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Quality Control in Automobile Manufacturing Industries

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Abstract: ***An organization needs to manufacture high-quality products to stand apart from its competitors in today's immensely competitive manufacturing environment. A quality check not only molds a product free from manufacturing defects but also stimulates more consumers and hence aids the organization in ameliorating their profit expectations. To refine their product, manufacturers need to put in the application the established Quality Control tools. Several industries have successfully implemented Quality Control practices in the manufacturing sector to achieve superior quality, decrease product complaints, and increase sales. However, some companies still fail to execute this practice effectively. This paper's objective is to provide a basic understanding of core Quality Control tools, the necessary procedure, and the manufacturing defects encountered in an Automobile Manufacturing industry involving a Case Study showing the implementation of a Quality Control tool.***

Keywords: Quality Control, Automobile Manufacturing, Tolerance, Limits, Manufacturing Defects

I. INTRODUCTION

Generally, when a product is manufactured in any industry[1], the manufacturer keeps in mind that the conditions that the product may face during the practical usage can become too much harsh and may leave an adverse effect on the product life[2], so modifications are done in the product such that it withstands an extensive assortment of harsh conditions[3].

The same is the case of Automobile Manufacturing; in Automobile Manufacturing, the different parts of a vehicle are manufactured at different locations either in the manufacturing plant itself or by outside vendors, which supply various parts to the company[4] . These different parts are assembled on the Assembly Line of the plant[5] . When the automobile assembly begins, production control specialists track each automobile's progress through its Vehicle Identification Number (VIN), a unique number given to each vehicle at the start of its assembly[6] . The production managers control the manufacturing sequence by analyzing the assembly pace and keeping a record of each vehicle hence preventing the intermittent process flow. Also, throughout the assembly process, a track of information regarding the integrity of various functional components of the vehicle is kept[5] .

After assembly, a vehicle may seem to be in a fully functional state, but it is not. This state of the freshly assembled vehicle is still not fit to be used[7] . For instance, at the assembly line, during tire fixing, the tires are fixed by simply tightening the bolts, they are not correctly aligned, in almost all the cases[8] . After this 'raw' fixing, it is necessary to align the tire to prevent improper and deflected vehicle movement so that the vehicle moves in a proper direction following the proper calibration with the steering[9]. These kinds of fixtures are to be required in almost all from a simple to complex parts of the vehicle after the assembly[10] . A vehicle with defects may not only cause frequent breakdown and system failure but can also prove fatal for the riders[11] .

For making a Vehicle fit to be used and to fix defects, Quality Control is required after assembly. A properly applied Quality Checking procedure can easily spot manufacturing defects (both physical and technical). Quality Controlling ensures that every car leaving the factory is of the highest quality without any physical or technical manufacturing defects [12] . It meets the industry standards, for instance, for some components like Emission and Exhaust system, meeting the correct standards is very important.

"Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skillful execution; it represents the wise choice of many alternatives."

-William A. Foster

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II. METHODS AND TOOLS

Usually, the conditions during Quality Control tests and procedures are kept more severe than the actual conditions that exist to ensure that the vehicle does not break down even if adverse conditions. Various sensors and programs can quickly get the detailed measurement of a vehicle's response to a test. Various automatic quality checking machines are installed on the Assembly line itself where physical defects like improper welding and unaligned parts are detected because detection of defect at a later stage of manufacturing can lead to more costly and time taking repair process. Here is a summary of some tools that are used in Quality Control of a vehicle:

1) *Advanced Product Quality Planning (APQP):* APQP is a cluster of various methods and techniques used for product quality assurance by communicating various requirements, specifications, and risks (Quality One International, n.d.). It is similar to the concept of Design for Six Sigma (DFSS)[13] . Five phases of APQP are Pre-planning and input, Planning and defining, Product assignment and development, product designing and development, and Product process validation (Quality One International, n.d. Quality Core Tools Quality-One. [online] Available at: https://quality-one.com/quality-core-tools/ [Accessed 7 Jun. 2020).
2) *Failure Mode and effect analysis (FMEA)*: In FMEA, all the possible modes of failure which can transpire are determined, followed by the determination of their root and the result issues. A technical risk level of the result is assigned. If the risk level is found to be much elevated, steps are taken to diminish the risk by repairing the defect. Several factors utilized in FMEA development are Severity, Occurrence, Detection, and Risk Priority Number (RPN), Criticality. Subject matter experts (SME) use their experience to determine potential failure modes (Quality One International, n.d. Quality Core Tools Quality-One. [online] Available at: https://quality-one.com/quality-core-tools/ [Accessed 7 Jun. 2020]).
3) *Measurement Systems Analysis (MSA)*: MSA is an experimental and a mathematical method that is used for calculation of variation within the measurement process, which contributes to overall process variability. MSA looks for five distinct parameters i.e., Bias, Linearity, Stability, Repeatability, and Reproducibility. Acceptance is based on two parameters: (a) percent error in tolerance limit and (b) percent error in variation (Quality One International, n.d. Quality Core Tools Quality-One. [online] Available at: https://quality-one.com/quality-core-tools/ [Accessed 7 Jun. 2020]).
4) *Statistical Process Control (SPC)*: SPC is a collection of statistical techniques intended to understand the exploits of a system. SPC uses central tendency i.e., Mean, Median, and Mode, as well as Variation and Standard deviation to control the quality and determine errors (Quality One International, n.d. Quality Core Tools Quality-One. [online] Available at: https://quality-one.com/quality-core-tools/ [Accessed 7 Jun. 2020]).
5) *Product Part Approval Process (PPAP)*: PPAP is a standardized process in the automotive and aerospace industries. It is the industry standard that ensures that engineering design and product specification requirements are without any flaw. It also helps to ensure that the process selected to manufacture parts can consistently reproduce parts at planned production volumes without any delay. A Cross Function team (CFT) is needed to complete PPAP documentation. The elements require input from (a) Supplier procurement and subcontracts (b) Design engineering (c) Processing and Manufacturing engineering (d) Quality Assurance and control (e) Manufacturing Operations (f) Lab Activities (Quality One International n.d. Quality Core Tools Quality-One. [online] Available at: https://quality-one.com/quality-core-tools/ [Accessed 7 Jun. 2020]).

III. MANUFACTURING DEFECTS IN AUTOMOBILES

The following are various inspections that are done to find the defects in an assembled vehicle during the vehicle Quality Control process :

A. Exterior Inspection
B. Interior Inspection
C. Paint Inspection
D. Functions Inspection
E. Engine Room Inspection
F. Physical Functions Inspection
G. Under-body Testing
H. Track/Road Test
I. Shower Test

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Table 1: Defects to look out for

S.No	Type of Checking	Defect type
1	*Exterior Inspection*	● Alignment ● Parts Gap ● Fitting ● Flushness ● Part Mismatch ● Model Mismatch ● Missing Bolts/Clips ● Scratches ● Looseness
2	*Interior Inspection*	● Parts Fitting ● Parts Gap ● Part-Model Mismatch
3	*Paint Inspection*	● Dents ● Lints ● Air Bubbles ● Chip off ● Paint peel off ● Under paint ● Dust ● Thin Paint ● Tool Mark ● Color Mismatch ● Missing Paint
4	*Functions Inspection*	● Lights ● Door Glasses ● Central and Remote locking
5	*Engine Room Inspection*	● Fitting of Engine parts ● Oil Leakage
6	*Physical Functions Inspection*	● Wheel turning angle error ● Speedometer reading error
7	*Under-body Testing*	● Looseness of parts
8	*Track/Road Test*	● Low Reliabilty and Robustness on rigorous road conditions
9	*Shower Test*	● Leakage in cabin or hood or boot

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IV. CASE STUDY

A case study was conducted in the Vehicle Quality checking department of an automobile manufacturing industry in Greater Noida.

V. OBJECTIVE

The objective of this project is to demonstrate how we can implement Quality Control tools to determine the defects and eliminate them so that a better quality product is obtained.

VI. ABOUT

The demands on car bodywork are increasing, not only from a technical viewpoint but also with regards to the optical design. Therefore, physical flaws such as uneven gaps and flushness can be detected easily by the eye of the prospective buyer. The usual approach for gap and flushness measurement is to use manual feeler gauges which is not only time-consuming but also inaccurate and expensive. This method is prone to error due to human factors, which is why the gap sensor is used in modern production lines to inspect the body quickly, reliably, and consistently. Apart from appearing as a visual flaw, a higher error in Gap and Flushness also affect the aerodynamic performance of the vehicle because of the unevenness achieved hence degrading its fuel efficiency.

Following defects were looked out for:

1) *Gap*: It is the error in distance between 2 components of a vehicle like Door to door gap. Gap between different components must be withing the specified limits.
2) *Flushness* : It is the error in the alignment of 2 surfaces. Flushness of parts must also be under specified limits.

Various places where Gap and Flushness can be checked are :

a) Fender and Bumper
b) Hood and Fender
c) Door and Fender
d) Door and Door
e) Door and Side Panel
f) Bumper and Side Panel
g) Trunk and Panel

Out of the above mentioned places Fender to Bumper and Trunk to Panel Gap/Flushness are being taken into account. First the error measurement before Quality Control were done and plotted followed by the measurement after Quality Control.

Table 2: Acceptable Limits

Place	Defect Type	Acceptable Limit
Fender to Bumper	Gap	0 to 1 mm
Fender to Bumper	Flushness	0.15 to 0.25 mm
Trunk to Panel	Gap	3.4 to 4.4 mm
Trunk to Panel	Flushness	0.85o 1.85 mm

A. Errors Before Quality Control

1) Abbreviation used

a) LH- Left Hand (Indicating Left-hand side of the car)
b) RH- Right Hand (Indicating Right-hand side of the car)
c) DLH- Deviation on Left Hand
d) DRH- Deviation on Right Hand

2) Quality Control Tools Used

a) MSA (Measurement System Analysis)
b) SPC (Statistical process Control)

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Table 3: Bumper to Fender Gap

Car No	LH	RH	DLH	DRH
1	1.2	1.2	0.2	0.2
2	0.7	1.1	0	0.1
3	1.3	1.2	0.3	0.2
4	0.9	1.3	0	0.3
5	1.4	1.2	0.4	0.2
6	1.7	1.8	0.7	0.8

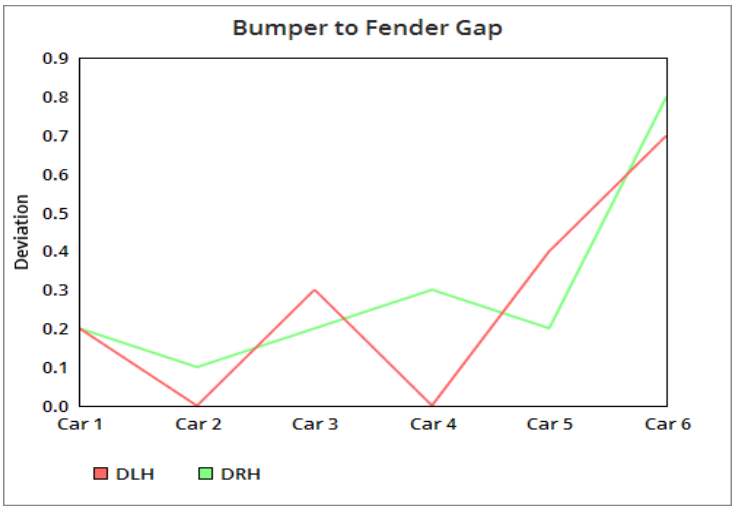


Table 4: Fender and Bumper Flushness

Car No	LH	RH	DLH	DRH
1	0.2	0.4	-0.05	-0.05
2	0.1	0.4	0	-0.05
3	0.1	0.4	-0.05	-0.05
4	0.1	0.4	-0.05	-0.05
5	0.2	0.4	0	-0.05
6	0.1	0.1	0	0

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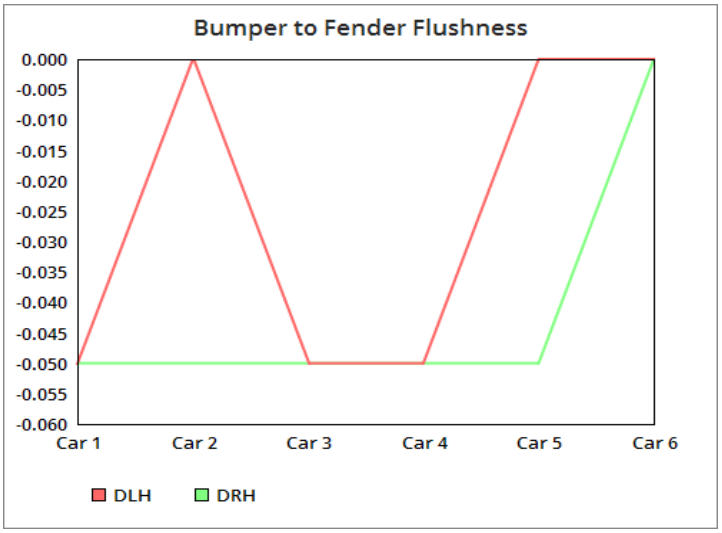
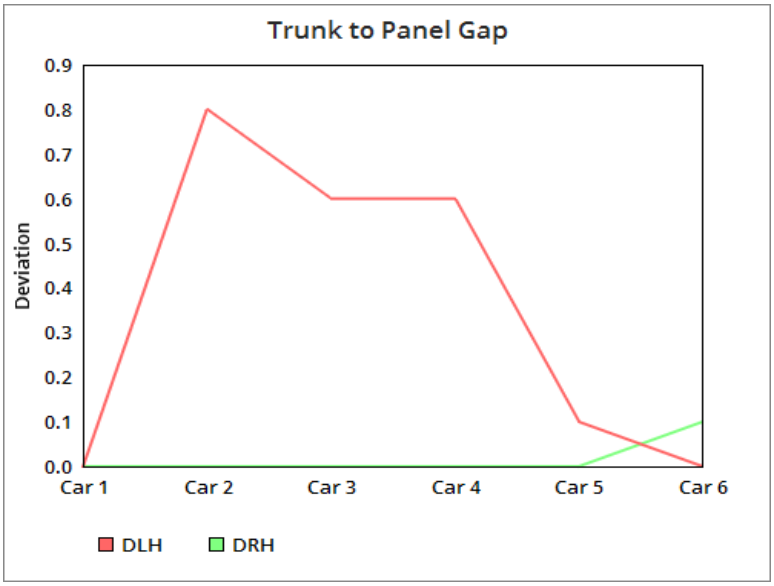


Table 5: Trunk to Panel Gap

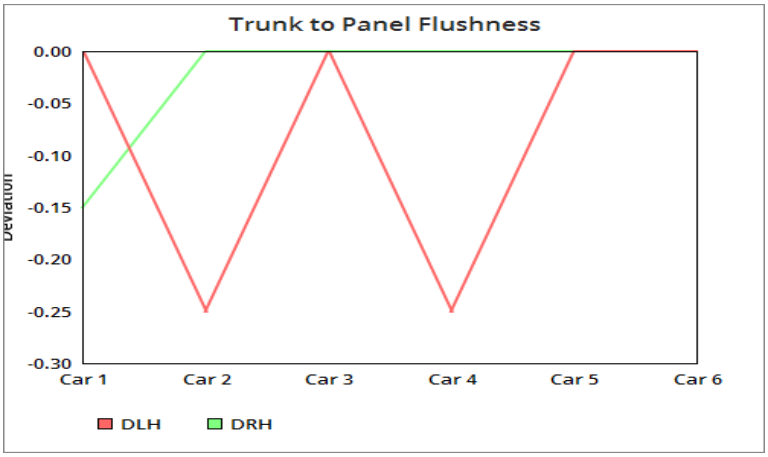
Car No.	LH	RH	DLH	DRH
1	3.8	4.4	0	0
2	5.2	3.8	0.8	0
3	5	4	0.6	0
4	5	4.2	0.6	0
5	4.5	3.9	0.1	0
6	4.1	4.5	0	0.1



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Table 6: Trunk to Panel Flushness

Car No	LH	RH	DLH	DRH
1	1.2	0.7	0	0.15
2	0.6	1.1	-0.25	0
3	1.5	1	0	0
4	0.6	1.1	-0.25	0
5	1.5	1	0	0
6	1.5	1.5	0	0



B. Errors After Quality Control

Table 7: Bumper to Fender Gap

Car No	LH	RH	DLH	DRH
1	0.8	0.8	0	0
2	1	1	0	0
3	0.6	0.7	0	0
4	1.1	1	0.1	0
5	0.7	0.7	0	0
6	0.5	1	0	0

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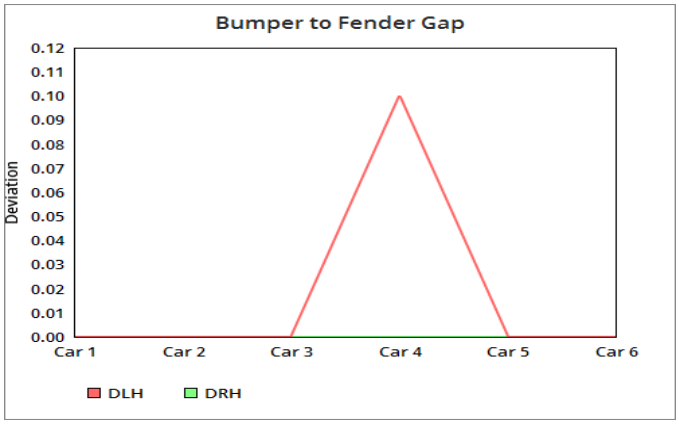
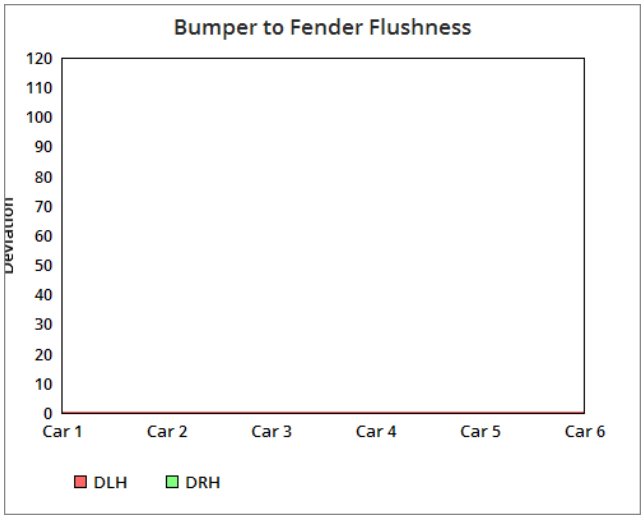


Table 8: Bumper to Fender Flushness

Car No.	LH	RH	DLH	DRH
1	0.5	0.2	0	0
2	0.4	1	0	0
3	1	1	0	0
4	0.2	0.3	0	0
5	0.5	0.5	0	0
6	0.3	0.2	0	0



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Table 9: Trunk to Panel Gap

Car No	LH	RH	DLH	DRH
1	4.3	4.4	0	0
2	4.2	4.1	0	0
3	3.9	3.6	0	0
4	4.2	4.1	0	0
5	4.2	4.2	0	0
6	3.5	4.4	0	0

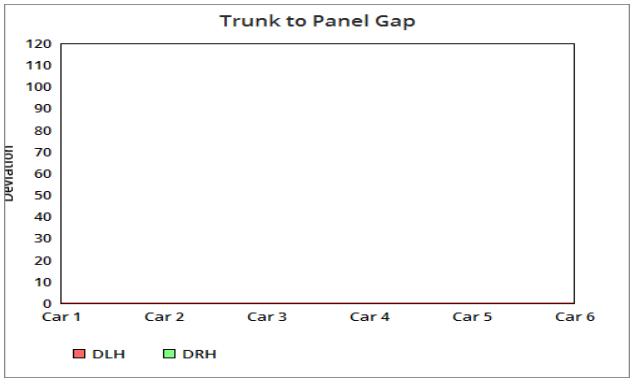
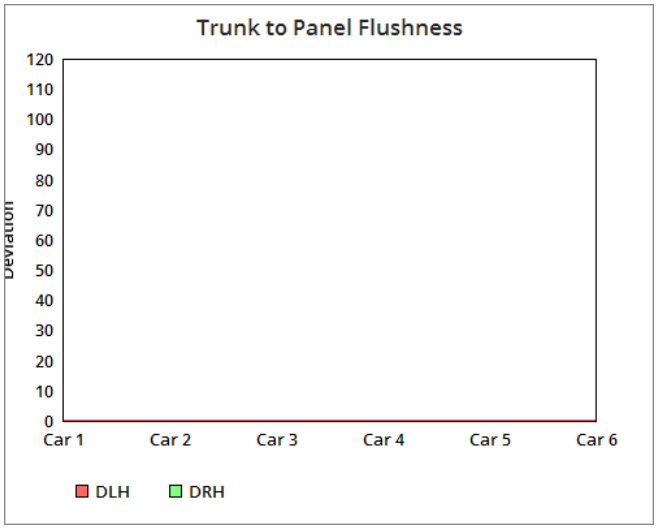


Table 10: Trunk to Panel Flushness

Car No.	LH	RH	DLH	DRH
1	1.8	1.8	0	0
2	1.6	1.7	0	0
3	1.3	1	0	0
4	1.2	1	0	0
5	1	1.5	0	0
6	1.5	1	0	0

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No deviation from the accepted tolerance limit was observed in the plots of table 8,9 and 10.

VII. DISCUSSIONS

Quality Control has a Herculean set of tools, methods and principles that when properly applied, can accomplish superior organizational-management and also financial goals. Its implementation principles must be appertained in the comprehensive industrial system to get more significantly the effects in workplaces and effective production systems. Producers who have successfully implemented Quality Control are lowering service costs, improving efficiency in productivity, and improving quality. Ultimately, producers following Quality Control principles will grow, inspiring new producers for embracing these techniques. Achieving these results requires a company to bring in a lot of effort and changes, which is strenuous, but in the long run, can give the most exceptional results. The most crucial ingredient for success is that constant improvement must become business cantillation, adopted by workers at all tiers and reinforced by the management system.

VIII. RESULTS

The improved graphs are showing very less or almost no deviation outside the tolerance zone after going through the Quality Control process as compared to the deviations observed before Quality Control of the vehicle. Elimination of the defects is observable. The necessary tools, i.e. MSI and SPC and processes like hammering and pressing, were implemented in the process to reduce these defects. The detection followed by repair and elimination of flaws is by making the process improvements in the current manufacturing line by embracing some Quality Control tools like MSA and SPC in this case.

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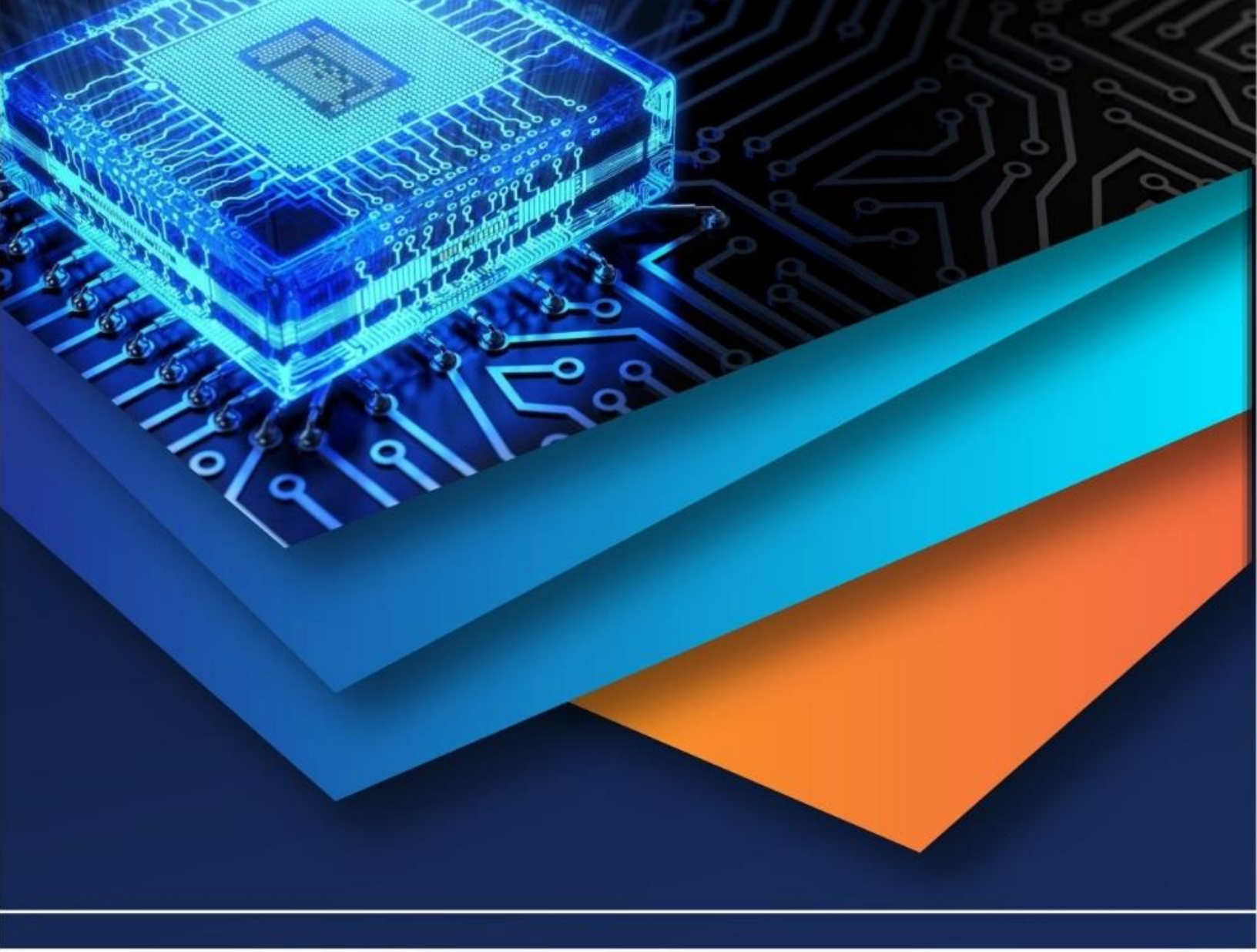
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