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Design, Analysis and Shape Optimization Disc Brake by Using Thermal Analysis and Practical Testing

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Abstract: The disc brake is a device for slowing or stopping the rotation of a wheel. Friction causes the disc and attached wheel to slow or stop. Brakes convert friction energy into heat energy and this heat will be transfer to the disc. By using disc heat is send to air. For sending heat to air disc having cut section and hole on surface to improve heat transfer. In this paper we work on to improve heat transfer to air by using shapes. We work on original disc brake and developed five new shape for analysis. When we do the thermal analysis we found that one disc having better result than original one. So we final this disc for manufacturing and we test both disc.

Keywords: Thermal analysis, heat transfer, disc brake, shape optimization.

I. INTRODUCTION

The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc (or rotor) usually made of cast iron or ceramic composites (including carbon, kevlar and silica), is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads (mounted on a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Most modern cars have disc brakes on the front wheels, and some have disc brakes on all four wheels. This is the part of the brake system that does the actual work of stopping the car. In today's growing automotive market the competition for better performance vehicle in growing enormously. The racing fans involved will surely know the importance of a good brake system not only for safety but also for staying competitive As we are aware of the fact that races are won over split of a second therefore the capacity of the brake system to slow down quickly at turns or corners is very important The brakes designed for the purpose of racing need to have very high braking efficiency. The wear and tear of the pads or the cost is not of great concern to the manufacturer of the racing car brakes.

A. Principle of working

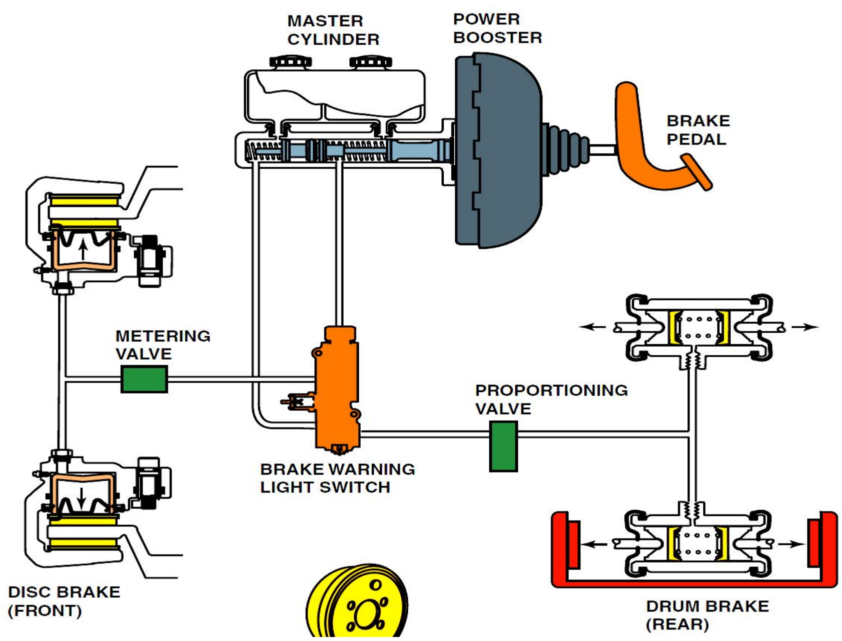


Fig.1. Principle of working of disc brake

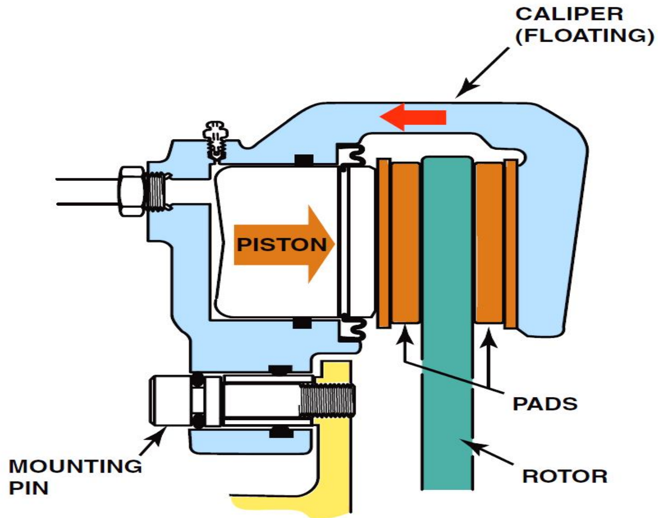


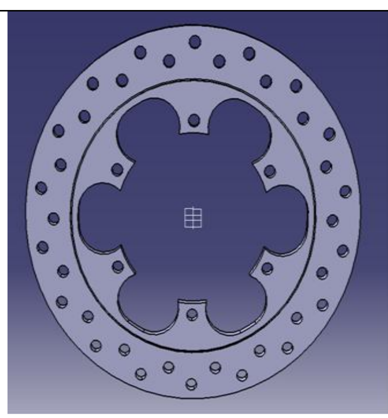
Fig. 2 single-piston floating calliper disc brakes

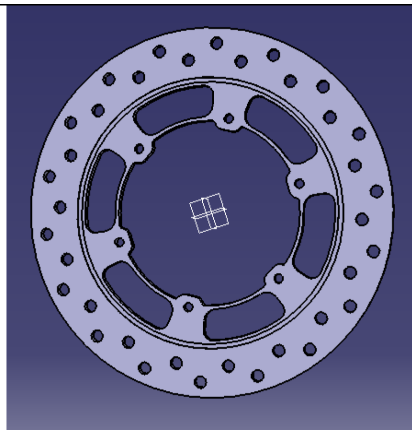
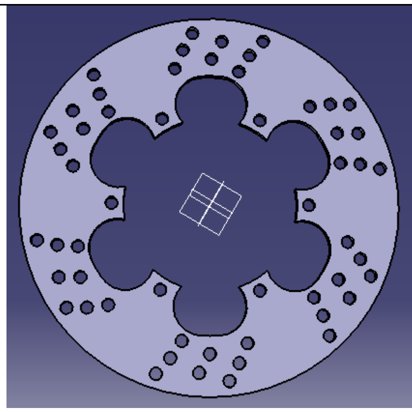
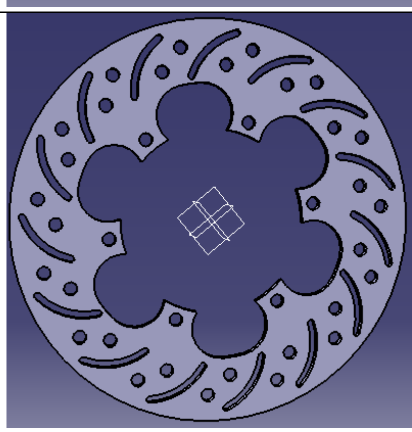
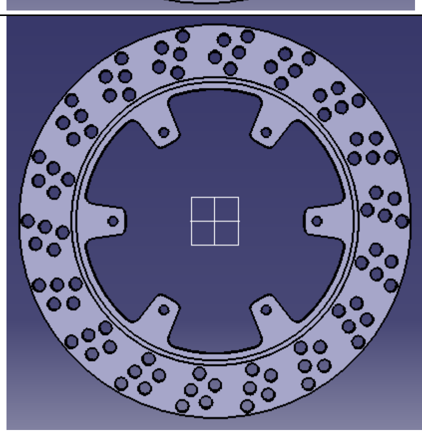
When hydraulic pressure is applied to the calliper piston, it forces the inside pad to contact the disc. As the pressure increases, the calliper moves to the right and cause the outside pad to contact the disc. Braking force is generated by friction between the disc pads as they are squeezed against the disc rotor. Since disc brakes do not use friction between the lining and rotor to increase braking power as drum brakes do, they are less likely to cause a pull. The friction surface is constantly exposed to the air, ensuring good heat dissipation, minimizing brake fade. It also allows for self-cleaning as dust and water is thrown off, reducing friction difference.
Unlike drum brakes, disc brakes have limited self-energizing action making it necessary to apply greater hydraulic pressure to obtain sufficient braking force. This is accomplished by increasing the size of the calliper piston. The simple design facilitates easy maintenance and pad replacement.

II. SCOPE OF WORK

In recent decades the improvement of the braking performances are required as the two wheelers run at high speeds. The generated frictional heat, during braking operation causes several negative effects on the brake system such as brake fade, premature wear, thermal cracks and disc thickness variation. It is then important to determine the temperature field of the brake disc which will be in the safe range. The brake disc manufacturing industries are in need of a suitable test setup to test the brake disc temperature with selected braking cycle and a selected braking force including related instrumentation. It is proposed to fulfill this need.

III.MODELING OF DISC

Sample Disc	Modification	Description
Original (01)		Original disc brake has been 6 holes Dia 8 mm arranged equally. There are 36 holes Surrounding disc Dia 8 mm arranged equally. Solid disc, Mass,(m)=0.98541Kg,Diameter(d)=240mm Thickness,(t)=5mm, Specific heat(Cp)= 586.0 J/Kg.K.

02		Sample no 1 disc brake has been reduces 6 holes Dia 6 mm. There are 36 holes Surround Dia 8 mm arranged equally. Sample no 1 disc brake has been added with 6 cut- section & changes central structure. Mass,(m)=0.99541Kg, Diameter(d)=240mm Thickness,(t)=5mm, Specific heat(Cp)= 586.0 J/Kg.K.
03		Original disc brake has been 6 holes Dia 8 mm arranged equally same .Original disc brake has been added with cut-section inlet & outlet airflow is large & small respectively. Mass,(m)=0.96941KgDiameter(d)=240mm Thickness,(t)=5mm, Specific heat(Cp)= 586.0 J/Kg.K.
04		15 Vanes have been arranged. 15 Elliptical shapes arranged between Vanes clockwise Inlet of air flow & outlet of air flow between the vanes is same. Mass,(m)=0.97541Kg,Diameter(d)=240mm Thickness,(t)=0.5mm, Specific heat(Cp)= 586.0 J/Kg.K.
05		Original disc brake has been Reduces 6 holes diameter 6 mm .There is 36 holes Surrounding disc are not contain. Original disc brake has been added with 18 cut section & changes central structure. Mass,(m)=0.98841Kg,Diameter(d)=240mm Thickness,(t)=0.5mm, Specific heat(Cp)= 586.0 J/Kg.K

IV. ANALYSIS

Original Disc

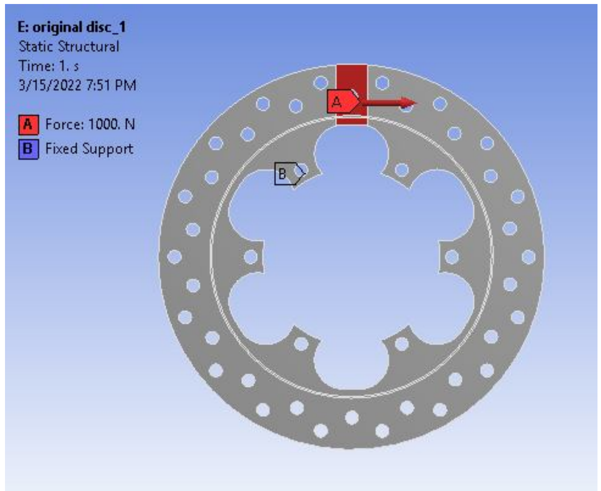


Fig.1 Boundary condition apply on original disc

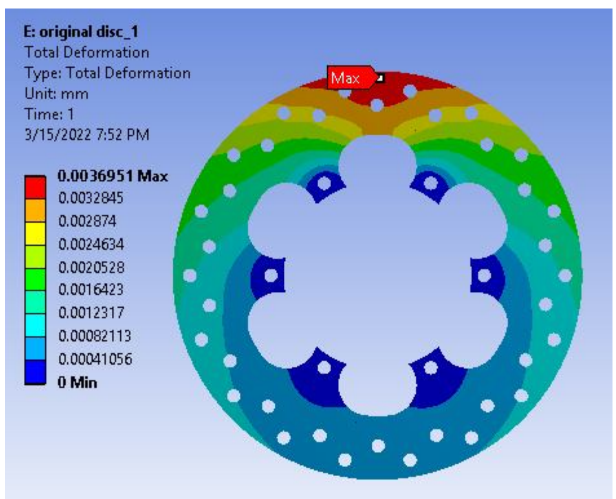


Fig. 2 Total Deformation of original disc brake

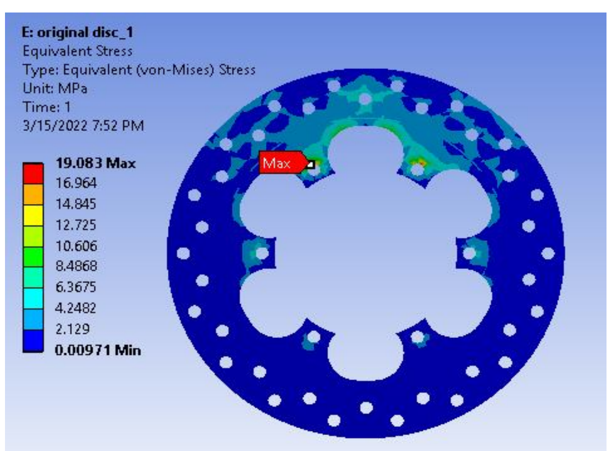


Fig. 3 Stress induced in original disc brake

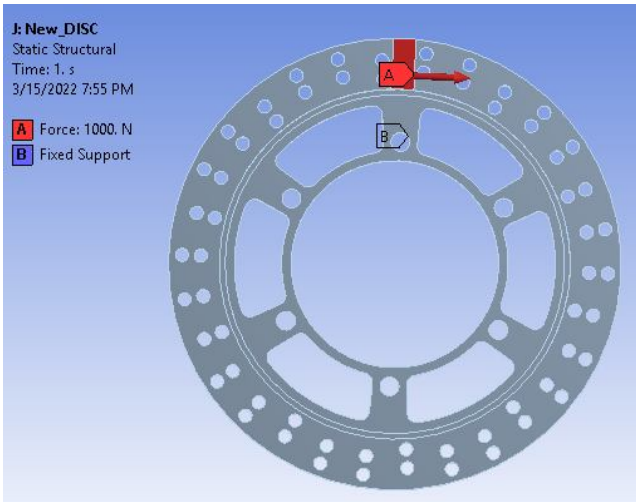


Fig.4 Boundary condition apply on new disc

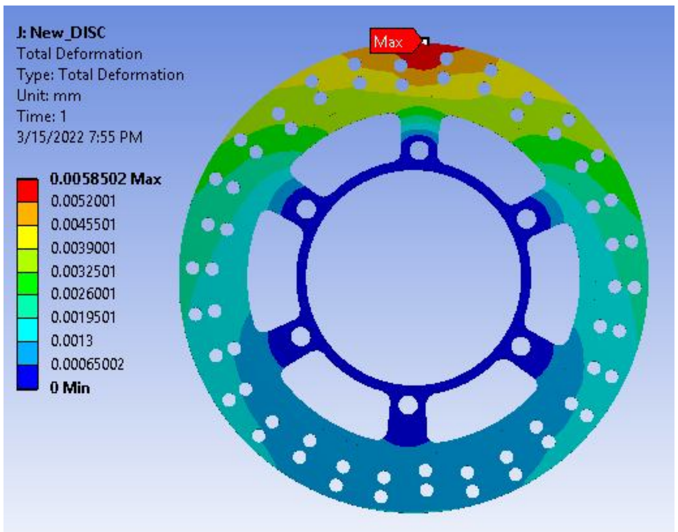


Fig. 5 Total Deformation of New disc brake

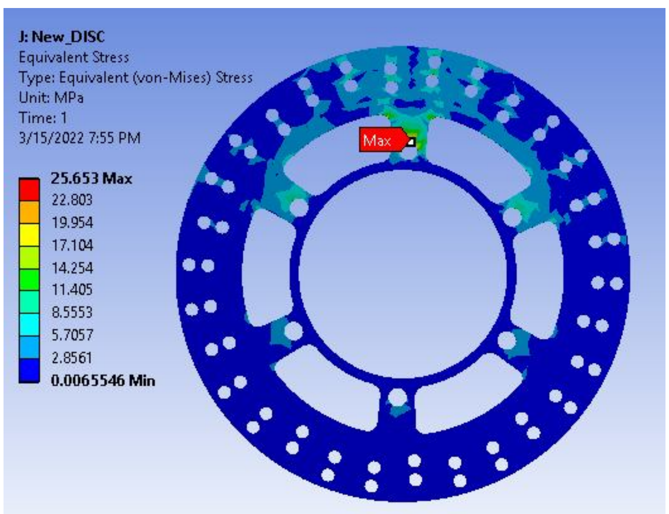


Fig. 6 Stress induced in new disc brake

1) *Sample Disc 1:* Nonlinear Transient Thermal Analysis Result

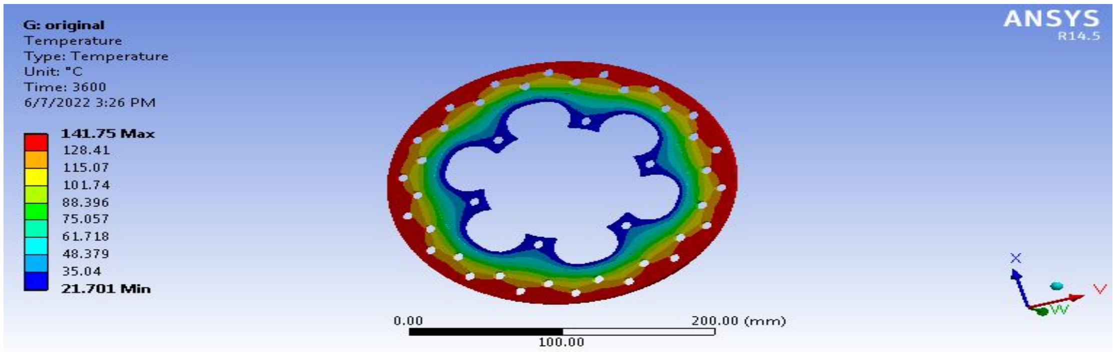


Fig. 7. Transient Thermal Analysis Result- Selected Disc (sample disc 1)

2) *Sample Disc 2:* Nonlinear Transient Thermal Analysis Result

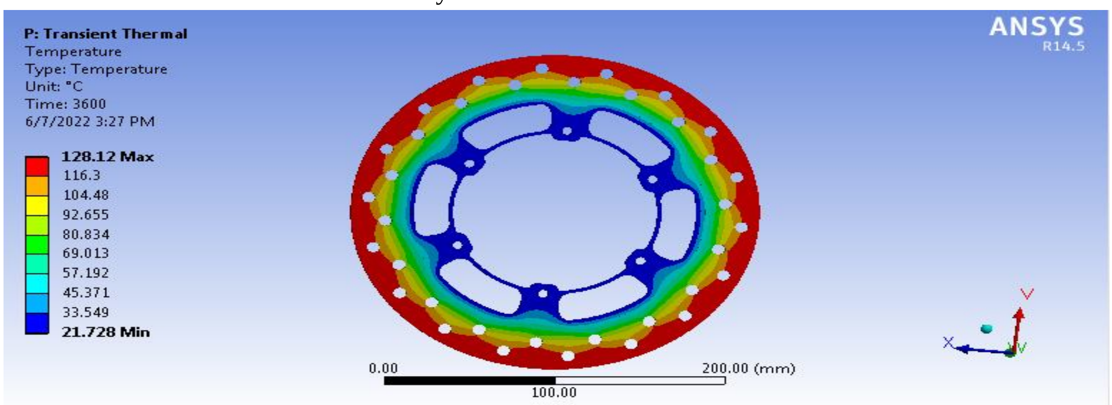


Fig. 8. Transient Thermal Analysis Result (ANSYS) of New Disc

V. EXPERIMENTAL SET UP

Experimental set up has various sub components as shown in schematic fig. 5.1. In this work, C channel angle frame base contains C channels of 80×40×5 and L channels of 35×35×5. This all frame structure is welded by arc welding and formed into predefined structure. The motor of 1.5HP is selected directly from market. This motor has a starter i.e. ON/OFF switch fixed on a channel of 25×25×3. This is coupled to shaft of length 200mm and diameter 25 mm. On this shaft, ball bearings equipped in the bearing housing of the size 25×60×150.

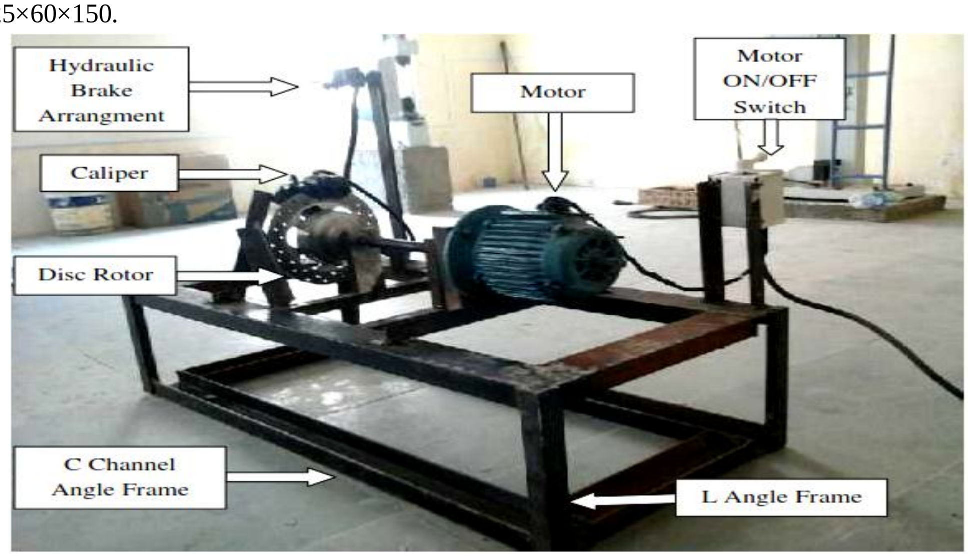


Fig. 5.3 Experimentation Setup

VI. RESULT TABLE

Sr. No.	Disc	Stress (MPa)	Deformation (mm)	Weight (Kg)
1	Original	19.83	0.0036	0.9854
2	New 1	19.67	0.0038	1.0811
3	New 2	29.91	0.0056	0.877
4	New 3	27.45	0.0053	0.965
5	New 4	18.00	0.0035	1.148
6	New 5	25.65	0.0058	0.897

Table 1. Result table of all discs in ANSYS Static analysis

Time(Sec)	Original Disc	New Disc
600	131.44	120.11
1200	140.89	127.53
1800	141.68	128.07
2400	141.75	128.11
3000	141.75	128.12
3600	141.75	128.12

Table 2. Result table of both discs in ANSYS

Time (Sec)	Original Disc	New Disc
600	105	99
1200	110	105
1800	118	109
2400	130	110
3000	132	110
3600	135	111

Table 3. Result table of both discs in testing

VII. CONCLUSIONS

1) The present study can provide a useful design and improved the brake performance of disk brake system.
2) From the above results, it is clear that performance of new designed disc in transient thermal analysis is better and optimized in accordance with braking temperature and thermal distribution over the disc area in comparison with given set of discs.
3) For structural analysis, result of both computational & experimental analysis of the new brake disk evidences the safer design.
4) High brake force carrying capacity of new designed disc during running condition without any crakes is demonstrated well.
5) Compared to the ANSYS simulation, experimental investigation is in good agreement.

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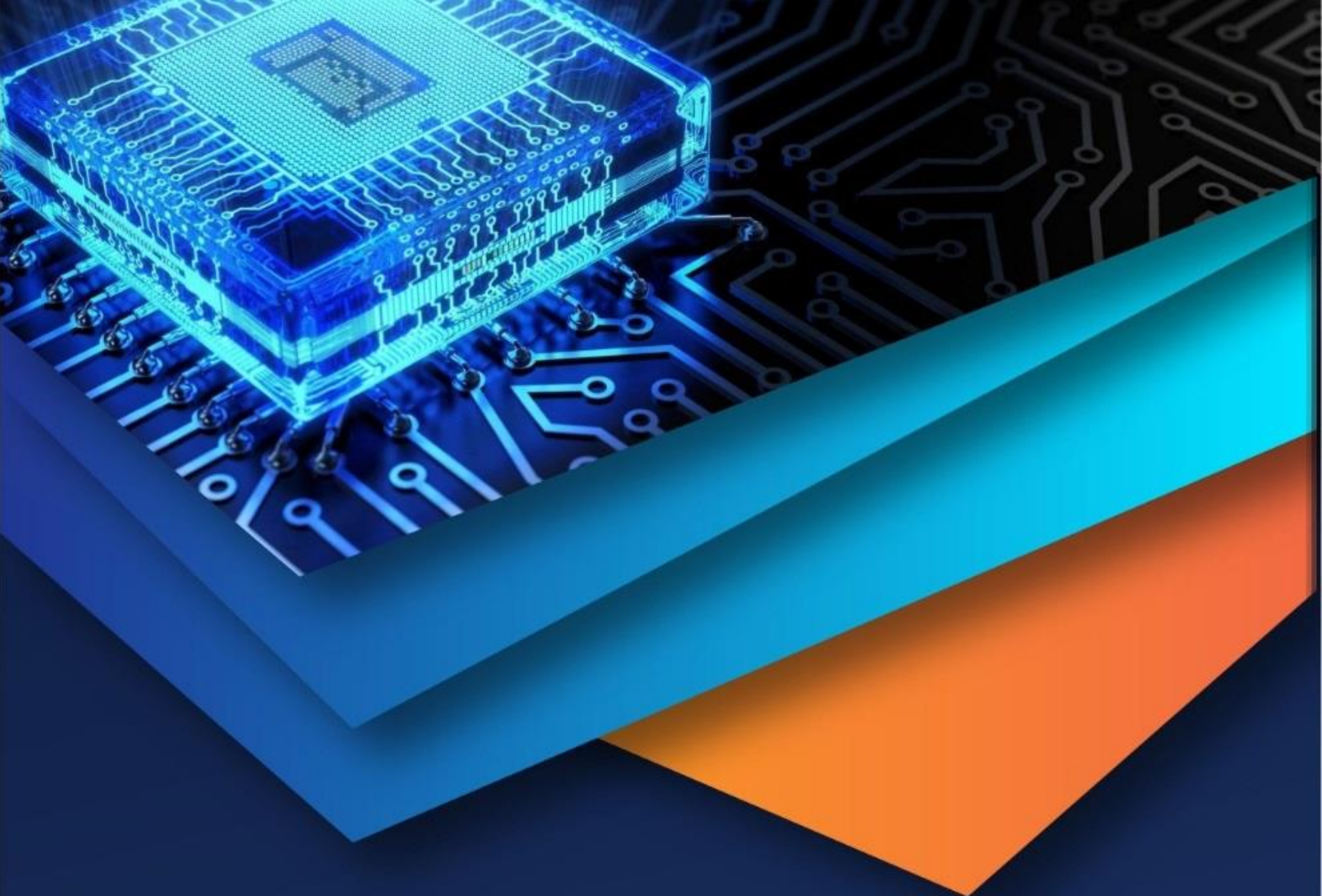

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