The Impact of Six Sigma and TQM on Quality Performance in Automobile Industries

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ABSTRACT
Purpose: of this paper: In the paper is presented a six sigma project, undertaken within company for production automotive parts, which deals with identification and reduction of production cost in the deburring process for gravity die-casting and improvement of quality level of produced parts.
Design/methodology/approach: The objectives are achieved by application of six sigma approach to quality improvement project in automotive industry. The applied six sigma approach includes team works through several phases: Define, Measure, Analyze, Improve, and control (DMAIC).
Findings: systematic application of six sigma DMAIC tools and methodology within an automotive parts production results with several achievements such are reduction of tools expenses. Cost of poor quality and labours expenses. It was shown that six sigma is an effective way to find out where are the greatest needs and which are the softest points of the process. Also, six sigma provide measurable indicators and adequate data for analytical analytical analysis.

Research implications: The possibility of application of several six sigma tools such are thought process mapping, pareto diagrams, process mapping, cause and effect matrix, and analysis of variation and capability studies.
Practical implications: Improvements through reduced production time, Control time, material and internal scrap have been yield significant financial. Furthermore, this pilot project enabled introduction of six sigma methodology in wider range of manufacturer activities.
Originality/value: The paper researches the possibility of six sigma application within manufacturing process. The paper is of the value to researcher in the field of quality management and quality improvement, as well as to professionals in the manufacturing industry, wherever the quality improvement is an issue.
Keywords: quality management; six sigma; capability analysis; measurement system analysis.

I. INTRODUCTION

Six sigma is new, emerging, approach to quality assurance and quality management with emphasis on continuous quality improvements. The main goal of this approach is reaching level of quality and reliability that will satisfy and even exceed demands and expectations of today’s demanding customer.

A term sigma quality level is used as an indicator of a process goodness. Lower sigma quality level means greater possibility of defective products, while higher sigma quality level means smaller possibility of defective product within process. If sigma quality level equals six, chances for defective products are 3.4 ppm. Achieving six sigma quality level involves leadership, infrastructure, appropriate tools and method while quality have to become a part of corporate business plan.

The main objective of six sigma initiative is to aggressively attack costs of a quality. Overall costs quality is, usually, divided in tangible and intangible part. The tangible or visible part of costs of quality, e.g. inspection and warranty costs, scrap, rework and reject, can be approximated with only 10-15 % of overall costs of quality. Remaining 85-90% of quality costs are usually intangible and, therefore, overlooked and neglected in companies quality costs analyses.

Tools and methodology within six sigma deals with overall costs of quality, both tangible and intangible and intangible parts, trying to minimize it, while, in the same time, increasing overall quality level contribute to company business success and profitability. Quality is excellence that is better than a minimum standard. It is conformance to standards and ‘fitness of purpose’ ISO 9000:2000 definition of quality. It is the degree to which a set of inherent characteristics fulfills requirements.
Quality is ‘fitness for use’ of the product –Joseph Juran. Quality is also defined as excellence in the product or service that fulfills or exceeds the expectations of the customer. There are 9 dimensions of quality that may be found in products that produce customer-satisfaction. Though quality is an abstract perception, it has a quantitative measure- \( Q = \frac{P}{E} \), where \( Q = \) quality, \( P = \) performance (as measured by the Mfgr.), and \( E = \) expectations (of the customer). Quality is not fine-tuning your product at the final stage of manufacturing, before packaging and shipping. Quality is in-built into the product at every stage from conceiving – specification & design stages to prototyping –testing and manufacturing stages. TQM philosophy and guiding principles continuously improve the Organization processes and result in customer satisfaction.

The 9 Dimensions of Quality

- Performance
- Features
- Conformance
- Reliability
- Durability
- Service
- Response-of Dealer/Mfgr. to Customer
- Aesthetics – of product
- Reputation – of Mfgr./Dealer

Customer satisfaction

- Is it due to Product quality?
- Is it due to pricing?
- Is it due to good customer service?
- Is it due to company reputation?
- Is it something more?

II. SIX SIGMA METHODOLOGY

A six sigma project, which deals with identification and reduction of production cost in the deburring process for gravity die-casting turbo compressor housing, was undertaken within company for production automotive parts. In this project the six sigma approach, based on teams, works through the structured DMAIC methodology (define, measure, analyze, improve, and control phases).

Define phase

Within define phase are articulated problem descriptions, objectives and metrics as well as solution strategy. The main goal was to identify and decrease expenses in the deburring department for aluminium castings through times and scrap reduction for at least 30%. There were several major causes for high expenses variability in castings quality, to many handcrafts, and to long control time. The main objectives of undertaken projects were to identify areas in the process where extra expenses exist, identify the biggest impact on production expenses, introduce appropriate measurement system, improve process and reduce expenses on production times, and implement improvements.
Measurement phase.

One of the objectives of project was to identify major process variables impacting the high expenses. Pareto chart for total expenses, shows that the highest impact has labour costs with 42.6%, following by production centre and headquarter costs, but the last two, as well as production service costs, were successfully reduced with internal system reorganization of company.

Based on pareto chart, formed team made decision to analyze and make improvements within labour and tools cost area, which together have amount of 48% of total expenses. Also, there were submitted that quality improvement and reduction of quality costs within process achievable.

The significant improvement could be accomplished by:
- Reduction of cycle time.
- Reduction of control time.
- Reduction of tool costs, and
- Minimizing or eliminating scrap.

Analyse phase
Firstly, FMEA for the deburring process was made. The most critical operations were the control operation and press operation. Conducted analyse showed that data before press operation were normal distributed while, after operation data were non-normal distributed.

The measurement system analysis for controlling the most important dimensions.

After the trials operation. The result showed that operator #1 needs some training, while operator #2 has good measuring results. In addition, the measurement gages are reliable.

Fig. 3. Thought process map

Fig. 4. Normality test for data after Press Operation
The data means were analyzed before and after Press operation and results showed that there wasn’t significant difference between group means, but although the factor of significance wasn’t smaller than 5 % it was very close (5.3 %) so obtained result should be taken with care. It was obviously that something affect normality of data during the Press operation and, after detailed analyses of all process conditions, it was decided to do additional analysis taking into consideration three-positioning points (N) in the casting parts, Figure 5. Also, additional measurements are made to check influence of burrs size to the variability of part dimensions. Results of Analysis of Variance, Figure 6, provide basis for conclusion that the size of burrs have direct influence on output dimension. Further data drilling, using box-plot, Figure 7, showed that higher size of burrs impact higher variation in the process. The applied correlation analyses also showed that increase in burrs result with decrease in dimension on base N. Results on Figure 8 showed that in the base N1 and N2 correlation is different from zero, while in the base N3 correlation is equal to zero which means that there aren’t linearity correlation between observed variables. At the end of this phase the Multi-vary analysis was conducted to check drawn conclusion, as is show on the Figure 9. Multi-vary analysis showed that the biggest variation was in the N1 and minimal variation in the N3. Also, castings with bigger burrs have smaller dimension after burrs removal. Analyses of parts construction explain the reason for different deformation in the squeezer operation in the different positioning points. The lateral section of part isn’t constant and the part is less loaded in N1 then in other two points.

**Improvement phase**

Through followed brainstorming session decision was made that tool modification is needed to reduce cutting forces and avoid scrap appearance. Modification was applied and significant results were obtained, primarily in scrap and tool wearing reduction. Although, significant improvements where achieved, defined goals where not jet met, so further experimentation where conducted with different clamping system in the machining area. Obtained results lead the way to made some amendments in the clamping system to avoid or decrease impact of material scrap and automatically decrease scrap expenses. After appropriate tool construction, several experiments with external clamping were done with process capability study and measurement system analysis (Gage R&R analyses).
Control phase:

The analyses results showed that there weren’t any significant differences on the critical dimensions, but the most important fact was that the radial accuracy in the defined diameters was unsatisfied. Experiment was repeated with external clamping system, but this time with burr classification, and controlling surface for clamping on parts. Results were analyzed and final decision made about external clamping system application in the machining area. After repeated experiment with external clamping system better results were obtained.
while, in the same time, all critical and functional dimensions had good capability. The most important conclusion was that dimension of burr hadn’t any important impact on machining area. Final decision was that the external clamping system will be applied on one production line and, if proved acceptable, after certain period of time will be applied on others production lines and map this solution on the similar castings. To make that possible some simple modifications was needed on the casting die to secure quality surface on the castings for external clamping. In this, final phase of DMAIC methodology, a control plan was developed to ensure that processes and products consistently meets our and customer requirements, and to check how external clamping system impact on quality production level [13, 14, 15].

III. DISCUSSION AND CONCLUSION

Six sigma is an effective way to find out where are the greatest process needs and which are the softest points of the process. Also, Six sigma provide measurable indicators and adequate data for analytical analysis. Systematic application of Six Sigma DMAIC tools and methodology within an automotive parts production results with several achievements. As is shown on Figure, the achieved results are:

☐ Reduced tool expenses for 40 %,
☐ Reduced costs of poor quality (CORQ) for 55 %, and
☐ Reduced labours expenses for 59 %.

Also, the significant results are achieved by two indexes that are not dependent on the volume of production:

☐ Production time reduction for 38 %, and
☐ Index cost/volume reduction for 31 %.

Generally, improvements through reduced Production time, Control time, Material and Internal scrap will give annual benefits of $ 72 000. Expected annual benefits of external clamping system application is $100000.

REFERENCES