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Review on Implementation of DMAIC Approach to Reduce Defects in Grinding Process and Quality Improvement

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ABSTRACT

The aim of study is to find out the effective way of improving the quality and productivity of a grinding process in manufacturing industry. The objective is to identify the defect in grinding process and create a better solution to improve it. Various industrial engineering technique and tools is implementing in this study in order to investigate and solve the problem that occurs in the grinding process.

Keywords: Grinding Defects; Patches; Productivity; Quality; DMAIC Approach; Taguchi Experimental Design; Analysis of Variance; ANOVA; Signal to Noise Ratio; S/N.

I INTRODUCTION

Quality and productivity are an integral component of organisations' operational strategies .In the globalisation of markets and operations, focus on quality and productivity is of utmost importance. Quality improvement in operations and production has been one of the most significant influences for organisation to be successful (Pande et al., 2000). Corporate consistently strives to build quality into their products based on customer needs. For manufacturing quality products, continuous improvement (CI) methodologies have been developed to get better productivity of the operations (Hobbs, 2004; Nave, 2002). During the past two decades, the quality progress has provided a broad collection of CI methods to accelerate the process of improving quality and productivity that supports the business growth (Cox et al., 2003).

Six Sigma is one of the recent CI approaches which are applied in the best-in-class companies (Bessant and Francis, 1999). Six Sigma is a highly structured process improvement framework that uses both statistical and non-statistical tools and techniques to eliminate process variation and thereby improve process performance and capability (Antony and Banuelas, 2002). Minimising defects to the level of 3.4 defects per Million opportunities (DPMO) is at the heart of this methodology (McAdam and Lafferty, 2004). To achieve target, this approach seeks to identify and eliminate defects, mistakes or failures in business processes by focusing on process performance characteristics (Snee, 2004).

industries (Caulcutt, 2001), highlighting the economic dimension of quality improvement. By employing DMAIC methodology, most of the Six Sigma efforts are focused on taking variability out of the existing processes (Park et al, 2005; Bhote, 2002). DMAIC is anagram of the major phases within the methodology namely, define measure, analyse, improve and control. The define phase entails the definition of the problem and critical-to-quality (CTQ) characteristic. The measure phase selects most appropriate quality characteristic to be improved and establishes metrics. In analysis phase, the root causes of defect are analysed. In improve phase, simple but powerful statistical tools/techniques are used to reduce the defect or process variations. In controlphase, the way of sustaining the improvement is formulated and put in force (Pyzdek, 2001; Montgomery, 1998). The DMAIC frame work utilises various tools and techniques like control charts, quality function deployment (QFD), failure mode and effect analysis (FMEA), design of experiments (DoE) and statistical process control (SPC) for variation management to drive out defects in operations. Among the available collection of tools and techniques, application of DoE is at the heart of DMAIC cycle.

DoE technique helps to identify key process parameters and to subsequentlyadjust them in order to achieve sustainable performance improvements (Pande et al., 2002). This technique determines significant factors and factor interactions that affect variability within a product at the improvement stage of Six Sigma application (Antony, 2001). There may be situations when there is a trade-off in the selection of process parameter levels to identify the optimum parameter level. To tackle the conflicting situations, Japanese scientist Taguchi (1986) has developed robust design approach (Robinson et al., 2003). Robust design is an efficient and systematic methodology that applies statistical experimental design for improving product and manufacturing process design. Robust design approach analyses the signal-to-noise (S/N) ratios as a means of finding a robust solution. The loss function is a contribution of robust design approach to address the process variability. This quadratic loss function informs about money value and product variability to all management. Classical DoE do not directly emphasise the reduction of process variability and translate this need toeconomic considerations for management. Moreover, classical DoE approach is deemed too costly and time consuming because of full factorial designs. Orthogonal array (OA)-based Taguchi DoE has been recognised as an economical tool to optimise process parameters in industry for quality and productivity (Nataraj et al., 2007). Taguchi technique found an alternative experimental design strategy to drive out the fit fall in classical approach. The basic promise between classical and Taguchi approach to higher quality is that one proposes that higher quality costs more and the other proposes that higher quality costs less.

II RELATIONSHIP BETWEEN QUALITY AND PRODUCTIVITY

Organisations wants to increase profits, it should increase productivity as well as quality (Park, 2003). Without improving quality, increasing the productivity may not be right. But improving quality will results in improved productivity. Looking at the relationship between quality and productivity, stresses improving quality in order to increase productivity. To become an excellent company, the management should find ways to improve quality as well as productivity simultaneously. Then, several benefits result:

• Productivity rises.

• Quality improves.

• Cost per good unit decreases. Price can be cut.

• Workers' morale improves because they are not seen as the problem.

Improving productivity through quality can produce all the desired results: better quality, less rework, greater productivity, lower unit cost, price elasticity, improved customer satisfaction, larger profits and more jobs. After all, customers get high quality at a low price, vendors get predictable long-term sources of business, and investors get profits, a 'win-win' situation for everyone.

III THE SIX SIGMA PROGRAMME

Six Sigma is a philosophy for company-wide quality improvement (McAdam and Lafferty, 2004). Six Sigma is a powerful breakthrough business improvement strategy that enables companies to use simple and powerful statistical methods for achieving and sustaining operational excellence. The statistical representation of Six Sigma describes quantitatively how a process is performing (Banuelas et al, 2005).

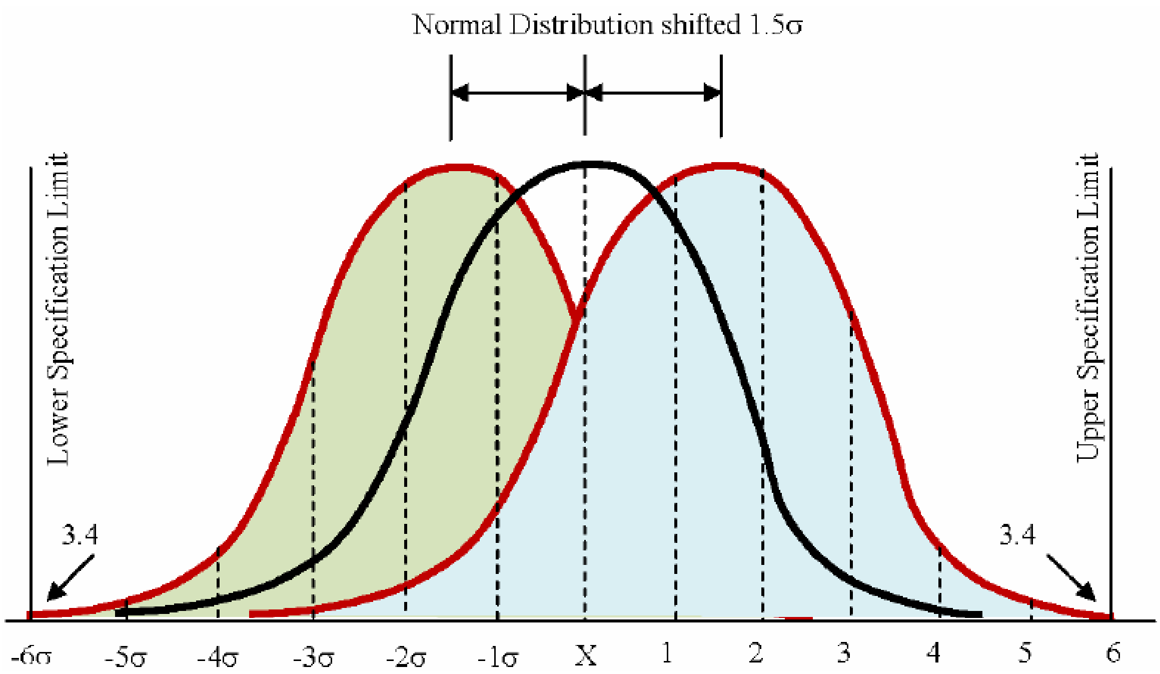

Figure 1 Non-central normal distribution with 3.4 ppm sigma quality level

The numerical goal of Six Sigma is reducing defects to less than 3.4 parts per million (PPM), reducing cycle time and dramatically reducing costs which impact the bottom line (Goh and Xie, 2004). As a process improvement method, Six Sigma is largely mechanistic or process focused (McAdam and Lafferty, 2004). Figure 1 illustrates the basic measurement concept of Six Sigma (Park, 2003). Sigma quality level includes a ± 1.5 σ shifts in mean value to account typical shifts and drifts of the process mean. Table 2 shows the number of

PPM that would be outside the specification limits if the data were normally distributed with mean shifted to $\pm 1.5\ \sigma$.

DMAIC is a disciplined and quantitative approach of Six Sigma for improving the product or process quality (Hahn and Doganaksoy, 2000). DMAIC provide teams a methodological framework to guide them in the conduct of improvement projects (Pande et al., 2002; Pyzdek, 2003).

Phase 0 (Definition): This phase is concerned with identification of the process or product that needs improvement. It is also concerned with benchmarking of key product or process characteristics of other world-class companies.

Phase 1 (Measurement): This phase entails selecting product characteristics; i.e., dependent variables, mapping the respective processes, making the necessary measurement, recording the results and estimating the short- and long-term process capabilities.

Phase 2 (Analysis): This phase is concerned with analysing and benchmarking the key product/process performance metrics. Following this, a gap analysis is undertaken to identify the common factors of successful performance.

Phase 3 (Improvement): This phase is related to selecting those product performance characteristics which must be improved to achieve the goal. Once this is done, the characteristics are diagnosed to reveal the major sources of variation. Next, the key process variables are identified usually by way of statistically designed experiments including Taguchi methods and other robust DoE. The improved conditions of key process variables are verified.

Phase 4 (Control): This last phase is initiated by ensuring that the new process conditions are documented and monitored via SPC methods. After the ‘settling in’ period, the process capability is reassessed. Depending upon the outcome of such a follow-on analysis, it may become necessary to revisit one or more of the preceding phases.

IV GRINDING PROCESS

Grinding is a material removal and surface generation process used to shape and finish components made of metals and other materials. The precision and surface finish obtained through grinding can be up to ten times better than with either turning or milling.

Grinding employs an abrasive product, usually a rotating wheel brought into controlled contact with a work surface. The grinding wheel is composed of abrasive grains held together in a binder. These abrasive grains act as cutting tools, removing tiny chips of material from the work. As these abrasive grains wear and become dull, the added resistance leads to fracture of the grains or weakening of their bond. The dull pieces break away, revealing sharp new grains that continue cutting. The requirements for efficient grinding include:

- Abrasive components which are harder than the work
- Shock- and heat-resistant abrasive wheels
- Abrasives that is friable. That is, they are capable of controlled fracturing

Most abrasives used in industry are synthetic. Aluminium oxide is used in three quarters of all grinding operations, and is primarily used to grind ferrous metals. Next is silicon carbide, which is used for grinding softer, non-ferrous metals and high density materials, such as cemented carbide or ceramics. Super abrasives, namely cubic boron nitride or "CBN" and diamond, are used in about five percent of grinding. Hard ferrous materials are ground with "CBN", while non-ferrous materials and non-metals are best ground with diamond.

The grain size of abrasive materials is important to the process. Large, coarse grains remove material faster, while smaller grains produce a finer finish.

The binders that hold these abrasive grains together include:

- vitrified bonds, a glass-like bond formed of fused clay or feldspar
- Organic bonds, from synthetic resins, rubber, or shellac
- Metal or single-layer bond systems for super abrasives

Wheels are graded according their strength and wear resistance. A "hard" wheel is one that resists the separation of its individual grains. One that is too hard will wear slowly and present dulled grains to the work and overheat, affecting the final finish. If too soft a wheel is used, it will deteriorate quickly, requiring frequent replacement.

Another aspect of grinding wheels is their pore structure or density, which refers to the porosity between individual grains. This pore structure creates spaces between the grains that provide coolant retention and areas for the chips to form. Dense wheels are best for harder materials, while more open densities are better for the softer metals.

The three factors of grain size, bond type, and pore structure are closely related, and together determine how well a wheel will perform.

Damaged wheels or even wheels suspected of being damaged should not be used. Safety steps for proper use of grinding wheels include, but are not limited to:

- Always having machine guards in place before turning on a grinding wheel
- running wheels for at least one minute before actual work begins
- Always using eye protection
- Properly balancing and dressing wheels before use

Wheel dressing and truing is done with special tools designed for that purpose. Although wheel dressing is often done manually between work cycles, some grinding machines perform the dressing task automatically.

The application of coolants to the grinding process is important. Coolants reduce grinding machine power requirements, maintain work quality, stabilize part dimensions, and insure longer wheel life. Coolants are emulsions, synthetic lubricants or special grinding oils. Coolants are applied by either flooding the work area or by high pressure jet streams.

V GENERAL PROCEDURE FOR REDUCING GRINDING DEFECTS

The basic procedure for analysing the casting for defects is taking place with the help of Defect Diagnostic Approach, as shown in the figure below, Different paper give different procedure for reducing defects out of best process select and try to implement further in project.

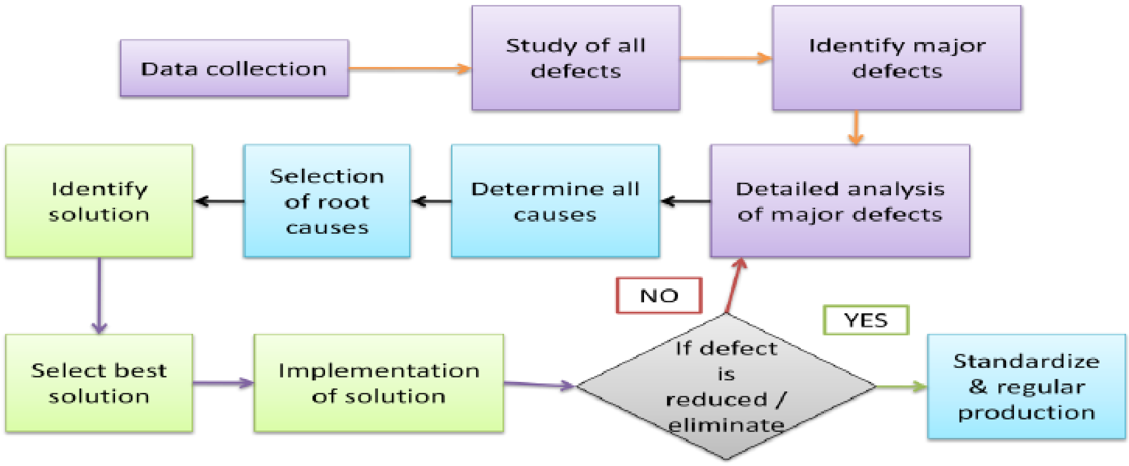

Fig.2 Procedure for Reducing Grinding Defects and select best solution

Figure shows grinding defects analysis is the process of finding the root cause of occurrence of defects in the rejection of grinding and taking necessary steps to reduce the defects and to improve the same. Different activity like (a) Preliminary study: The study was made in a medium scale industry producing (b) Data collection: The rejection data for a month period were collected. (c) Study of all the defects: The next step in the analysis is to study all the grinding defects occur in the process. (d) Identify major defect A Pareto chart is drawn using the rejection data of this (e) Detailed analysis of the major defect- The detailed analysis of this major defect is made in this step. It is essential to know whether the patches defect was occurring in particular days of production or it was distributed to all the days of production in the study period. (f) Determine all causes- The possible causes for this defect due to various parameters and processes are found out with the help of Cause- Effect diagram. In this way root cause for the formation of defect is determined. (g) Selection of Root cause- The detailed examination of rejected item is required to identify the root cause for this major defect. For reducing this defect, the proper analysis of the component is required. (h) Selection of the best solution- The best solution can be selected according to the availableresources. (i) Implement that solution in company (j) standardizes and regular production.

VI LITERATURE REVIEW

S. Suresh, A. L. Moe and A. B. Abu (2015)have used Six Sigma DMAIC methodology for Defects Reduction in Manufacturing of Automobile Piston Ring. Using the Six Sigma method, the rejection percentage is reduced by

13.2% from the existing 38.1% of rejection. Further improvement in the rejection is expected in the long run after the continuous implementation of all the solutions.

Jitendra A Panchiwala et. al (2015)carried out the research work made by several researchers and an attempt to get technical solution for minimizing various casting defects and to improve the entire process of casting manufacturing.

Vivek Patil et al. (2015)studied Quality control and Statistical Techniques used to improve Productivity and to reduce Rejections due to Casting Defects.

B. Naveen et. al (2015)presents the current performance of outputs and capacity of the plant calculated using continuous data collected in shop floor. In each workstation the processing time is different and the longest time consumption workstation will be identified as a bottleneck workstation. The identified bottleneck station will be analyzed to reduce the processing time which increases production rate.

Joshua Chan Ren Jie, Shahrul Kamaruddin and Ishak Abd Azid, (2014) has proposed a DMAIC as a Lean Six Sigma (LSS) framework in his paper in Small Medium Enterprise (SME). He has focussed on the SME's problem of facing the pressure from its competitors; mainly large companies as they could provide products of greater value with lower cost as compared to SMEs. The DMAIC framework has been developed and verified in a label printing company by author. This SME label printing company produces various types of labels such as computer labels, offset & silkscreen stickers and bar code labels. The productivity of the label printing section shows an increase by 584 impressions/hour, which is an increase of 21.93% of the current production output.

S. Arun Vijay (2014) has the objective of his research to reduce the cycle time of the patients discharge process using Six Sigma DMAIC Model in a multidisciplinary hospital setting in India. He has conducted study through the five phases of the Six Sigma DMAIC Model using different Quality tools and techniques. This study suggested various improvement strategies to reduce the cycle time of Patients discharge process and after its implementation; there is a 61% reduction in the cycle time of the Patients discharge process. Also, a control plan check sheet has been developed to sustain the Improvements obtained. This Study would be an eye opener for the Health Care Managers to reduce and optimize he cycle time of Patients discharge process in Hospitals using Six Sigma DMAIC Model. This study validated the application of Six Sigma DMAIC methods to reduce and optimize the patients discharge process with specific focus on a Medical and Surgical Department. Even though the average discharges time reduced from 234 minutes to 143 minutes demonstrating 61% decrease.

Ghazi Abu Taher & Md. Jahangir Alam (2014)finds out the effective way of improving the quality and productivity of a production line in manufacturing industry. The objective is to identify the defect of the company and create a better solution to improve the production line performance. Various industrial engineering technique and tools is implementing in this study in order to investigate and solve the problem that occurs in the production. However, 7 Quality Control tools are the main tools that will be applied to this study. Data for the selected assembly line factory are collected, studied and analyzed. The defect with the highest frequency will be the main target to be improved. Various causes of the defect will be analyzed and various solving method will be present. The best solving method will be chosen and propose to the company and compare to the previous result or production. However, the implementation of the solving methods is depending on the company whether they wanted to apply or not**.**

VII SUMMARY OF LITERATURE SURVEYED

Six Sigma DMAIC methodologies has been used in the manufacturing industries like automotive part manufacturing, metal processing, gloves manufacturing, file manufacturing, laser mouse manufacturing, semiconductor manufacturing, grinding operations, rolling mills. In one of the papers the Six Sigma is used for safety level improvement. Six Sigma DMAIC methodologies also have been used in the service industries like hospital and educational institute. The Six Sigma DMAIC methodology also found its application in delivery commitment fulfilment project. There is also thorough literature review done by many authors on the Six Sigma DMAIC methodology.

From the study of all the research paper of six sigma conclude that six sigma is a breakthrough improvement methodology with the use of six sigma it is confirm that we get a min.50% improvement, if we work hard and top management involvement is good. It can also be concluded that DMAIC methodology is mostly used by the industries for their performance improvement. This study will help small scale industry to initiate Six Sigma projects in their organizations and improve their performance in terms of customer satisfaction as well as financial benefits with increase in competitiveness in worldwide market of manufacturing

VIII CONCLUSION

The six-sigma framework provides an impetus for establishing best practice with the company. It also provides the company with a performance benchmark on which it could base its future performance enhancement programs. As it has been observed that the level of its sigma is not satisfactory, there is no way to improve this by DMAIC. The implementation of six-sigma will save money which will result higher profit of the organization. As the businesses are influenced by globalization, the competition is arising more and more and so, to sustain in the global business every organization needs to maintain appropriate quality level. This study will contribute to a new management approach on improving business process for both efficiency and consistent quality customer service. After reviewing the benefits and limitations behind Six Sigma, a company should determine whether or not Six Sigma is for them.

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