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Reduction of paint line defects in shock absorber through Six Sigma DMAIC phases

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Abstract

In modern era, the Six Sigma tools and techniques have been implemented in various manufacturing sectors, which strive to ameliorate continuous improvement in achieving less variation, cost and high quality of end products. This case study narrowly focuses on reduction/elimination of two imperative responses in spray painting process producing shock absorbers, namely peel off and blisters using the Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) approach that highly impacts quality at customer end. The define phase rolls out the tools such as Pareto chart, voice of business (VOB) and project charter which identifies pretreatment in the spray painting process as the critical stage. The measure phase reveals the continuous assessment of spray painting process, with intense brainstorming sessions the imperative responses were culminated as peel-off and blisters. In analyzing phase, the vital root causes that impact the responses were identified as cleaning temperature, phosphate temperature and phosphate pH (power of Hydrogen) by using cause and effect diagram and Likert scaling. The improve phase concentrates on optimizing the vital root causes which impact the responses by using Taguchi robust design approach. The L27 orthogonal array (OA) had been constructed with three factors and levels, results of experimentation had been analyzed by using Analysis of Variance (ANOVA) and multivariate regression which identifies the condition of optimality on peel off and blisters in the pretreatment process. In control phase, the confirmation run with optimality conditions were conducted, the results obtained from runs are satisfied which embarks the sigma level from 3.31 to 4.5. The continuous pursue on eliminating variation in the processing stage was attained by framing a control plan to control the variation within acceptable levels in the pretreatment process.

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1. Introduction

Customers are the life blood of any business, the organization should relentlessly look for new ways to consistently uphold the expectation of customers by accentuating on quality, manufacturing cost that leads to competitive enhancement and increase in market share. This case study focuses on a leading shock absorber manufacturing company experiencing a gap in customer perception due to the high rejection rate in the painted damper outer tubes of shock absorbers that results in abasement of quality in the manufactured product. To overhaul this woe, project charter team espouses a statistical breakthrough tool called Six Sigma to analyze the variations in the processing stages for reducing the defect less than 3.4 defects per million opportunities (DPMO). [1] Proposed “Six Sigma is a measure of variation about the average in the manufacturing process or the service industry”. The empirical woe in the aforementioned concern can be vanished completely in a hierarchical manner by using DMAIC phases, which improve the efficiency and effectiveness of the existing business process. [2] Portrayed that by using DMAIC procedure, the variance, waste and errors that beset an operation can be ingrained. [3] Brought the DMAIC approach to analyze the manufacturing lines of a brake lever at a Connecticut automotive component manufacturing company. [4] Proposed that integration of Six Sigma with Statistical quality systems results in effective proceeding to identify the most relevant improvement areas. The optimality can be attained in the improvement area by using the Taguchi robust design which deploys traditional method of conducting the experiments using an OA and ANOVA with a new class of statistics called signal to noise ratio (S/N ratio). The inceptive stride of this paper involves literature survey on Six Sigma and Taguchi robust design approach in manufacturing industries continue with the experimental work on manufacturing process using the DMAIC phases followed by conclusions and future scope of work.

2. Literature review

2.1. Six Sigma

Six Sigma is a formal and highly disciplined methodology for reducing process variation to ensure customer satisfaction, cost reduction and profitability of the organization. [5] States that the fundamental plan behind the Six Sigma philosophy is to monitor the process continuously and aims at elimination/reduction of defects or failures from the manufacturing processes. [6] States that defect can be defined as any deviation in the performance of the critical to quality (CTQ) characteristics. The Six Sigma’s unique approach to continuous process and quality improvement is DMAIC methodology [7]. [8] Claims that prominent key success factors to Six Sigma is the step by step approach or road map using DMAIC methodology. In this case study, the statistical tool called Taguchi robust design was used for analysis of various critical process parameters. [9] Deployed Six Sigma along with Taguchi robust design to analyze various painting process parameters that affect the quality characteristics, after intensified implementation the optimized process parameters were achieved that result in reduced defect rate.

2.2. Taguchi robust design

Taguchi robust design was developed by Genichi Taguchi in the year 1980 is a statistical approach widely utilized to optimize the quality characteristics of manufacturing goods by studying variations [16]. [10] Proved that Taguchi's experimental design is a simple and systematic way of analyzing a complex process with less experimental trials. [11] Applied the Taguchi method to find the optimum process parameters for end milling. [12] Affirms that Taguchi robust design is found compatible for determining the optimal setting of controllable factor and levels for a single response problem on thickness of solder. By learning and applying this artistry of Taguchi robust design, researchers can significantly reduce the time required for experimental exploration. The results obtained from Taguchi robust design was analyzed by using ANOVA table to find the significant factors for responses. In Taguchi robust design, optimization of multi responses can be done by using two vital tools, namely (1) S/N ratio and (2) OA [13].

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