iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 **Issue:** III **Month of publication:** March 2014

DOI:

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

Productivity improvement through six sigma methodology in bearing manufacturing

Darshan D. Patel
(M.E. Student, Department of Mechanical Engg. C.U.Shahcollege of Engineering &Technology, Wadhwan city-363060, Gujarat, India)
K.R.Gawande
(Associate Professor, Department of Mechanical Engg., C.U.Shah college of Engineering &Technology,Wadhwan city-363060,Gujarat,India)

Abstract: Purpose of this paper: In the paper is presented a Six Sigma project, undertaken within company for production in BEARINGS, which deals with identification and reduction of production cost & process.
Design/methodology/approach: The objectives are achieved by application of Six Sigma approach to quality Improvement project in bearing 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 bearings 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 process needs and which are the Softest points of the process. Also,
Research implications: The possibility of application of several Six Sigma tools such are thought process mapping, Pareto diagrams, cause and effect diagram, 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. This 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: Six Sigma; Capability analysis; Measurement system analysis

1. INTRODUCTION

Roller bearings - Similar in appearance to cylindrical roller bearings, needle roller bearings have a much smaller diameter-to-length ratio. By controlling circumferential clearance between rollers, or needles, rolling elements are kept parallel to the shaft axis.A needle roller bearing's capacity is higher than most single-row ball or roller bearings of comparable OD. The bearing permits use of a larger, stiffer shaft for a given OD, and provides a low-

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

friction rolling bearing in about the same space as a plain bearing.

The basic needle roller bearing is the full-complement, drawn-cup bearing. The outer race is a thin, drawn cup that has been surface hardened. Roller ends are shaped so that lips on the outer race keep them from falling out. Because the outer race is thin, it must be installed in a correctly sized and properly backed-up housing to transmit load effectively. In most instances, a hardened shaft acts as the bearing's inner race, although an inner race can be supplied when the shaft cannot be hardened.

2. COMPONENT OF NEEDLE ROLLER BEARING

1) Inner cage
2) Outer cage
3) Rollers

3. RESEARCH METHODOLOGY

This section explains the methodology adopted for this case study. Scientific investigation on innovating a system or improvement to the existing one needs to begin with some structure and plan. This structure and plan of investigation were conceived so as to obtain answers to research questions in the research design. The researcher worked with the company to provide support for the project in the Six Sigma techniques, whilst recording data about the exercise from which to develop a case study. A literature review was undertaken with an objective of identifying the past history of various improvement initiatives carried out to address process-related problems. The methodology is divided into four major sections namely problem definition, literature survey, case study design and data analysis. Based on the available data on the process, the team studied the baseline status of the process and drafted a project charter, which explains the details of the problem. A detailed literature review was undertaken in Six Sigma with an objective of identifying the type of improvements carried out by different people in various organizations to address process-related problems. A case study entails the detailed and intensive analysis of a single case—a single organization, a single location or a single event28. Yin29 describes a case study as an empirical inquiry that investigates a contemporary phenomenon within its real life

Context. According to Lee30, the unit of analysis in a case study is the phenomenon under study and deciding this unit

Appropriately is central to a research study. In this paper, a case study is designed to study the underlying process problem so that solutions can be implemented for process improvement. The collected data were analysed using descriptive and inferential statistics. Measurement system analysis, ANOVA, DOE with Taguchi methods, etc. were used for analyzing the data and inferences were made. Graphical analyses, such as histogram and control chart, were also utilized for summarizing the data and making meaningful conclusions. Minitab statistical software was used to analyse the data collected at different stages.

Case study

This case study deals with the reduction of defects in the fine grinding process in a Bearing manufacturing company. These Bearings were used in cars, trucks and buses throughout the world. A schematic view of bearing is given in Figure 1.

FIG.1 Overview of Needle Roller Bearing

The current project was undertaken in the bearing grinding process, which is done by fine grinding machine. Different types of bearing were fine ground in this machine. This is a sophisticated and very expensive CNC fine grinding machine.

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

After fine grinding, Bearings were inspected visually to find various defects. Since the production of Bearings were in thousands per shift, it was not practically possible to do 100% inspection of these components by objective methods. Hence visual inspection was carried out for all the components with reference to master pieces and visual limit samples. Since the rejection level of Bearings after fine grinding process was very high and the function of the component in the product was highly critical, it was essential to do 100% inspection. Under these circumstances, the project was of highest priority to the management as it was clear that an effective solution to this problem would have a significant impact in reducing rework/rejection and improving productivity. Also, it was clear to the team members and champion of the project that the elimination of this problem will help the organization to cater to the increasing demand of market. In the past, many attempts were made to solve this problem by using different methodologies, which were unsuccessful. The Six Sigma problem solving methodology (DMAIC) was recommended when the cause of the problem is unclear. Hence, it was decided to address this problem through the Six Sigma DMAIC methodology.

3.1 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 aluminum castings through times and scrap reduction for at least 30%. There were several major causes for the high expenses variability in castings quality, too 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. An adequate metrics for evaluating projects success should be established. These metrics includes ratio volume/cost, labour cost, tool cost, scrap cost, number of nonconforming or defect parts per million (ppm), and Rolled Throughput Yield (RTY), the probability that a part will pass through multiple process steps without a defect. When the project was started, few useful historical data were available, so the first step was to collect and select these data in the deburring processes. On the base of the collected data decision about selection of process for improvement should be made, all process phases should be screened and appropriate action plan for minimizing variability within the process as well as reduction of production times prepared. In accordance to Six Sigma philosophy, Define, Measure, Analyse, Improve and Control strategy approach was employed. In accordance with DMAIC methodology, project goals should be defined, cross-functional teams formed including individuals with adequate process knowledge, historical information collected, and appropriate process selected for improvements. Furthermore, process map and cause and effect diagram should be define, process conducted and, based on obtained results, required actions and tools for process analysis selected. Appropriate action plans and design of experiment methods should be employed and diverse control charts used for success monitoring.

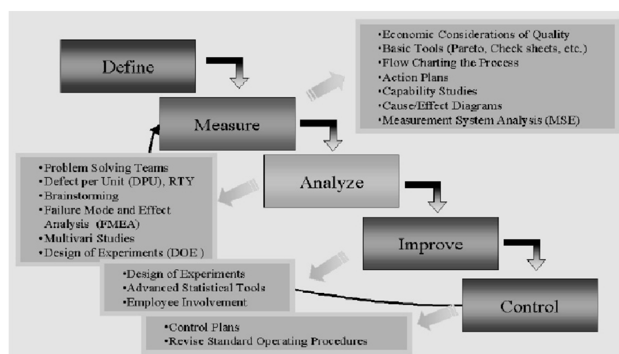


Fig. 2:-DMAIC

3.2 Measure phase:-

The Six Sigma project team needs to come out with an explicit list of vital inputs, desired outputs and process metrics that they are planning to track. This decision has large scale implications on the performance of the project and is usually taken by the

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

Project Leader on the basis of data provided by the Six Sigma team and the Process Owner. There have been many cases of measurement bias in Six Sigma history. The bias may have its roots in the complexity of the calculation, the wrong method of data collection or the bias of the person performing the exercise. One of the biggest challenges of this phase is to validate the fact that the measurement system in place is good for the purpose. This challenge has been discussed in detail in the section titled Measurement Systems Analysis.

The objective of the measure phase is to understand and establish the baseline performance of the process in terms of process capability or sigma rating. The CTQ considered in this case was the rejection percentage of Needle roller bearings after the grinding process. These rejections were mainly due to the occurrence of different types of defects, such as burr, shades, deep lines, patches and damage, on the component after machining. The schematic representation of these defects is presented in Figure. After machining, the components were visually inspected for these defects. Master samples were provided for identifying each of these defects and inspectors did the inspection. Since there was no instrument involved in the inspection process and only visual inspection was performed, before going ahead with further data collection, the team decided to carry out Attribute Gage Repeatability and Reproducibility (Gage R & R) study to validate the measurement system. In such studies, intra-inspector agreement measures repeatability (within inspector), inter inspector agreement measures the combination of repeatability and reproducibility (between inspectors) 31. The non-chance agreement between the two inspectors, denoted by *Kappa*, defines as

For conducting the study, 100 components were selected and they were classified as good or bad independently by two inspectors. From the resulting data, the *Kappa* value was calculated and was found to be 0.814 with a standard error of 0.0839. Since the *Kappa* value was more than 0.6, the measurement system was acceptable31. After the measurement system study, a data collection plan was prepared with details of types of data, stratification factors, sampling frequency, method of measurement, etc. for the data to be collected during the measure phase of this study. The data collection plan thus prepared is presented in Table I. The data were collected as per the plan to understand the baseline status of the process. During the defined period of data collection, 368 219 components were inspected and 61 198 components were rejected due to various defects. Each one of the rejected components was having one or more defects. The detailed data on the type of defects were collected and the same was graphically presented as a Pareto diagram (Figure 3). The collected data shows that the rejection in the process was 166 200 PPM. The corresponding *sigma rating* of the process can be approximated to 2.47. For any improvement initiative in this organization, the general goal set by the management was to reduce the rejection by 50% from the existing level. Based on this policy, the target set for the study was to reduce the rejections at the fine grinding process to 83 100 PPM from the existing level of 166 200 PPM.

3.3 Analyse phase

After mapping the process, the team proceeded to analyse the potential causes of defects. A cause and effect diagram was prepared after conducting a brain storming session with all the concerned people from the process along with the project team. The output of the cause and effect diagram depends on a large extent on the quality and creativity of the brain storming session. The next step in this phase was to gather data from the process in order to obtain a better picture of the potential causes, so that the root cause/s can be identified. The team had detailed discussion with the process personnel to identify the possible data that can be collected on the potential causes in the cause and effect diagram. Based on this discussion, a cause validation plan was prepared to detail the type of data to be collected and the type of analysis possible for each of these causes.

The potential causes, such as ‘variation in input parts’, ‘supplier material variation’ and ‘program parameters not OK’, can be validated by statistical analysis on the data collected from the process. But potential causes, such as ‘improper cleaning after dressing’ and ‘repair batches mix up’, have to be validated only

ISSN: 2321-9653

by observing the process. Hence for few causes, detailed data were collected and statistical analyses were planned, and for the remaining causes was planned to validate the causes.

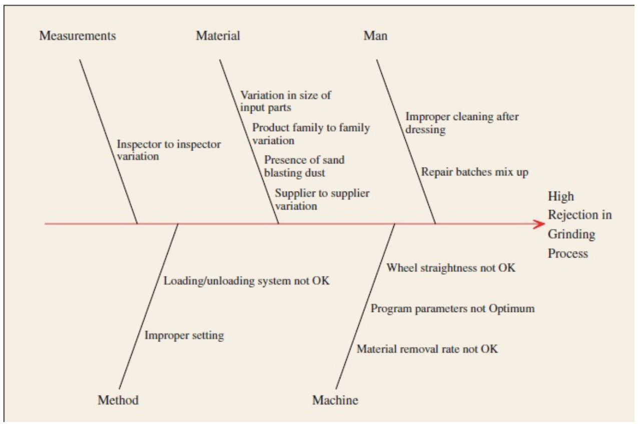


Fig:-3 cause & effect diagram

As three different suppliers provided the raw material, it was suspected that there was possibility of supplier-to-supplier variation with respect to the thickness of input raw material. To study this variation, the data on the thickness of components from all the three suppliers were collected and ANOVA (A statistical procedure used to determine the significant effect of a variable under study23.) was performed in the data and *p-value* was observed. *P*-value is a means for judging the significance of a statistical test. The smaller the *p-value*, the more significant the results are. Typically values below 0.05 are considered indicative of a significant test outcome25. In this case, *p-value* was found to be 0.407, ruling out the possibility of significant difference between the suppliers23. Further to validate the potential cause of variation in size of input parts, batches of Bearings were selected and thickness measured. The data were subjected to *Anderson Darling* Normality test, and found to follow normal distribution. Process capability study was carried out on this data and found to be capable, confirming that the thickness variation in input part was not a root cause33. The Process capability study is a comparison of the process output with customer requirements to determine whether a process is capable of meeting customer expectations.

Table:-1 Summery of validation of causes

Improper cleaning after dressing	GEMBA
Repair batches mix up	GEMBA
Variation in size of input parts	Process capability analysis
Product family to family variation	Chi-square test
Presence of sand blasting dust	GEMBA
Supplier to supplier variation	ANOVA
Material removal rates not OK	ANOVA
Process parameters not Optimum	Design of experiments
Improper setting	DOE
Loading/unloading systems not OK	GEMBA
Wheel straightness not OK	GEMBA
Inspector to inspector variation	Gauge R & R

3.4 Improve phase

At this stage, as decided earlier, a DOE was planned for optimizing the process/machine parameters. The team along with champion, MBB, the production supervisor and operators of the process conducted a series of brain storming sessions to identify the important parameters for experimentation. The

ISSN: 2321-9653

parameters selected through these discussions were load applied, initial load setting, coolant flow rate, upper wheel rpm, lower wheel rpm and cage rpm. Since the relationship between these parameters and MRR was not known, it was decided to experiment all these parameters at three levels26. The existing operating level was selected as one level for experimentation.

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 make 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).

3.5 Control phase

The real challenge of the Six Sigma implementation is the sustainability of the achieved results. Due to variety of reasons, such as people changing the job, promotion/ transfer of persons working on the process, changing focus of the individual to other process-related issues elsewhere in the organization and lack of ownership of new people in the process, quite often maintaining the results are extremely difficult9. Sustainability of the results requires standardization of the improved methods and introduction of monitoring mechanisms for the key results achieved. It also requires bringing awareness among the personnel performing the activities. Standardization of the solutions was ensured by affecting necessary changes in the process procedures that was a part of the quality management system of the organization. The quality plans and control plans were revised as per the solutions implemented and issued to the corresponding users. As a part of ISO 9001 implementation, once in three months internal audits were carried out in the process. After implementation, the data were compiled from the fine grinding process with respect to the defects for one month and the rejection percentage was found to be 1.19. Hence, as a result of this project, the rejection percentage of the bearings at the fine grinding process reduced from 16.6 to 1.19%. The corresponding approximate sigma level was estimated as 3.76. Thus, the sigma level of the process has improved from 2.47 to 3.76. This shows significant improvement in terms of sigma rating as well as defect percentage.

3.6 Conclusion:-

Six sigma is an effective way to find out where the greatest process needs are and which the softest points of the process are. Also, Six sigma provide measurable indicators and adequate data for analytical analysis. Systematic application of Six Sigma DMAIC tools and methodology within a bearing production results with several achievements. The achieved results are:
1) Reduced tool expenses for 40 %,
2) Reduced costs of poor quality for 55 %, and
3) Reduced labours expenses for 59 %.
Also, the significant results are achieved by two indexes that are not dependent on the volume of production:
4) Production time reduction for 38 %, and
5) Index cost/volume reduction for 31 %.
Generally, improvements through reduced Production time, Control time, Material and Internal scrap.
In Six Sigma also there were inherent difficulties in executing this project. Availability of people for attending training during their busy schedule of day-to-day work was very difficult. Getting support of the people at the lower levels in the organization for participating in the implementation of the solutions was not easy. Since the organization did not have any software for capturing data automatically, collection of data from the process during different phases of the Six Sigma project implementation was also very difficult. The team, by involving people at all levels in the organization, achieved the expected results. Finally, the significant achievement of this

ISSN: 2321-9653

project has created many followers for Six Sigma in the organization.

REFERENCES

Journal Papers

[1] Snee RD, Hoerl RW. Leading Six Sigma: A Step by Step Guide Based on Experience at GE and Other Six Sigma Companies. Prentice-Hall: New Jersey, 2003.

[2] Keller PA. Six Sigma Deployment. Quality Publishing House: Arizona, 2001.

[3] Kumar M, Antony J, Antony FJ, Madu CN. Winning customer loyalty in an automotive company through Six Sigma: A case study. Quality and Reliability Engineering International 2007; 23(7):849--866.

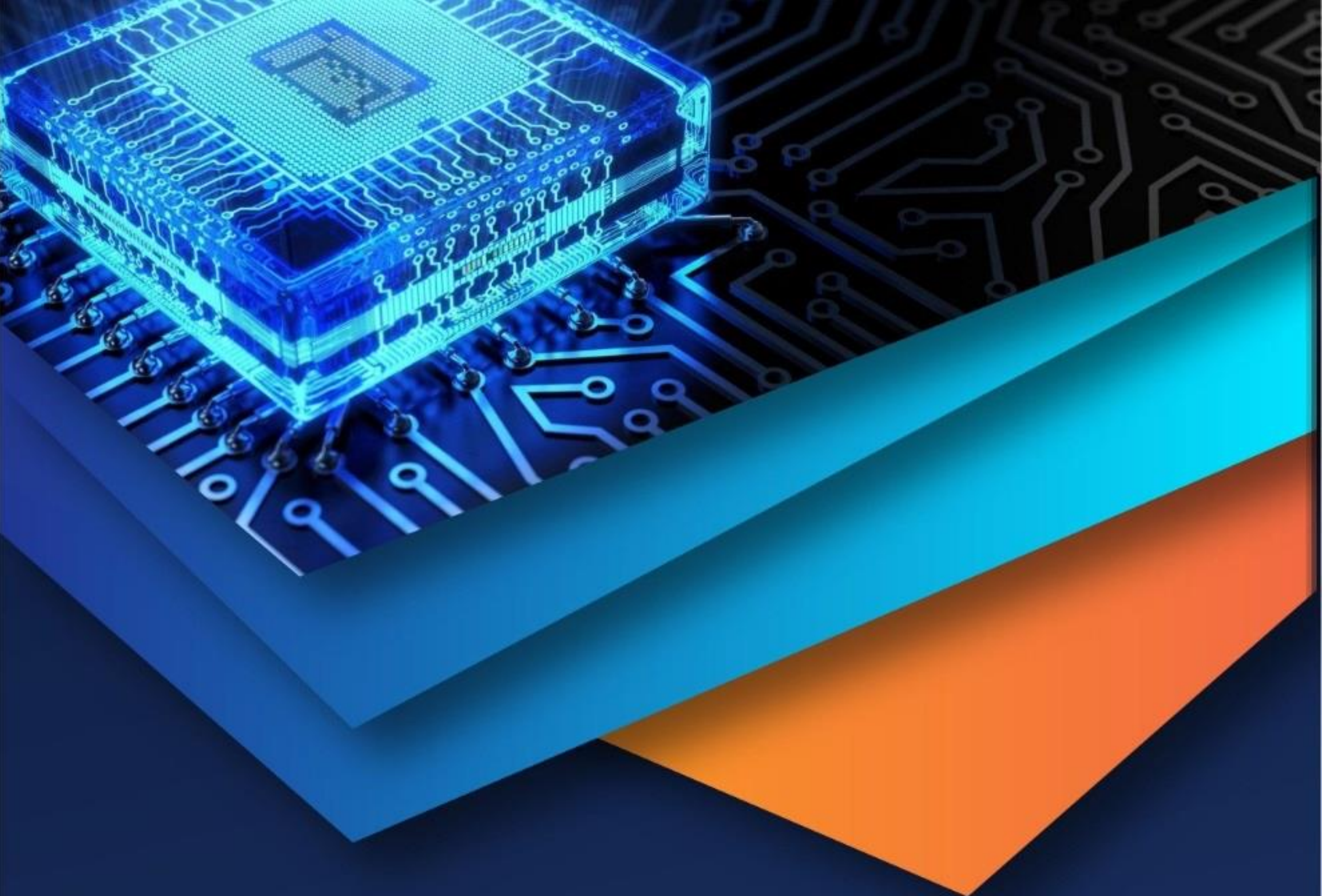
[4] T. Pyzdek, The Six Sigma Revolution, Quality America Inc.,1999.

[5] M. Harry and R. Schroeder, Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations, Currency, New York, 2000.

[6] F. W. Breyfogle III, et al, Managing Six Sigma, John Wiley & Sons, Inc., New York, 2001. M. Sokovic, D. Pavletic, R. Matkovic, Measuring-system analysis for quality assurance in a Six Sigma process, Stroj. Vestn., Vol. 51 No. 9 (2005) 589-599.

[7] D. Pavletic, S. Fakin and M. Sokovic, Six sigma in process design. Stroj. Vestn., Vol. 50 No. 3 (2004) 157-167.

[8] M. Sokovic, D. Pavletic, S. Fakin, Application of six sigma methodology for process design quality improvement, Proceedings of the 13th International Scientific Conference AMME '05, Gliwice-Wisla, Poland, May 2005, 611-614.



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY