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Evaluation and Visualization of surface Defects on Automotive Body Panels by Root-Cause Methodology

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Abstract: ***The evaluation analysis leads a best approach to detect defects categorized as dents and scratches on car body surfaces, which is currently one of the most important issues facing quality control in the automotive industry. Defect analysis and prevention is an activity that influences the entire development life cycle of the product surface. The problem was explored using the principle of 6M. Using the fish bone diagram various causes and effects of the problem were analyzed. Systematically review factors that affect or contribute to a given problem or effects will be identified and the probability of the causes is derived to meet the quality assurance of the surface defects. Inline verification for 6M principle was done to find all the possible causes – Man, Machine, Material, Method, Morale and Measurement which contributed to the rejections. To ensuring a systematic defect prevention process and to introduce a quantifiable approach to measure the effectiveness of the defects through a scoring model. From the real time analysis, it exposes various stations and their methodology where detailed report was generated examining all the possible causes leading to the rejections. Finally, minimize the rejection of products, cost of reworks and time of reworks increasing the productivity of assembly shop.***

Keywords: 6M principle, rejection of products, cost of reworks, time of reworks

I. INTRODUCTION

Minimization of reworks during production in plants very difficult and spend more amount of money. Three type of reworking cost consumption in production line are, 1. Rejections in assembly line collection of Rejection details from assembly reveals that touch up and chassis repair alone contributes for 50% of rejections that is what we indicated in the above bar diagram by dotted lines. Nearly 80580 quantity was rejected in touch up section and 42660 was rejected in chassis repair, 2. Cost of rework in assembly line the cost of rework in assembly line reveals that touch up alone contributes for 50% of total cost of rework. So, the touch up section alone contributes most of the cost reworking process. Amount invested for rework in touch up section is around 141.82 lakhs. The chassis repair work cost around 62.71 lakhs, whereas the road test, ok line, trim section, shower cost only minor percentage of total rework cost.3. Time of rework in assembly line Collection of time of rework in assembly line reveals that touch up alone contributes for 55% of total time of rework. The time spent for rework process in touch up section is about 40290(in hours) whereas in chassis the time spent for rework process is about 17775(in hours). Laura Arnal et al.,[1] In this paper, a new vision algorithm based on deflectometry techniques for detecting dings and dents on specular surfaces in general, and car body surfaces in particular, has been presented. This approach is based on the information obtained by reflecting a light pattern on the specular surface to detect structural deformations thereon. Jaime Molina et al., [2] these techniques is based on the information obtained by reflecting a light pattern on the specular surface to detect structural deformations thereon. Hauke Baumgärtel et al.,[3] sensor system for the detection and classification of minor damages in vehicle bodies is currently under development in the research project Sergei Gontscharov et al., [4] The approach presented in this article, dealing with the validation of detected damage to a vehicle body by means of a sensor node network. It requires expert knowledge as a foundation for the logical combination between the calculated damage data of the sensor nodes and additional vehicle information from the control CAN bus Johannes Macher et al., [5] Phase Measuring Deflectometry was applied for the detection of visually perceptible sink marks on high-gloss surfaces. The major advantage of this method is its working principle

II. PROBLEM DEFINITION

At the final stage of quality inspection for the surface morphology of the body structure, some real time defects are identified and this brings bottleneck for the final dispatch of the product. The term defects always relate to one or more fundamental faults in an artifact. A defect might originate in one development stage and be perceived in the same or a future stage. Major identified defects are grouped into

A. Types

The types of touch up reworks are

1) *Dent:* A depression in a surface made by a pressure or a blow is called dent. Dent may be caused due mishandling of tools i.e. man related problems, method and also due to tool slippage. Dent is commonly seen in aperture, right and front left door, side outer, silpanel etc.
2) *Scratches:* To make a thin shallow cut or mark the surface by rubbing, scraping or tearing with something sharp or rough is known as scratch. Scratches are also due to man related problems (due to tool slippage, wearing rings, buckle belt). Scratches are also commonly seen in right and front left door.

B. Measurable Of Rejection

1) *Cost of Rework:* Rework cost is the standard or actual cost that is spent on correcting defective work. Rework cost is an unnecessary and additional cost, which affects overall operating costs.
2) *Quantity Rejected:* The number of quantities rejected is taken into account and thus they form the parameter for the measurable of rejection.
3) *Time Taken to Rework:* The total time spent for the rework or touch-up also comes under the measurable of rejections.

III. PROBLEM DETAILS

A. Data Collection Method

The data for the problem analysis were collected from touch up line through personal examination and with the help of record sheets from touch up line.

B. Observation

The lines were observed from 15th February 2017 to 28th February 2017. The car body that are prone to dents and scratches were divided into 20 different regions for easy segregation of the area that is of major interest and the observations are as follows

1) Scratches

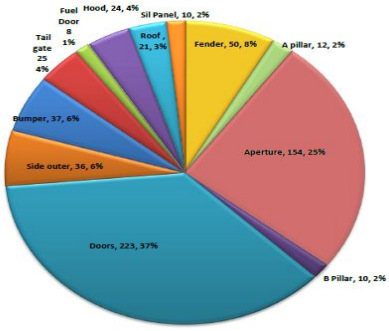

Figure 1 Scratch Area Wise Distribution

2) Dents

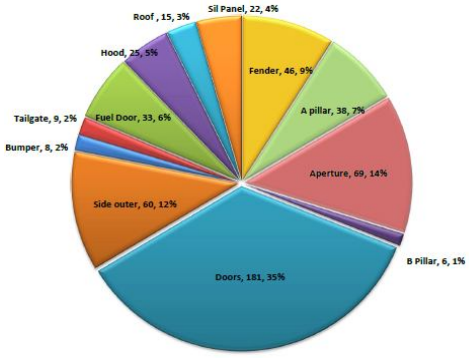

Figure 2 Dent- Area wise distribution

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IV. EFFECTS OF PROBLEM

A. Cost Of Rework

The number of rejections noted for duration of ten days from 15th February to 28th February resulted in 512 dent problems and 612 scratch problems respectively. This totaled to 1122 rejects. With the indicative average rework cost per reject in the touch-up line being Rs 142, the total amount spent on the rework of 1122 rejects amounted approximately to Rs 1, 59,324.

B. Time Of Rework

It is noted that the company spends an average of 30 minutes to rework every rejection. Using the information available we find that the company, during the period of ten days from 15th February to 28th February, uses approximately 305 man hours to rework the rejections due to scratches and another 256 man hours to rework the rejections due to dents.

C. Projected Time

The company spends approximately 763 man hours per month to rework the rejections due to scratches and 640 man hours to rework the rejections due to dents. This sums to approximately 1402 man hours per month. This shows that 9150 man hours and 7680 man hours is used per year to rework every rejection due to scratches and dents respectively. Hence it is known that company exhausts approximately 16830 man hours annually to rework rejections due to dents and scratches.

V. PROBLEM APPROACH

A. 6M Analysis

This fishbone diagram is prepared using 6M principle of Toyota Production System (TPS). The potential causes for
Inefficient Time Management are contributed by Man / People, Material, Method /Process and Measurement. Our solution tries to address these elementary level causes as much as possible. After the problem was identified the group was split into two. One group analyzed the causes for dents and the other identified the causes for scratches. The fish bone diagram is depicted below. Linear analysis was done in various stations across the plant.

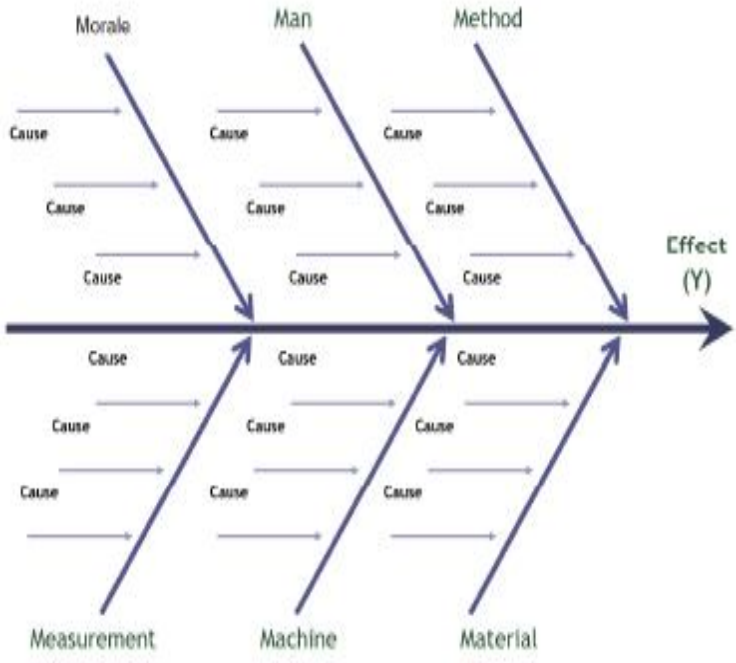

Figure 3 Fish Bone Diagram

6M analysis was carried out each and every station of the different lines through personal examination of the works. The operations of the workers, the tools used, the materials used were observed thoroughly.

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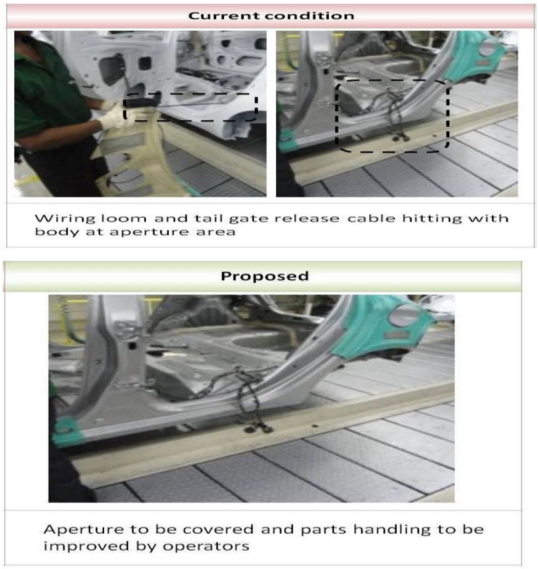
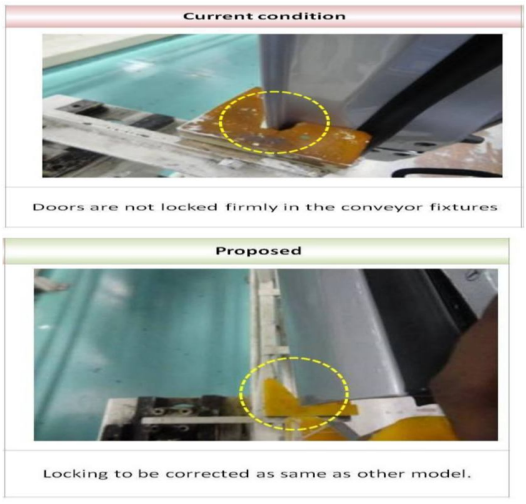
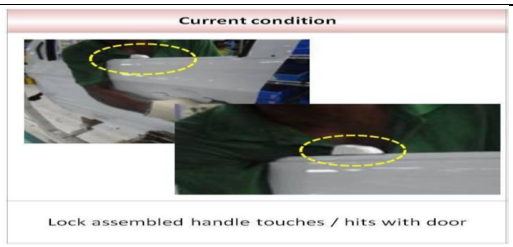
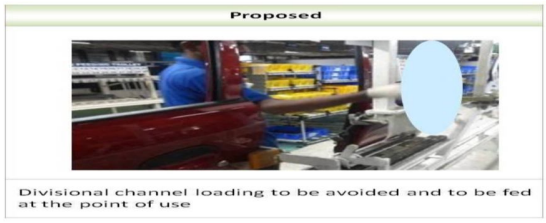
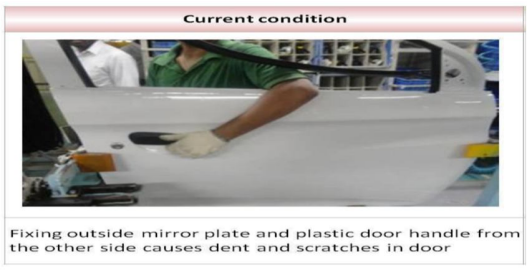
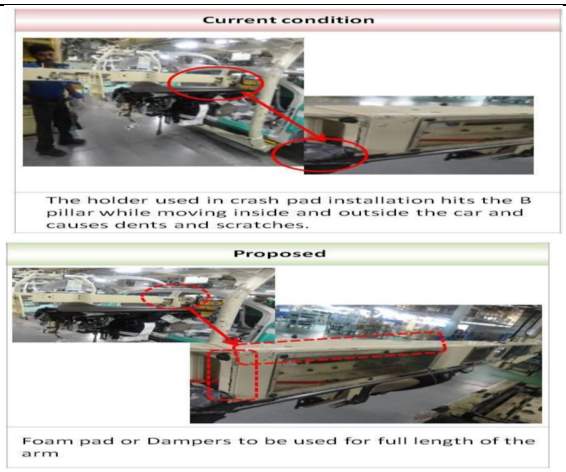
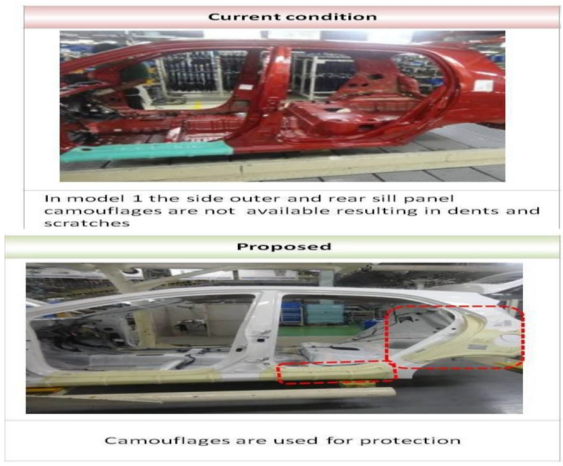
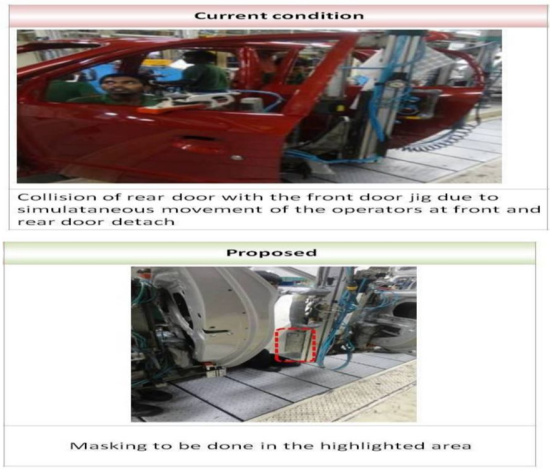
B. Observations

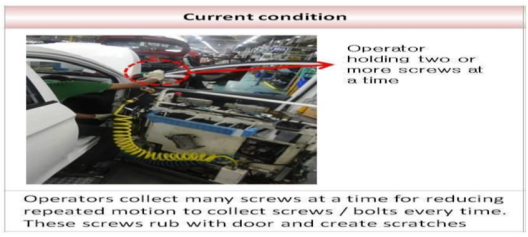
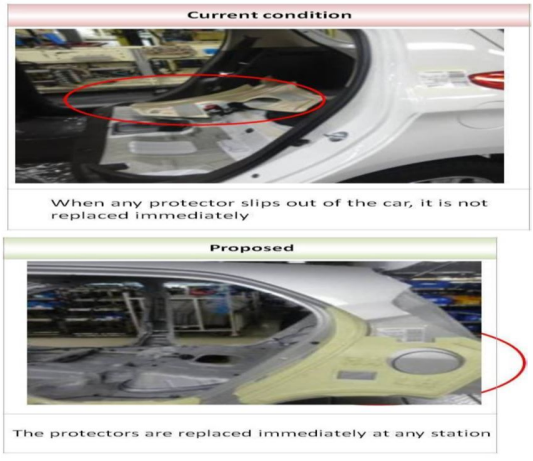
Table 1 Root cause analysis

Ob no	Cell	Critical parts	Problem	Effect
1	Trim 1 6M Methodology METHOD	Wiring Loom	Aperture covering done after the parts loading into the body	Scratches at aperture 
2	Trim 1 6M Methodology METHOD	Tail gate release cable	Tail gate release cable & wiring loom hitting with aperture	Aperture dent 
3	Door sub assembly 6M Methodology METHOD	Door	Doors are not tightly locked, easily shaking	Dent at edges 
4	Door sub assembly 6M Methodology	Outside handle	Lock assembled handle kept over the door	Scratch at door

	METHOD			 Proposed : Should not be kept over the door
5	Door sub assembly 6M Methodology METHOD	Divisional channel	Part kept over the fixture in previous station to assembly station through the gap between 2 doors	Scratch at door  
6	Door sub assembly 6M Methodology METHOD	Divisional channel	Divisional channel hitting with the door during sub assembly of channel with runner	Scratch and dent  
7	Door sub assembly 6M Methodology METHOD	Divisional channel	Outside mirror plate and O/Side handle hitting with door	Scratch 

				Proposed  Camouflage for the shaded area of doors supported at the side edges
8	Final 3 6M Methodology METHOD	Sill panel	Removal of Sill Protectors at beginning of final 3	Scratch and dent Current condition  Removal of Sill Protectors causes sill panels scratches or dents during the door and seat assembly that are carried out in the consecutive stations Proposed  Sill panel protectors are retained till final station for all other models .
9	General 6M Methodology METHOD	Side outer	Absence of magnetic holders in some protectors	Scratch and dent Current condition  Protectors without magnet tends to slip which leads to dents and scratches Proposed  The magnetic pad restored in those protectors
10	Chassis 1 6M Methodology MACHIN	B Pillar	Crash pad installation holder hits the B pillar	Scratch and dent

	E			
11	Chassis 1 6M Methodology METHOD	B Pillarl	Crash pad installation holder hits the B pillar	Scratch and dent 
12	Trim 1 6M Methodology MACHINE	Doors	Collision of door and jigs during door detach	Scratch and dent 
13	Trim 2 6M Methodology METHOD	Aperture, Side outer	Striker installation	Scratch

				
14	Final 3 6M Methodology MAN	Aperture, Door	Operators handling many screws at a time	Scratch  Proposed : Operators can be given an apron with pockets to take screws instead of having screws in hand
15	Final 3 6M Methodology MATERIAL	Aperture, B-Pillar	The metal part of the seat belt hits the body Parts	Scratch  Proposed : The metal part of the seatbelt is covered with a plastic cover
16	General 6M Methodology MAN	Aperture, Side outer	Replacing foam pads	Scratch 
17	Final 3	Aperture, Door	Operators	Scratch

	6M Methodology MAN		handling more than one tool at a time	 Proposed: 1. Operators to handle 1 tool at a time 2. Tools to be placed at correct holders
18	Trim 1 6M Methodology MAN	Door	Door lift during door detach	Scratch  Proposed : Operators carry out a controlled motion to load the doors
19	Final 3 6M Methodology MATERIAL	Aperture	During door installation the check arm hits the aperture	Scratch and Dent  Proposed : Plastic/rubber cap is provided on the checker arm head

VI. STUDY ANALYSIS

Total number of observations made = 22
Total number of observations attributed to MAN = 5
Total number of observations attributed to METHOD = 13
Total number of observations attributed to MACHINE = 2
Total number of observations attributed to MATERIAL = 2
Total number of observations attributed to MORALE = 0
Total number of observations attributed to MEASUREMENT= 1

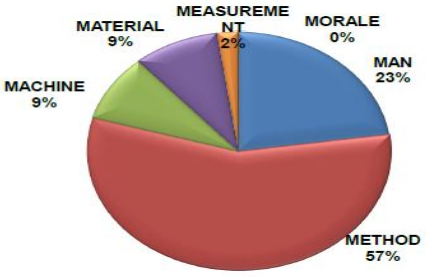


Figure 4 Chart representation of study result

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VIII. APPROVED BENEFITS

The corrective measures offered to MAN resources were not expected to be completely successful throughout since it is highly susceptible to change from person to person and all the corrective measures offered for MACHINE, MATERIAL, METHODS, MEASUREMENT approved 100% results. 25 working days a month is used for projecting the observation to annual scale.

A. Reduction In Quantities Rejected

1) Scratches

Total number of scratches observed in Door area = 223
Total number of scratches in doors after improvement = 56 (75% avoided)
Total number of scratches observed in Aperture area = 154
Total number if scratches in apertures after improvement = 38 (75% avoided)
Total number of scratches in all other areas = 233
Total number of scratches in other areas after improvement = 117 (50% avoided)
Total number of scratches observed in 10 days = 610
Total number of scratches after improvement = 211
Reduction in number of scratches = 399 nos. (For 10 days)
Reduction in number of scratches = 399*2.5
Reduction in number of scratches = 998 (Per Month)
Reduction in number of scratches =998 *12
= 11790 nos. (Per Annum

2) Dents

Total number of dents observed in Door area = 181
Total number of dents in doors after improvement = 45 (75% avoided)
Total number of dents observed in Aperture area = 69
Total number if dents in apertures after improvement = 17 (75% avoided)
Total number of dents in all other areas = 262
Total number of dents in other areas after improvement = 131 (50% avoided)
Total number of dents observed in 10 days = 512
Total number of dents after improvement = 193
Reduction in number of dents = 319 (for 10 days)
= 319*2.5
Reduction in number of dents = 798 (Per Month)
Reduction in number of dents = 798 * 12
= 9570 nos. (Per Annum)

B. Reduction In Time Of Rework

The time of rework (Man hours) is directly related to the quantity rejected. Therefore the time of rework for dents and scratches in door and aperture areas are reduced by 75% and for other areas it is reduced by 50%. The time of rework for a unit scratch/dent provided by Hyundai Motor India Ltd. is 30 minutes.

1) Scratches

Time of rework for scratches in Door areas = 112 hrs.
Time of rework for scratches after improvement = 28 hrs. (75% avoided)
Time of rework for scratches in Aperture areas = 77 hrs.
Time of rework for scratches after improvement = 19 hrs. (75% avoided)
Time of rework for scratches in other areas = 116 hrs.
Time of rework for scratches in other areas after improvement = 58 hrs. (50% avoided)
Total time of rework for scratches = 305 hrs. (For 10 days)
Total time of rework for scratches after improvement = 105 hrs.
Total time of rework saved = 305-105 = 200 hrs. (For 10 days)
= 200*2.5

Total time of rework saved = 500 hrs. (Per Annum)
= 500*12
Total time of rework saved =6000 hrs. (Per Annum)

2) Dents

Time of rework for dents in Door areas = 91 hrs.
Time of rework for dents after improvement = 23 hrs. (75% avoided)
Time of rework for dents in Aperture areas = 35 hrs.
Time of rework for dents after improvement = 9 hrs. (75% avoided)
Time of rework for dents in other areas = 130 hrs.
Time of rework for dents in other areas after improvement = 65 hrs. (50% avoided)
Total time of rework for dents = 256 hrs. (For 10 days)
Total time of rework for dents after improvement = 97 hrs.
Total time of rework saved = 256-97 = 159 hrs. (For 10 days)
= 159*2.5 47
Total time of rework saved = 398 hrs. (Per Month)
= 398*12
Total time of rework saved = 4770hrs. (Per Annum)

a) Reduction Of Rework Cost

Cost of rework for a unit scratch/dent provided by Hyundai Motor India Ltd. Was Rs.442

i) *Scratches:* No. of scratches avoided after improvement = 11970 (per annum) Cost of rework saved after improvement =11970*442=Rs.52.9 lakhs (approx.)

ii) *Dents:* No. of dents avoided after improvement = 9570 (Per Annum) Cost of rework saved after improvement =9570*442=Rs.42.3 lakhs (approx.)

X. CONCLUSION AND DISCUSSION

Thus, the measurable of rejections are improved to a great extent and considerably reducing the quantities rejected, the cost of rework and the time of rework thereby increasing the productivity of assembly shop 1. The results are

Quantity rejected per annum as per projection = 33,660 nos.
Quantity rejected per annum after improvement = 12,300 nos.
Number of rejects REDUCED per annum = 21,360 nos.
Time of rework per annum as per projection = 16,830 hrs.
Time of rework per annum after improvement = 6060 hrs.
Time of rework SAVED per annum = 10,770 hrs.
Cost of rework per annum as per projection = Rs. 1.48 crores (approx.)
Cost of rework per annum after improvement = Rs. 52.8 lakhs (approx.)
Cost of rework SAVED per annum = Rs. 95.2 lakhs (approx.)

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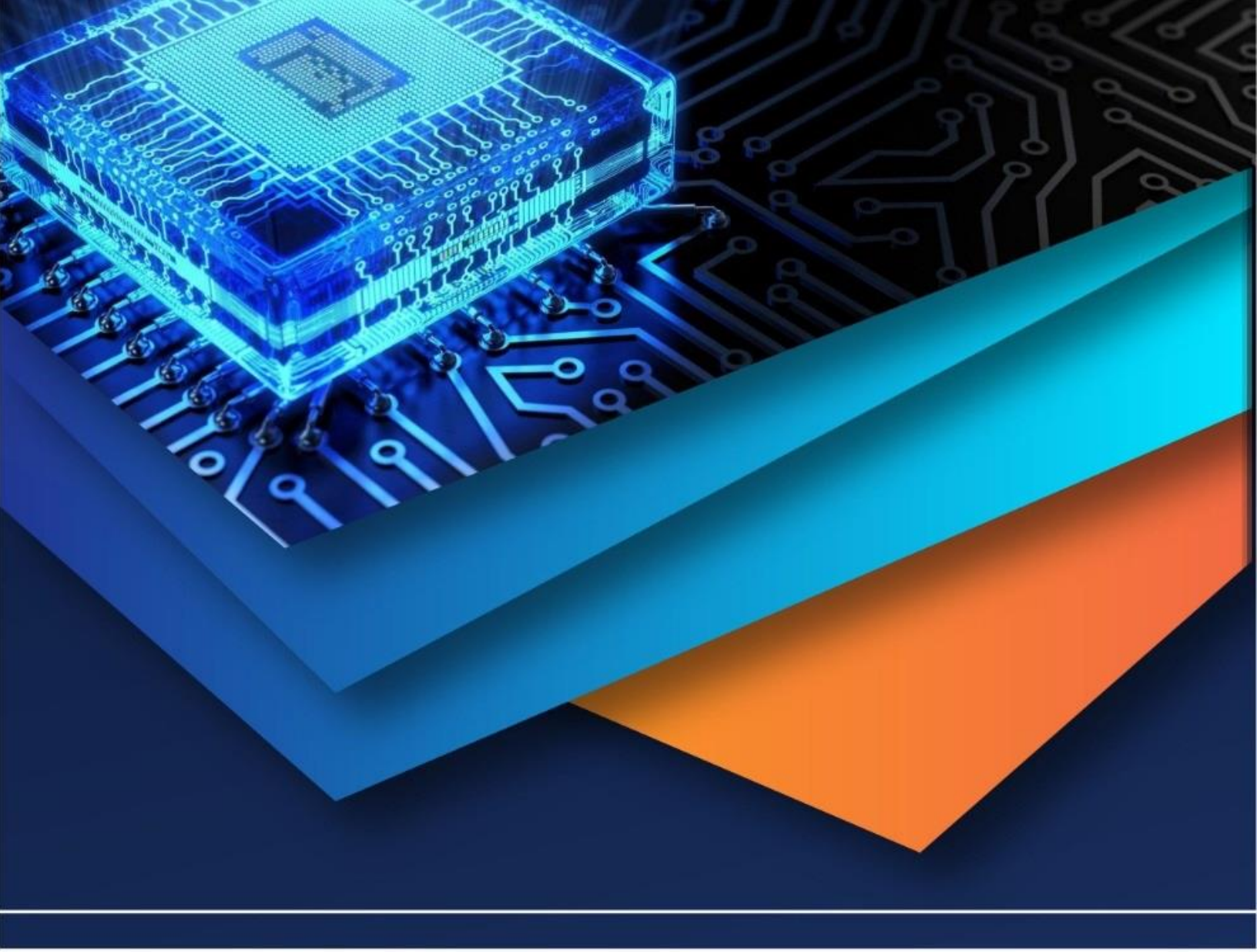

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