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Quality Evaluation of a RMC Plant using Six Sigma Approach

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Abstract: ***Quality is an important parameter in any construction industry. There are various costs which are related to the quality. Ready Mix Concrete is a mechanised process by which a concrete is provided to the various clients for various purposes readily. As the concrete is manufactured mechanically, a central location quality control is more over the process & output.***
Still manufactured concrete has number of defects due to various causes in the quality of concrete. The major defects are – strength, workability, bleeding, surficial cracking & many other. To reduce these kind of defects, traditionally checklists were used. Further many quality control methods, techniques are evolved.
The Total Quality Management (TQM) has origin in 1950s. It became more popular in 1980 by steady growth. Culture, attitude & organisation of company are major three aspects of TQM. Management &employees are get involved in TQM methodology for the continuous improvement of the company. The scope of TQM infinite & adaptable. TQM is now becoming recognised as a generic management tool. This study focuses on standardization of quality of the concrete manufactured at RMC plants using SPC tools.
Keyword: TQM, DMAIC, USL, LSL, UCL, LCL, Sigma level.

I. INTRODUCTION

A. Overview on Indian Construction Industry & RMC

A construction industry in India has gained rapid growth in the last decade. In India construction industry contain urban development segment as well as real estate. Construction sector has prime role in driving Indian economy. It includes power, bridges, dams, roads & urban infrastructure. In 2008, India ranked 44th out of 167 countries in World Bank's Logistics Performance Index (LPI) 2018.Roughly 10% GDP is contributed by construction industry. Construction industry has forward & backward linkages with other industries like cement, steel, bricks, etc. These linkages catalyses employment generations in the country.

RMC emerges as an advantageous for faster development. However, due to absence of proper & effective quality monitoring systems in the most of the batching plants in India, are lagging behind. Hence there is need of quality monitoring systems in RMC plants in India. Using quality monitoring techniques we expect much more organised & efficient production of concrete from RMC plants. In RMC sector there is need to focus on faulty zones. In the terms of QA/QC systems, quality of manufactured concrete have many issues and progress is not upto the mark.

The manufactured concrete from RMC has many issues like issues with workability, slump problem, issues with strength of RMC concrete, post production strength issues, cracks, shrinkage & lots more.

In India, RMC introduced about two decades ago. Lack of proper manuals, high initial investments, lack of awareness were major causes that led to set of RMC industry. In rapidly growing era of urbanisation resulted increasing demand for the good quality of concrete to make structures adequately safe & sound.

Quality improvement tool like six sigma is beneficial for construction quality. Approximately, very large amount of concrete is produced in a day at RMC plant & inspected properly before delivered. Industry is facing critical quality related problems & sometimes rejection by the lots of customers. There are number of studies which uses six sigma tools for quality evaluation of product but only few are related to the construction.

The RMC reduces the time of construction. The quality of RMC is proved as sub-standard in some of areas. For improvement of quality of concrete, the RMC plants are need to be standardize. The quality control measures should be assessed in production process & it should be continuous process improvement.

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The roots of the six sigma are traced back to the Carl Friedrich Gauss (1777-1855). He introduced a concept of normal curve. Six sigma is a measurement standard for the product variation can traced back to the 1920. Walter Shewhart showed that three sigma from the mean is a point where a process require correction. After six sigma many standards (Cpk, zero defects, etc.) came later. The credit for coining the "Six Sigma" term was goes to Motorola engineer Bill Smith. From then, "Six Sigma" is a federally registered trademark of Motorola.

Due to six sigma Motorola reduces their cost & variations in many processes & won the Malcolm Baldrige National Quality Award in 1998.

Six Sigma is a quality program which provides a framework for the continuous improvement of an overall process. The database required to perform six sigma are facts, statistical data, root causes to solve problems. In this study, six sigma as a TQM tool is implemented on RMC plant for the quality evaluation purpose.

Six sigma has two man methodologies namely, DMAIC & DMADV. The DMADV (Define-Measure-Analysis-Design-Validate). The DMADV is methodology mainly for the new processes & there are need to develop some new processes. The DMAIC methodology is a measurement based strategy. It focuses on the improvement of the existing process & to reduce variations in the process. The six sigma DMAIC process is used for the process which is falling below the specification limits & process require incremental improvement.

B. Research Objectives

1) To study the production process of RMC plant & collection of compressive strength data of previous production.
2) To calculate the six sigma level of the plant for different grades of concrete with the help of histogram.
3) To find out stability & process capability of the production process using control charts & analysis of correlation using scatter plot.

II. SIX SIGMA DMAIC METHODOLOGY

For the quality evaluation of the existing production process of the RMC plant, a DMAIC methodology is applied. The DMAIC methodology basically is, Define-Measure-Analysis-Improve-Control. The DMAIC methodology is a measurement based strategy. It focuses on the improvement of the existing process & to reduce variations in the process.

A. Define Phase

The very first step of DMAIC methodology is define the quality problem related to the product. There are mandatory tests are performed on concrete till casting on the site such as compressive strength test for measuring its workability, quality. There are so many issues that are related to the concrete.

That issues affect the performance of the concrete in structural elements. At the starting point of concrete like from the plant production, there are many types of defects are observed. The quality of the concrete is determined by the segregation or bleeding at the time of casting or pouring.

The final check is conducted when there is no cracks observed on the concrete. Because concrete deterioration can cause huge defect in the structural elements.

The DMAIC methodology is used to identify the critical quality parameter of the product. In this study, quality parameters of the RMC have been considered.

From number of literature reviews & based on site observations, the workability at site, homogeneity & compressive strength are the critical quality parameters of RMC [1].

B. Measure & Analyze Phase

After the define phase the next is measure the performance of the current process of the RMC plant. For measurements, the layout of the plant & production process of the Sagunamata Readymix Concrete Solution Pvt. Ltd., Somanthali was studied thoroughly. The compressive strength data of various grades like M-20, M-25, and M-30 of previous time was collected from the quality department of the plant. The test reports of raw materials like aggregates, natural & artificial sand, and fly ash also studied.

In analyse phase, to understand the collected data, simple statistical analysis tools are used.

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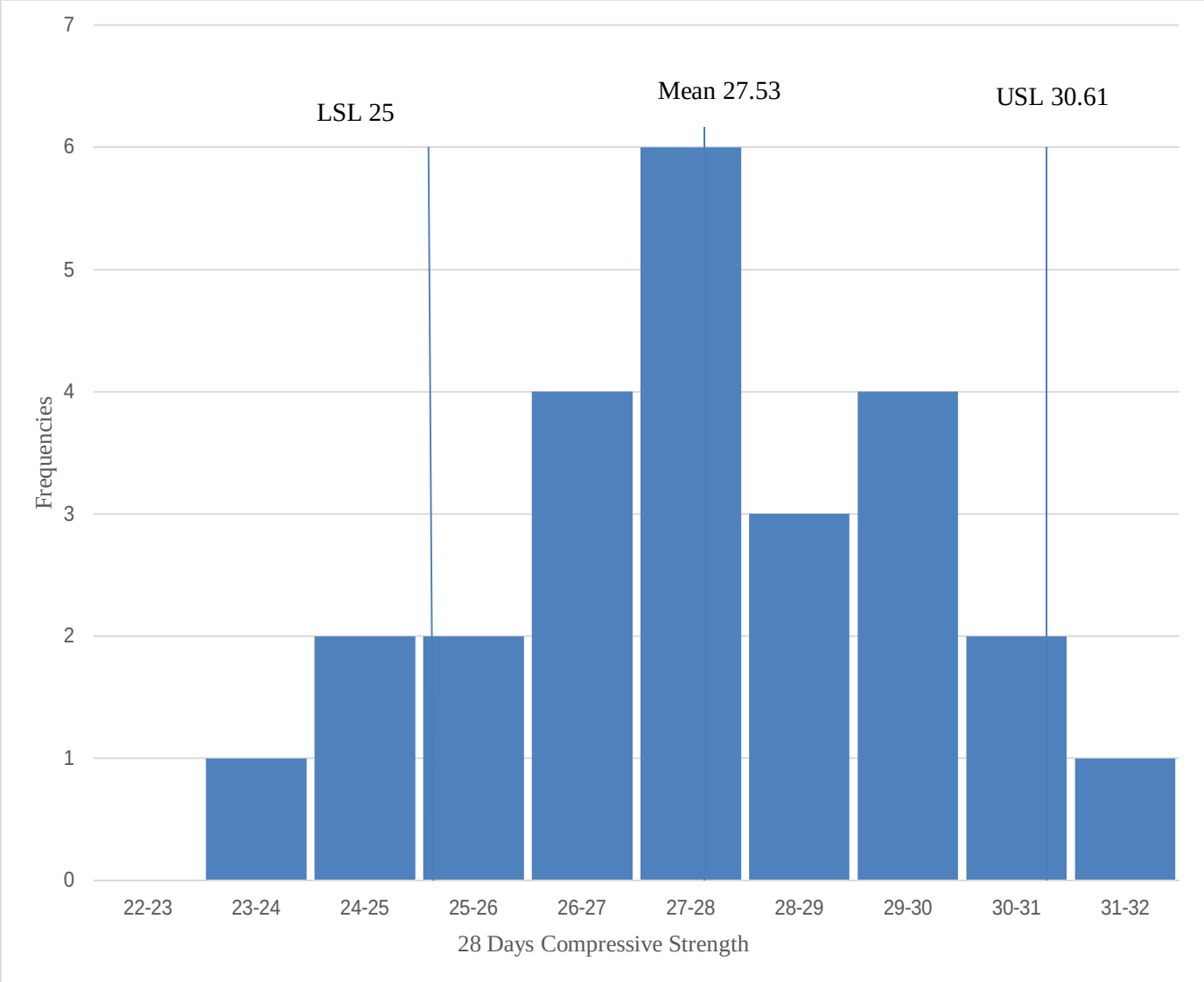

Figure 1: Histogram & Process capability analysis of M-25 Grade of Concrete

The first objective is to find out the sigma level of the process. Lower the sigma level, more will be the defects. The histogram of M-25 grade of concrete is drawn using M.S. Office Excel software as shown in fig. 1. From the calculations, the sigma level is 1.35. The very low sigma level of the process means there are deviation in the process. Sigma level indicates substantial variation in the process performance. Sigma level is the minimum of either {(USL - Mean)/ σ} or {(Mean – LSL)/ σ} [1].

Process capability can be calculated by the expression {(USL-LSL)/6σ} [1]. The process capability (Cp) for the process is found out as 0.5 which is less than 1 and hence the performance is undesirable.

The control charts uses graphical representation to study how a process behave over the time. Time is important parameter in control charts. Control charts has centre line, UCL (Upper Control Line) & LCL (Lower Control Line). The X bar chart & R bar chart for M-25 grade of concrete are shown in fig. 2 & 3 respectively. The sub-group size for these control charts is 3. From X bar Graph it is clear that most of the points are out of the control limits. The manufacturing process has poor performance. These variations are due to changes in raw materials & their quality. Due to improper calibration of equipments variations in the process was observed.

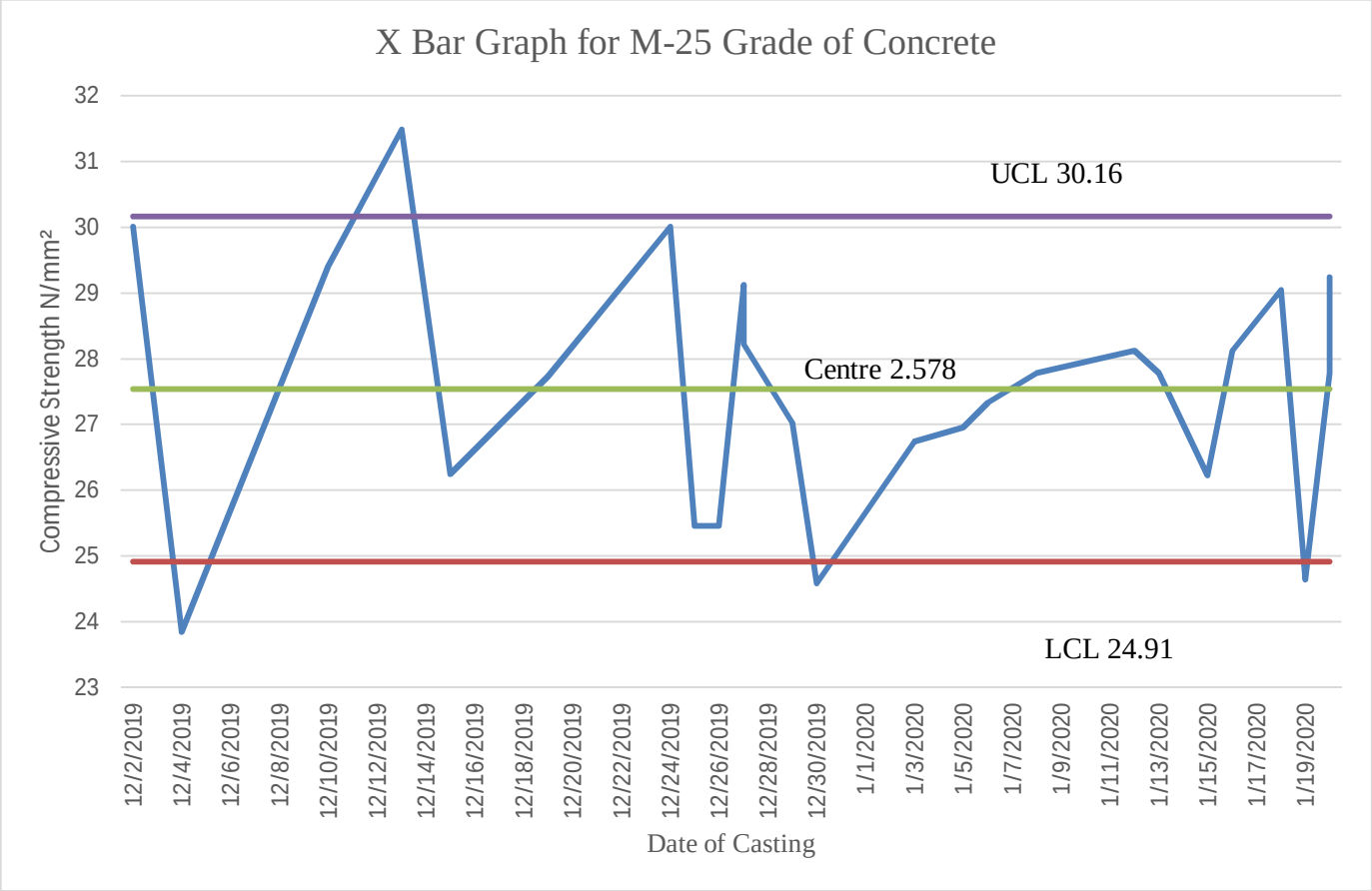

Figure 2: X bar chart for M-25 grade of concrete

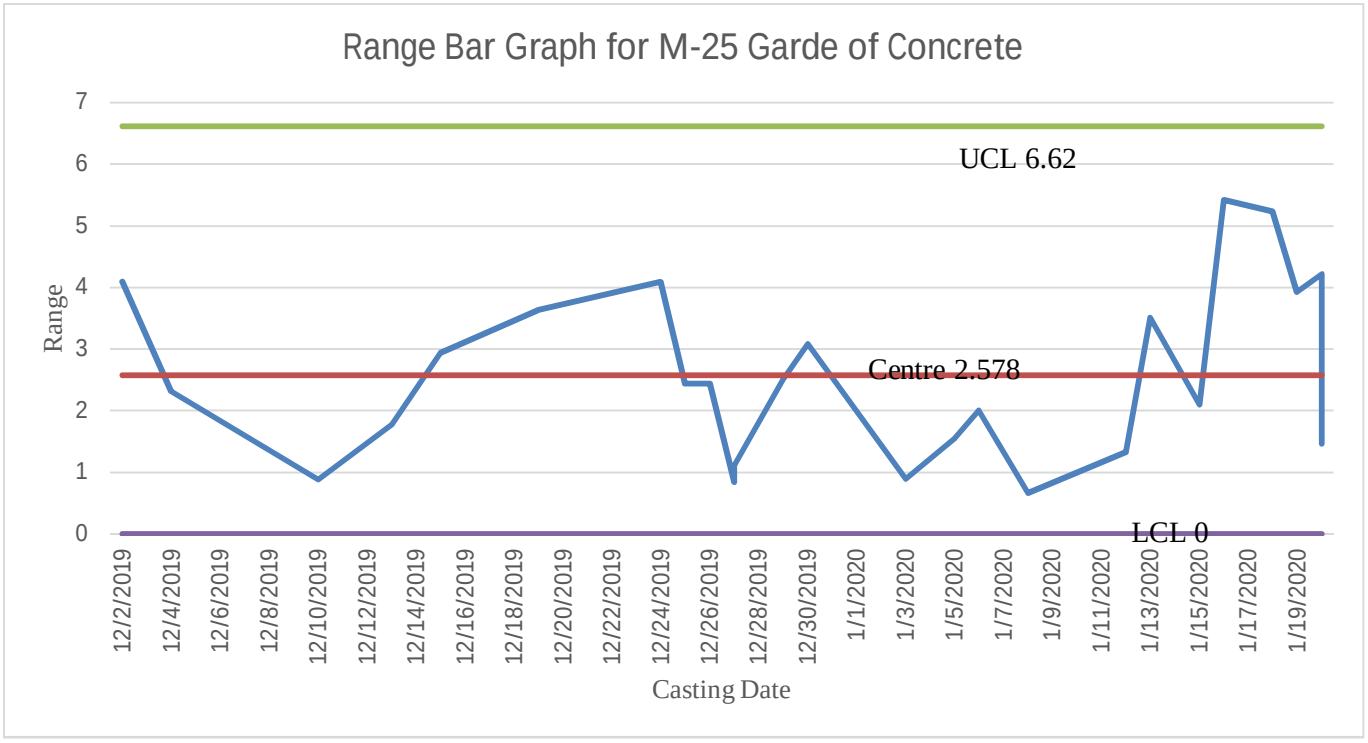

Figure 3: R bar chart for M-25 grade of concrete

Scatter plot is the most useful tool amongst the quality control tools. The correlation from the two variables can be found out from the scatter diagram. Correlation between two variables can be negative, positive or null. Fig. 4 shows the scatter plot of M-25 grade of concrete. From the diagram the correlation (R^2) between compressive strength & date of casting is 0.0074. The coefficient of correlation which is extremely less than 1 this means that compressive strength with the date is very weak.

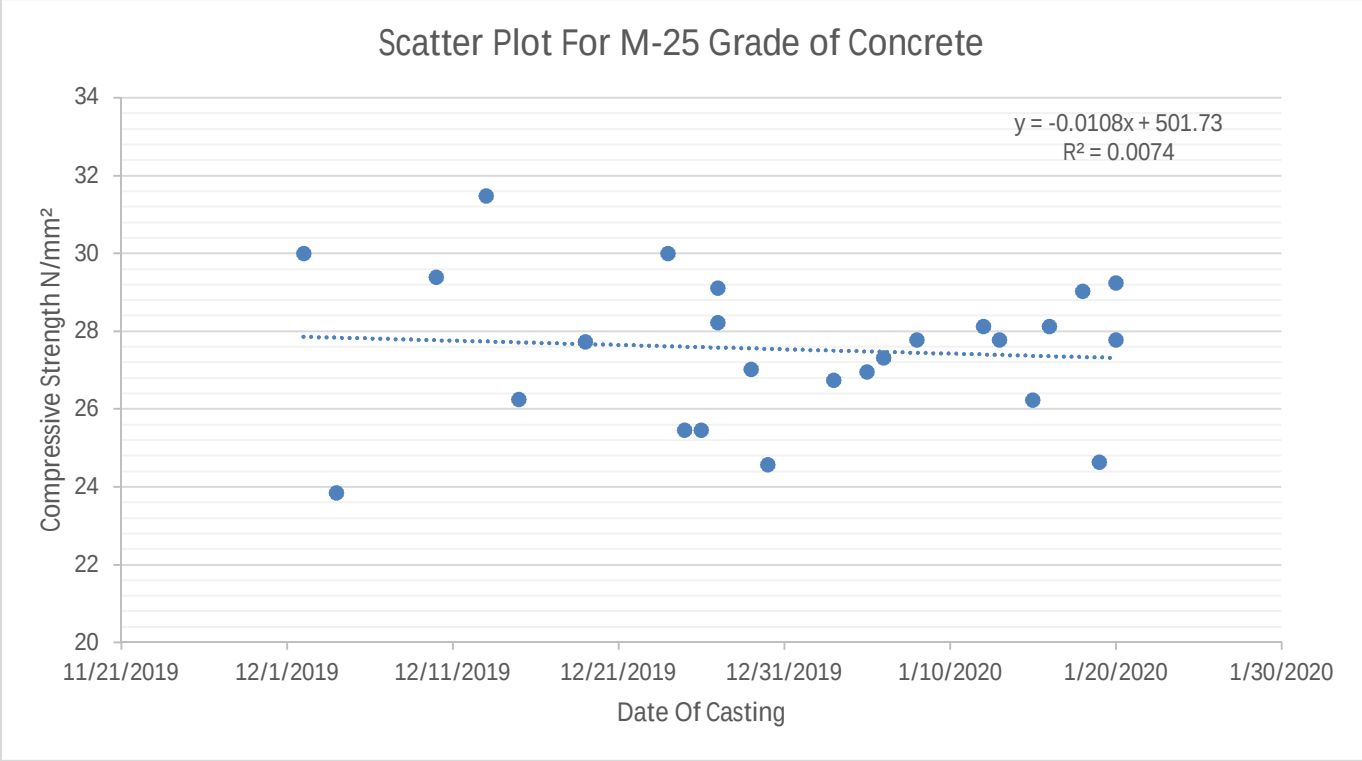

Figure 4: Scatter Plot for M-25 grade of concrete

C. Improve & Control Phase

From the statistical analysis of the data from the RMC plant & from various graphs it was clear that there was a poor quality management systems. The six sigma value of the process of RMC is very low. The process capability analysis shows process is not capable of delivering quality outputs. The control charts showed that there are variations from the mean values. DMAIC (Define-Measure-Analysis-Improve-Control) is a systematic, widely & easily implemented approach for measuring quality problems that are occurred in the process, calculating variations, findings the defects that are occurred in the process & their causes & also improving the process.

III. CONCLUSION

A. From the statistical analysis of compressive strength data of the M-25 grade of concrete the sigma level of the production process is found out to be 1.35, which is very low. The value of six sigma is low because of poor quality management at RMC plant.

B. The process capability (Cp) is 0.5 which is less than 1. This indicates that process is neither capable nor stable. The Cp values shows the poor performance the current process. The output from the process is not capable. It lack in terms of the quality parameters. The plant needs to reduce these variations in the process. Apply higher specification limits or discuss with customers. The adjustments are need to be made to centre the process. The plant should accept the loss & have to rework efficiently.

C. The control charts (X bar & R bar chart) were used to measure the performance of the process. Control charts showed process was out of control limits. Control charts showed some variations from the centre line of the data.

D. The coefficient of correlation (R^2) from the scatter plot diagram is 0.0074 which is far from 1. This value indicates that compressive strength with the time is very weak.

E. The Six Sigma DMAIC methodology can be applied to the RMC production process to figure out the root causes, eliminate that root causes & using quality tools such as fish bone diagram or SPC tools to improvise overall production process.

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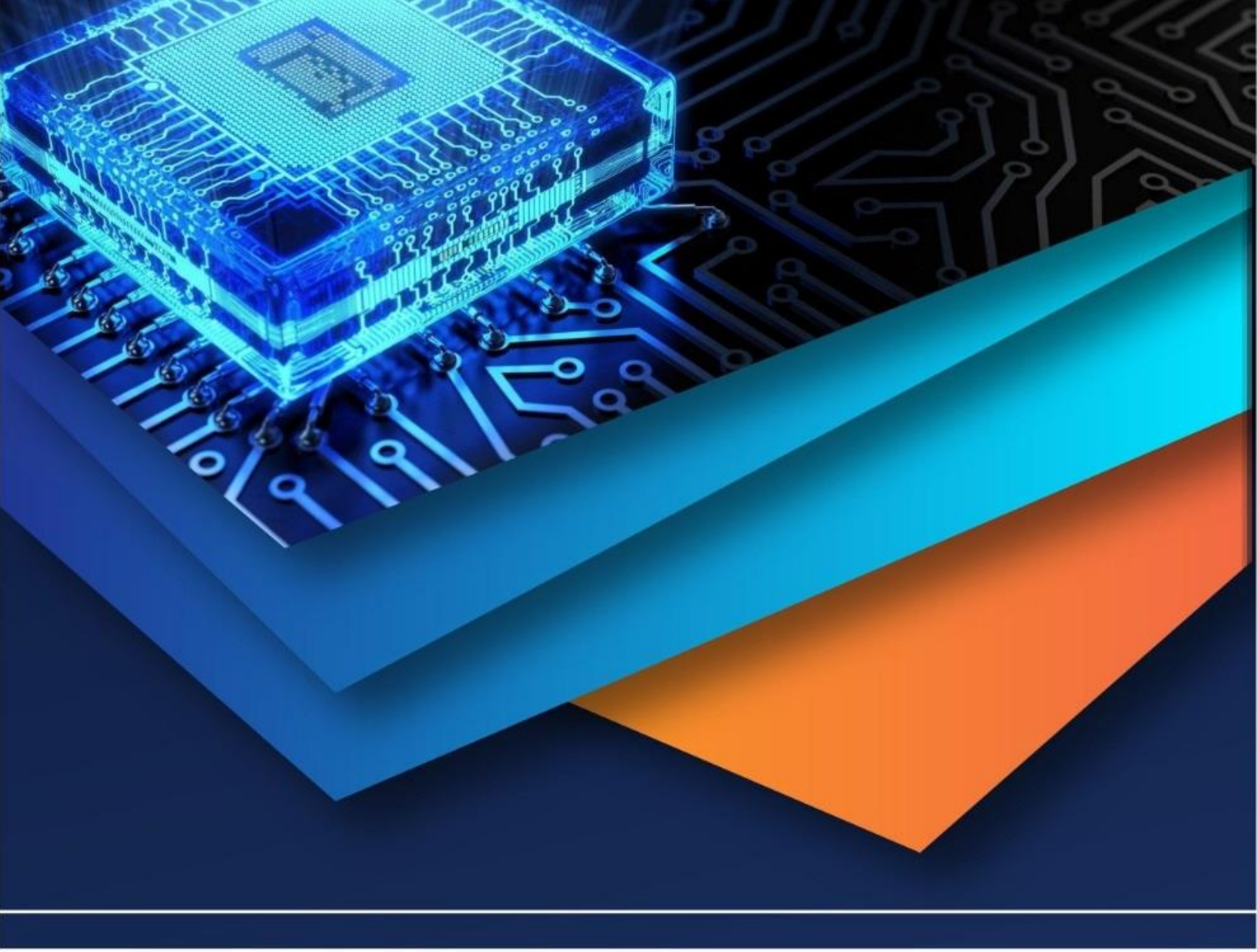

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