. Through QCPC's, data identify any "turn back" taking place during the process to assign improvement efforts. Groups are organized identifying people involved on the process and ensuring they have the knowledge necessary to uncover different aspects. This action decreases risk of not identifying all areas and never finding the real solution to the problem. Is important to assign tasks to the each group individual, stating common purposes and goals, identifying roles for team members, identifying conflict resolution strategy and brainstorming with team members stating ideas and placing them in visual aids.

Investigate

Investigate phase concentrates strictly on the problem at hand and follows the logical path. Logical path often includes point of recognition, point of occurrence and point of occurrence and root causes. During this investigation team performing the study must use feedback data or process information found in a relentless root cause analysis that will invoke a fishbone analysis, five why's techniques and quality metrics.

Verify

Verifying step involves testing for root causes and testing potential solutions developed using brainstorming and prioritizing ideas by engaging a group of people. Verify phase includes applying mistake proofing concepts, which involve moving from inspecting for errors after they have occurred to analysis and control of the processes that cause errors, to finding and eliminating errors at their sources. This step will end when the implementation of mistake proofing and control plan is developed.

Ensure

Ensure step includes implementing solutions and tracking product and process performance to monitor improvements and identify new opportunities. Ensure also involves documenting and sharing the solution publicly as giving recognition to the team success.

RESULTS AND DISCUSSION

This section contains the problem statement analysis and approach to achieve the project objectives and their respective results using DIVE strategy.

Define Phase

During defining phase a meeting was held with associates involved directly or indirectly with the process in order to create a group with different point of views to decrease the risk of not identifying all possibilities within variables.

Project Scope

The project scope is to improve inductor-potting operation on the cell.

Problem Statement

Operators performing potting operation had problems meeting dimensional specifications required by customer and identified as critical to quality. The bobbin assembly is supposed to be fixed into a housing and a cover plate. The operator enter the bobbin assembly into a housing and with the help of a fixture, he would attach the cover plate (top part). Inductor detailed process for potting is explained through a process flow chart.

Team Members

- Mario Correa (Mfg. Eng / Team Leader)
- Harry Vega (Mfg. Eng)
- Jose Castellar (Assembler Operator I)
- David Rodriguez (Mfg.Eng.Sup)
- Oscar Santiago (Mfg.Eng.Sup)
- Francisco Pellot (Quality Engineer)

Team Tasks

1. Clarify roles of team members
2. Sequence tasks
3. Define common purpose and goals
4. Implement system for evaluation
5. Use Brainstorming for RRCA.

To provide an overview on how the process behaves, a process flow chart was designed shown below in figure 1. This process flow chart will provide critical information for the project scope and project boundaries.

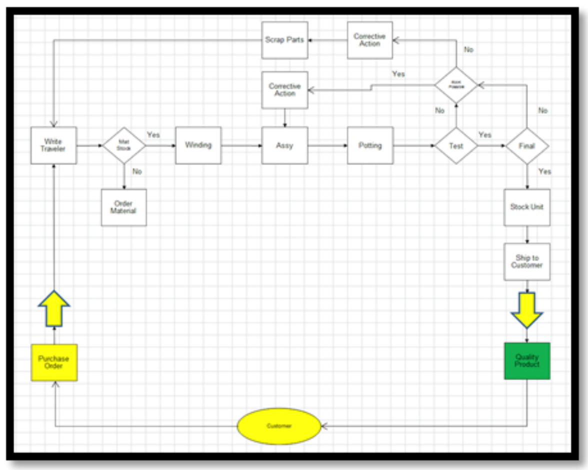

Figure 1
Process Flow Chart

Once a project scope was established and process flow chart was determined, as a team we gathered all data discussed monthly through QCPC's to begin the analysis. Presented in figure 2, data associated with dimension defects for the inductor. This data includes the amount of defects on inductors and the types of defect found.

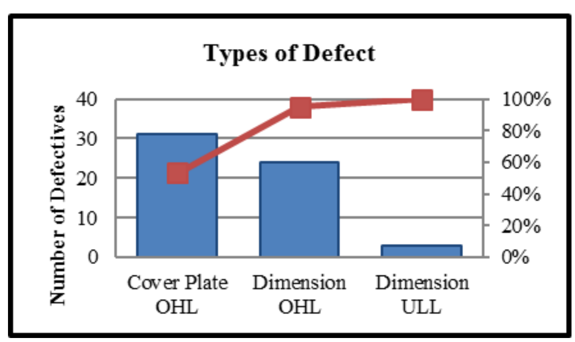

Figure 2
Types of Defect

Identifying all possible defects that occurred during potting operation associated with dimension was required to comply with critical to quality metrics stated by drawing and required per client. Analyzed data was extracted from quality charts available for months: March, May, June, July, Aug and Sept in which there was demand for affected inductors.

The pareto shown above in figure 2, helped identifying major offender type of defect during operation. The type chosen, as our biggest offender was "Cover Plate OHL", if we solve all or most of the problems with Cover Plate OHL, it could affect some of the problems observed in Dimension OHL and Dimension ULL as well.

Investigate

During investigation phase several Ace tools were required, in order to determine a possible root cause. Process information in a relentless root cause analysis (RRCA) will need to capture and organize the team ideas of potential contributing factors to a problem. As a brainstorming tool we used fish bone analysis discussed below in figure 3, to identify and prioritize potential factors contributing to the clearly defined problem. This tool will help the team in order to push beyond symptoms to uncover potential root causes and it also ensures that no major possible cause is overlooked [5].

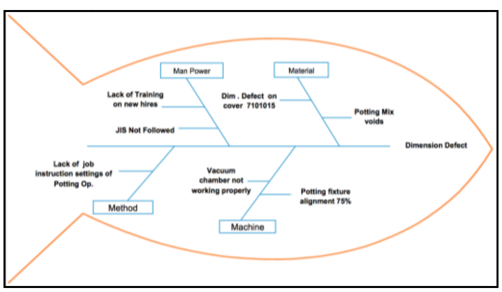

Figure 3
Fish Bone Analysis

Fish bone analysis was categorized into four sections: Man power, Material, Method and Machine. As our head of the fish we selected dimension defect to represent the main problem. The group decided to analyze the major possible causes generating this dimension defect, which the fish bone analysis identified as a common variable appearing in method, material and machine sections. This dimension defect variable could be controlled and represents ¾ parts of our problem stated during figure 3.

During our process to determine a possible root cause, the group analyzed all possible variables causing the defect and understands that cover plate needs to be in control with the other components of bobbin assembly and housing. We decided to establish a 5 Why Diagram to explain why the inductor defect is taking place. This diagram will prevent the team from being satisfied with superficial solutions that won't fix the problem in the long run.

5 Why's Diagram

1. Why the inductor had a defect?
   Because the unit was not complying with the drawing specifications.
2. Why the inductor does not comply with drawing specifications?
   Because the unit was not assembled correctly.
3. Why the unit was not assembled correctly?
   Cover plate was not fixed with the tooling required and placed flushed against the housing.
4. Why the plate is not flushed against the housing using the required tooling?
   The required tool only has control of 75% of the top cover plate.
5. Why the tools are not working perfectly?
   Because tools need a better design to eliminate defect created by not having a proper fitment or cover plate not being flushed against the housing.

Defined Root Cause

During Potting Operation, operators weren't able to establish a 100% horizontal finish between the inductor housing and cover plate; creating a defect during potting operation. Fixture held only 75% of unit in place, leaving the other 25% prone to risk. When potting was finally applied, unit potting will cure unevenly as shown in figure 4.

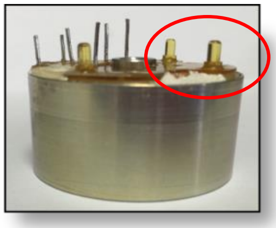

Figure 4
Inductor Cover Plate OHL

Verify

During verifying phase engineering team performed a containment action to aid the fixture on assembly process and subsequently, prevent movement while unit is curing at oven. Containment was to assign a Teflon piece in order to assist a determined position on the current fixture until the supplier delivered new improved fixture. This modification will determine if the root cause established during investigation phase will eliminate the defect, taking place during potting operation.

The original fixture is presented in figure 5. This fixture is only capable of controlling ¾ parts of the inductor top part cover plate. The containment for this original fixture will provide an extension in order to control the top part entirely.

Figure 5
Assembly Fixture

The Teflon aid was used for five inductors assembly process taken as engineering sample, showing good results. The top part was better controlled against the housing. After the unit is assembled it must continue its process to the potting operation which incurs in filling the inside housing with a potting mix and allowing the unit to cure at oven for few number of hours.

First Time Containment

Since a good feedback was obtained, engineering decided to apply this containment for all assembled inductors until the new fixture was received and validated. The yield for inductors, presented in figure 6, increased by 9% from March to May and by 1% from May to June with the aid being implemented during final days of March.

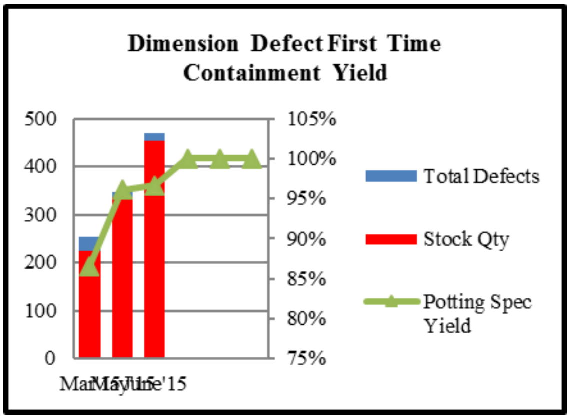

Figure 6
First Time Containment Yield

The yield for inductors, presented in table 4.2, increased by 9% from March to May and by 1% from May to June with the Teflon aid. This tested robust solution aid is shown to affect the proven dimension defect that was affecting the critical output.

$$Yield = \frac{Inductors\ out}{Inductors\ In}(100\%) \tag{1}$$

Consequently, a delta run for validation once the new fixture arrives was issued on three separate orders. Once the quality department complete validation for this three orders, work instructions for all affected inductors will be updated including new fixture and new assembly instructions.

Ensure

During ensuring phase is important being able to monitor the possible defects still occurring with new fixture implementation. This process would take place every week during meetings held by quality department between process supervisor and manufacturing engineers. During these meetings the group will analyze top defect hitters for each cell using QCPC gathered data.

Engineering team was able to establish a horizontal finish with new fixture implementation shown in figure 7, increasing 25% of control with the additional pin modification, between inductor housing and cover plate. The cover plate is completely stabled thus aligning the coil assembly perfectly.

Figure 7
Assembly Fixture 2.0

For reference purposes, an inductor is shown in figure 8 presenting the unit with a perfectly flushed cover plate and housing.

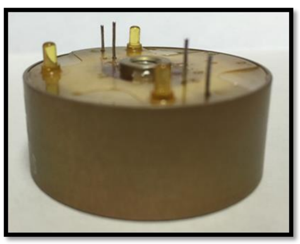

Figure 8
Inductor

New Fixture Implementation

Once the fixture was received during final days of July and given to engineering team, delta run was issued. During delta run, units were achieving an excellent yield with the fixture being designed to engineering specs; taking into consideration all variables that could produce a negative effect. During the containment inductors yield for months of March through June, increased about 10%. Surprisingly, during months of July through September dimension defect yield had increased an extra 3% with the new fixture design, achieving a perfect yield (100%) for this defect. In figure 9 the results are explained from months of March through September to visually represent improvement once the FXT was introduced through the assembly process, affecting potting operation.

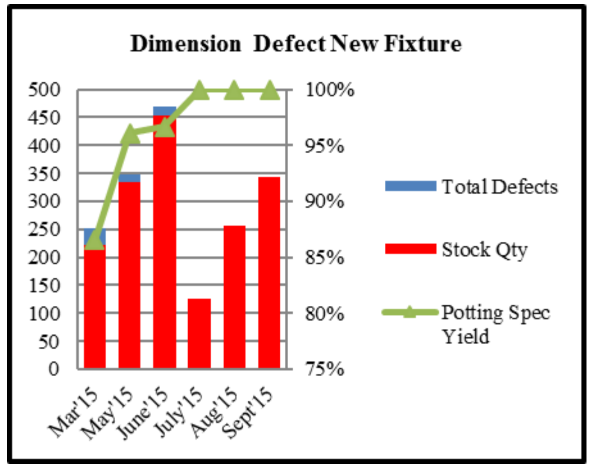

Figure 9
New Fixture Yield

Financial Results

Upon these positive results detailed in figure 9, finance department were incredibly satisfied with the opportunity the group had positively affecting potting operation. The group had to make an investment of $1.25k to buy the initial 30 new fixtures. This investment would have an impact on monthly savings in terms of productivity. Monthly saving in productivity equation is explained below.

$$\boldsymbol{Monthly\ Saving\ Productivity} = \frac{\boldsymbol{SRR}}{\boldsymbol{Total\ Months}} \quad (2)$$

If we divide the average of Scrap, Rework and Repair (SRR = $8,805) presented in figure 10, during months of March through June (3 months) we obtain a total cost of $3000 the company has to invest if the defect is still present.

$$\boldsymbol{Monthly\ Saving\ Productivity}\ (\$) =$$

$$\frac{(\mathbf{5,076}) + (\mathbf{1,790}) + (\mathbf{1,939})}{\mathbf{3}} = \mathbf{2,935} \approx \mathbf{3}\boldsymbol{k} \quad (3)$$

Since we eliminated 100% of Cover Plate Over High Limit defect during potting operation, the company will be saving monthly around $3,000 in terms of productivity.

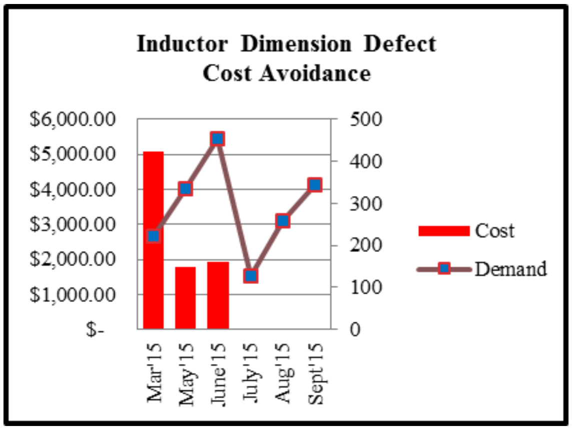

Figure 10
Cost Avoidance

Total payback for the implementation of new fixture is in about ½ months. This payback is favorable due to process improvement requirements from X Aerospace Company mechanical division.

$$Payback = \frac{Investment}{Monthly\ Saving\ Productivity}$$

$$Payback = \frac{1.25k}{3k} = 0.41\ Month \approx {}^{1}/_{2}\ Month \quad (4)$$

Mistake Proof

The group developed several mistake proof actions to prevent mistakes before they occur. Our fixture design provides a mistake proof level II since the operator needs to assemble the bobbin assembly into the housing and fix the cover plate with the new fixture. This process could not be achieved without the help of this tooling, thus the importance of removing the old fixtures from the process. Engineering team was in charge of training associates performing the operation to discuss the improvements.

Action Item	Owner	Due Date	Mistake Proof Level
Redesign Existent Fixture	D. Rodriguez	4/24/15 – Completed	N/A
Obtain Quotation from suppliers	H. Vega / D. Rodriguez	4/30/15 – Completed	N/A
Containment (Teflon Piece)	M. Correa / D. Rodriguez	5/1/15 – Completed	III
Implement New Fixture and Train Operators	M. Correa	6/29/15 – Completed	II
Ensure Old FXT's are replaced by New FXT's	M. Correa / H. Vega	7/10/15 – Completed	N/A
Change JIS instructions to reflect read across other assemblies part #'s.	J. Hoffmann	10/30/15 – Completed	III

Figure 11
Mistake Proof

Conclusions

As part of this project DIVE framework and its problem solving tools helped providing a reliable method to analyze problems in a structured manner, identify "real causes" and develop and implement preventive actions that can sustain over time to keep the problem from reoccurring. As a result of this project, team was able to reduce potting dimension out of specification condition and internal defects with the implementation of the newly designed fixture. The yield for this potting operation was 87% before the implementation, and gradually increased to a 100%. Company will save around $3,000 in monthly productivity. Also, total payback for the initial investment on new fixture implementation would be around ½ months. This payback is favorable due to process improvement requirements from X aerospace company mechanical division.

References

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