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Advanced Impact Absorbersin Automobilesto Reduce Collision Impact

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Abstract**: *Accidents are increasing day by day in this busy world. The safety of the passengers inside the vehicles is not ensured. This project mainly focusing on the safety of the passengers as we are adopting a new safety system that will absorbs the impact which occurs due to the sudden head on head collision. This system reduces the deceleration rate of vehicle thus the impact too. The system includes a compressed pneumatic piston cylinder configuration which is fixed to the chassis of vehicle connecting the bumpers. As the vehicle collides, first the system absorbs the impact force to a great extent. While the piston is pushed in ward, the pressure valve opens releasing extreme pressure inside the cylinder to the atmosphere. Thus the risk for re-bounce is minimum. Thus absorbs most of the impact and rest is transferred to the frame and chassis. Thus reduces overall collision by better impact energy absorption. The project focuses on small overlap crashes because it affects or the impact is vulnerable to passenger cabin. A framework is provided to the bumper for effective force or impact distribution. The project can be made possible by implementing the system into a scaled proto-type of any selected vehicle considering its rating and standard limits and certain crash tests have to be done to analyse the impact before and after the system is implemented.***
Keywords: Accidents, Collision Impact, Vehicle Crashes, Impact distribution, Impact energy absorption

I. INTRODUCTION

Through this project is aiming to reduce the head on head collision of automobiles by focusing mainly on small overlap collisions. Some safety components are added to the basic frame work of the car so that the impact during collision could be distributed or absorbed by the entire vehicle instead of a single focused area to which the object hits. The main objective of this project is to reduce the crumbing zone of the provided vehicle. In conventional method, at high speeds (more than 50 kmph), crumbling zone of the present day cars, even if it's the most strongest or safest, the impact crosses over the crumbling zone reaching the passengers. And if we say for small over-lap crash, its 100% sure the driver's chance for survival is 10%. A present day vehicle does not have advanced technology to reduce it and on other hand the body strength is reduced for better fuel economy. This leads to more chances to damage and harm.This project aims to reduce the impact of vehicle at high speed by not letting the impact crossing over the crumbling zone by using an impact absorbing safety system and advanced frame work for better distribution of impact. It uses a pneumatic cylinder configuration to absorb the impact and release the impact energy to atmosphere.

This project can be widely used in automotive sector as this sector is becoming a part of human life. And safety cannot be compromised. This design can be implemented to any vehicle design by not altering the basic design. It uses the presently available space of chassis of vehicle. This system can be implemented with least cost also. Thus overall more safety with least investment can be achieved.

II. REVIEW OF LITERATURE

A car is made by considering its safety for passengers. Vehicle is being designed to with stand any collision that it faces. But none of the car can withstand a crash above 50 kmph. At those speed its 100% sure the impact covers the crumbing zone reaching the passengers. By considering the present day road and traffic, it's too risky for passenger to drive a car. On the other hand present day vehicles are much efficient in speeds. As IIHS says the highest safety car can only withstand an impact about 50 kmph in half over-lap crash. Coming to quarter overlap crash none has passed above speed 40 kmph.

Some of the small over-lap crash test results are shown below which IIHS has conducted:

Volvo Lexus


Honda Audi

Fig 2.1: IIHS results of top safe cars

These tests were done at speed 42 kmph. Above shown are known safest car in the world wide, but in fact they couldn't get through these tests.Byeong Sam Kim, Kyoungwoo Park, and Youn-Min Song [1] performed crash analysis was performed of upper body and sub frame for NEV electric car. The purpose of this study was from the upper body for EV, and sub-frame was established to develop the analytical model simulation results were able to make predictions. FE analysis using LS-DYNA shows in frontal impacts the vehicle undergoes heavy deformations on the front end whereas the central and the rear portions hardly undergo and deformations. G. Yedukondalu, Dr. A. Srinath, Dr. J. Suresh Kumar [2] perform the simulation analysis of crash test in CAD model of "TATA Indica" bumper frame and the results shows that during the crash analysis test the maximum Von-Mises stress was observed to be 2.271 E+03 for a low speed collision with a velocity of 30 m/s. Tejasagar Ambati, K.V.N.S. Srikanth & P. Veereraju [3] simulate a frontal impact crash of an automobile and validate the results. The software used for the simulation is LS-DYNA. It is widely used by the automotive industry to analyze vehicle designs. It accurately predicts a car's behaviour in a collision and the analysis of the obtained results indicated that the most of the energy of the impact is absorbed by the bumper, radiator, engine and the rails. These components absorb most of the energy of the crash before the tires impacts the wall.Zhida Shen, Xin Qiao and Haishu Chen [4] conducted a vehicle frontal crash FEA model is established according to CMVDR294. Vehicle frontal crash simulation calculation is conducted by LSDYNA. The front, middle and rear energy absorption areas are the basis of multiply force transmission routes in frontal crash. Setting of multiply force transmission routes in frontal crash for frontal crash may effectively absorb energy and transmit crash force. From the simulation calculation they discovered that the middle part of the right longitudinal beams has seriously bent before the energy absorption box is entirely squashed. Chunke Liu, Xinping Song, Jiao Wang [5] analyzed that the front longitudinal beams don't have enough strength to prevent bending deformation. Energy absorption is inadequate, while the excessive invasion of the dash panel easily hurts front deformation. The dash panel invasion and the front longitudinal beam deformation have been effectively improved by changing their thickness.hacker et.al [6] conducted crash-testing simulation study of a 1997 Honda Accord. Originally, a real vehicle was obtained and then the vehicle was stripped down to its basic parts, each component was identified, labeled, and the material evaluated. Data that could be efficiently extrapolated from existing sources were collected.

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III. DESIGN OF THE PROPOSED PROJECT

A case study of Mitsubishi Lancer which weighs 1500 kg crash test analysis data's shows the energy absorption in each parts. The crash test held at 50 kmph crashed to a wall

Table 3.1. Energy absorption performance of Mitsubishi Lancer

Part	Energy/J Percent/%
Bumper cover	6407.4 4.63%
Radiator	3915.4 2.83%
Bumper cross beam	7227.62 5.23%
Energy absorber	absorber8782.24 6.35%
Front longitudinal beam	25508.3 18.45%
Hood	5031.18 3.64%
Front wall	3467.41 2.51%
Fender	660.75 0.48%
Power train	16.010.01%
Sub-frame	27307.96 19.75%
Guard plate	1433.97 1.04%
Door	164.64 0.12%
Floor	7589.47 5.49%
Steering system	2394.560 1.73%

From the experiment the main frame, bumper etc. accounts the main impact. And they are said to the main impact absorbing agents. Total energy absorbed by the total body is 138260 J and front part alone is 68826.12 J which account about 49 % of the total impact. 61% is being distributed to other parts which might account passenger cabin.Considering small overlap crashes the force of impact goes down because the material area exposed to impact is less. Thus it causes impact to go further to cabin space. " Through this project, an additional device is designed which fits inside chassis and goes all through the bumper which has the capability to absorb a portion of impact thus less impact will be delivered to cabin space.

A. Design Section

In this project an additional impact absorbing mechanism is implemented. This is coupled to the frame and chassis of the vehicle. The absorbing mechanism is a pneumatic cylinder configuration which has compressed gas pre-installed connected to a safety valve via control valve. The pressure is set to the standards of frame and chassis. The cylinder is bolted to the chassis and other end is fixed to the bumper through a framework. Fiber bumper is screwed to the frame work. The cylinder is internally supported by a hollow bar thus excess impact could be distributed all over the chassis.

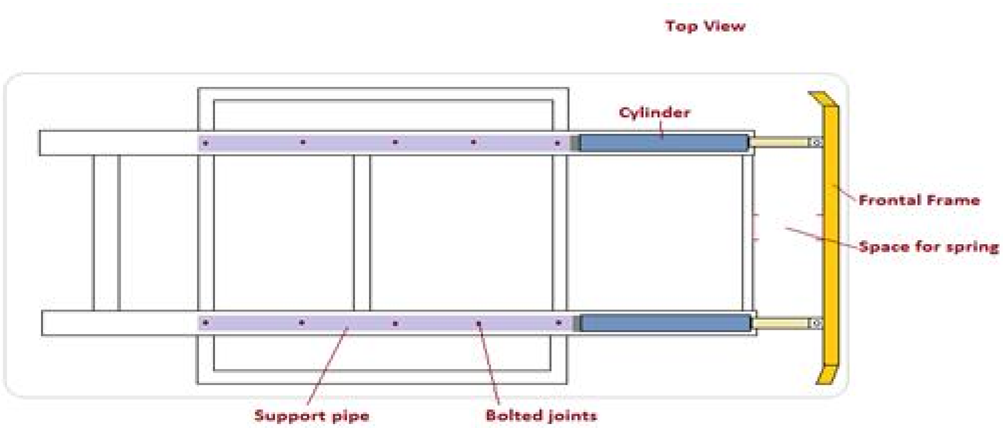

Fig 3.1: Design of the proposed project

IV.COMPONENTS OF THE PROPOSED MODEL

A. Pneumatic cylinder

Pneumatic cylinder (sometimes known as air cylinders) is mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Like hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage. Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement

B. Pressure relief valve

The pressure relief valve (PRV) is a type of valve used to control or limit the pressure in a system or which can build up for a process upset, instrument or equipment failure, or fire. In high-pressure gas systems, it is recommended that the outlet of the relief valve is in the open air. In systems where the outlet is connected to piping, the opening of a relief valve will give a pressure build up in the piping system downstream of the relief valve. If the valve is opened the pressure has to decrease enormously before the valve closes and also the outlet pressure of the valve can easily keep the valve open. Another consideration is that if other relief valves are connected to the outlet pipe system, they may open as the pressure in exhaust pipe system increases. This may cause undesired operation.

C. Control Valve

A flow control valve regulates the flow or pressure of a fluid. Control valves normally respond to signals generated by independent devices such as flow meters or temperature gauges

V. METHADOLOGY

The pneumatic cylinder is inserted into the chassis and is bolted to it. The cylinder is supported by an internal pipe which goes through the chassis structure. This pipe is bolted in different points to the chassis.

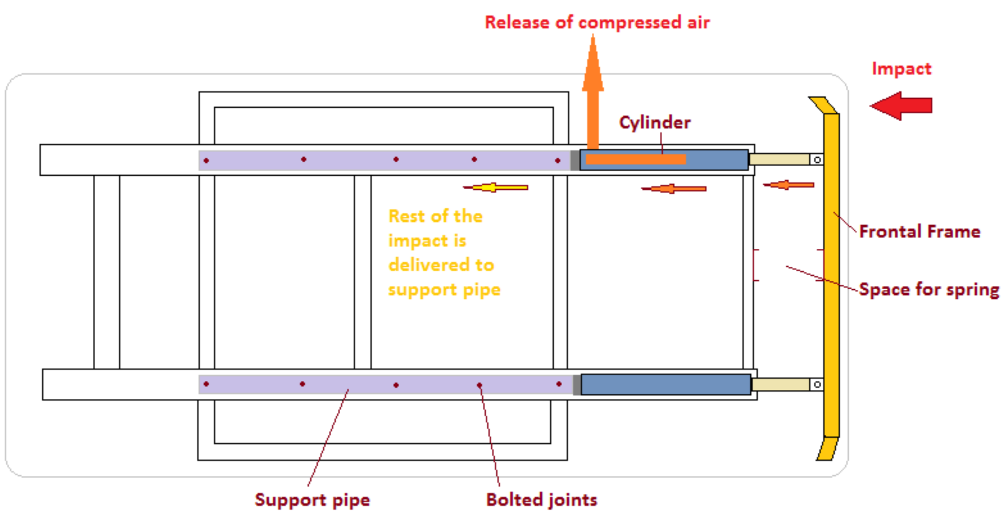

Fig 3.2: Working diagram of project

Consider a vehicle is experiencing a crash having the proposed system.

A. While hitting the impact affects the bumper first. Bumper delivers the impact force to the frame work on bumper.
B. The frame work takes the impact and transfers it to the piston cylinder to which it is coupled.
C. Thus the piston moves in raising the pressure inside the cylinder.
D. The pressure release valve opens after pressure becomes too high. Thus further pushing the piston inwards.

E. After maximum pushing the piston then the remaining impact is transferred to the supporting pipe which is bolted to the chassis and thus get distributed to the whole chassis.

Here as the piston moves in, the sudden deceleration gets minimised. If deceleration is too high, impact will be severe. The aim of this project is to make slow deceleration due to impact. Here majority of impact could be absorbed by piston and the rest is passed to the chassis with bolted support bar. Thus most of the balance impact will be distributed all over the body. Through this the severe impact of focused collision can minimised and chances of crossing the impact over crumbling zone and reaching the passenger cabin could be minimised.

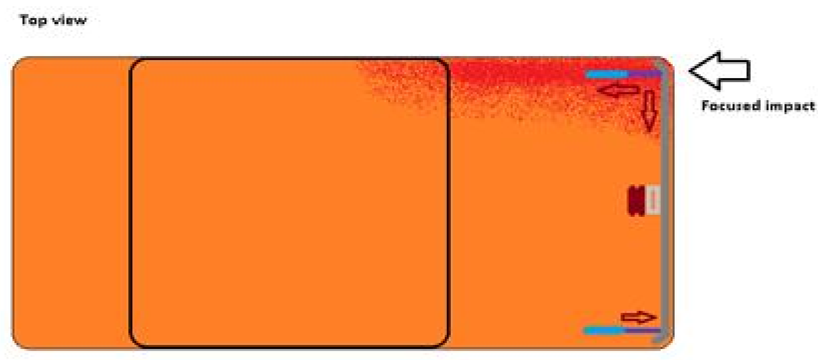

Fig 3.3: Impact distribution on collision including the spring setup

VI. RESULT AND DISCUSSION

The experiment conducted with the designed frame structure with different masses and the principle behind the impact energy absorption is based on the conservation of momentum.

ie, $M \times V = C$………………… (1)

And: F is proportional to dP/dt

Therefore: $F=k\times dp/dt$

Where $P=M\times V$

Therefore $F=k\times M\times dV/dt$

Assuming k=1 and dV/dt = a

Therefore,

$F=M*A$………………… (2)

A. Condition 1

Here two vehicles of mass and at a velocity in opposite direction crash towards each other. Calculations are based on conservation of momentum:

$$M_1U_1+M_2U_2=M_1V_1+M_2V_2$$

Here M_1, M_2 are the masses of two vehicles, U_1, U_2 are the initial velocities V_1, and V_2 are the final velocities. Final velocity varies with the mass and velocity.

The impact absorber which could absorb a portion of impact and release it in the form of compressed air. So the impact energy is used to compress the air inside the cylinder and this compressed air released into air. In this system the safety valve is set to maximum pressure to 6 bar. The pre - test conducted shows up to 150 to 170 N load can be stored inside the cylinder. The cylinder is capable of storing that much force without releasing the air to atmosphere. If the load exceeds 170 N the safety valve opens. The finds are given below

Table 6.1: Setting pressure of safety valve

Mass	Force N	Safety Valve status
10	98.1	Closed
13	127.53	Closed
15	147.15	Closed
18	176.58	Open (Pressure < 6 bar)
20	196.2	Open
23	225.63	Open
25	245.25	Open

Resultant graph is plotted below showing the Load at which the safety valve opens:

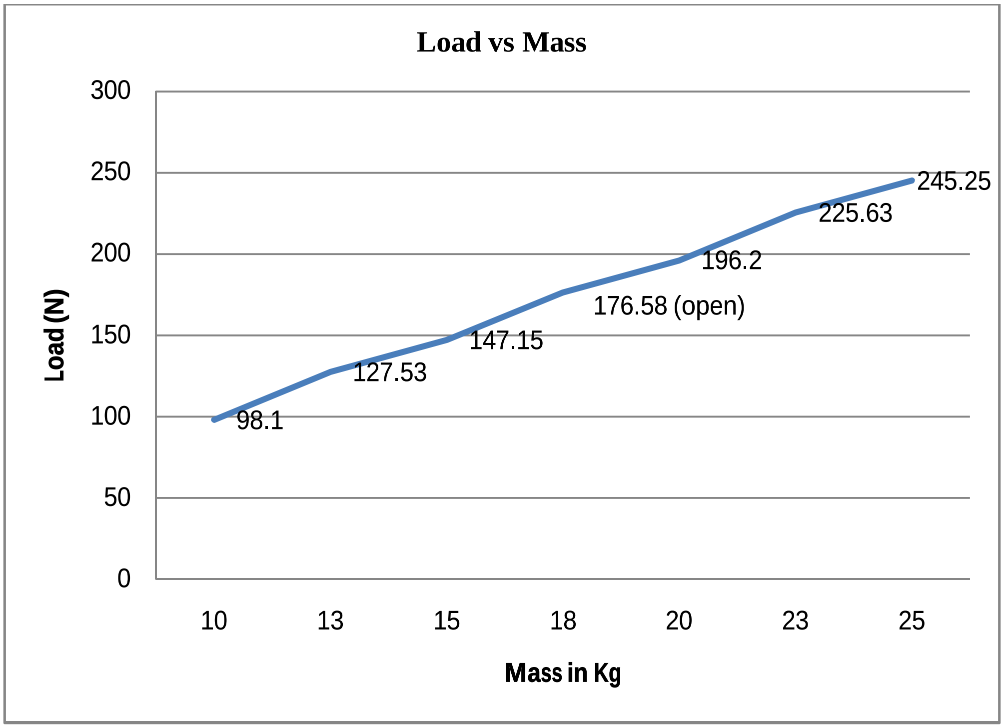

Fig 6.1: Load vs Mass (operation of safety valve).

The results with and without the device is given below:-
Test method: Hammer testing.
Height selected: 5m
Mass used: 10,15,20,25 kg.

B. Without the proposed system

Table 6.2: Impact forces without proposed safety system

Mass Kg	Impact duration in sec	Impact force in N
10	0.1352	731.51
15	0.1105	1342.53
20	0.1098	1801.46
25	0.1102	2243.65

C. With the proposed system

Table 6.3: Impact forces with the proposed safety system.

Mass kg	Impact duration in sec	Impact force in N
10	0.2075	476.62
15	0.1906	778.33
20	0.1784	1108.74
25	0.1468	1684.26

The graph is plotted showing the difference in impact with and without the proposed system

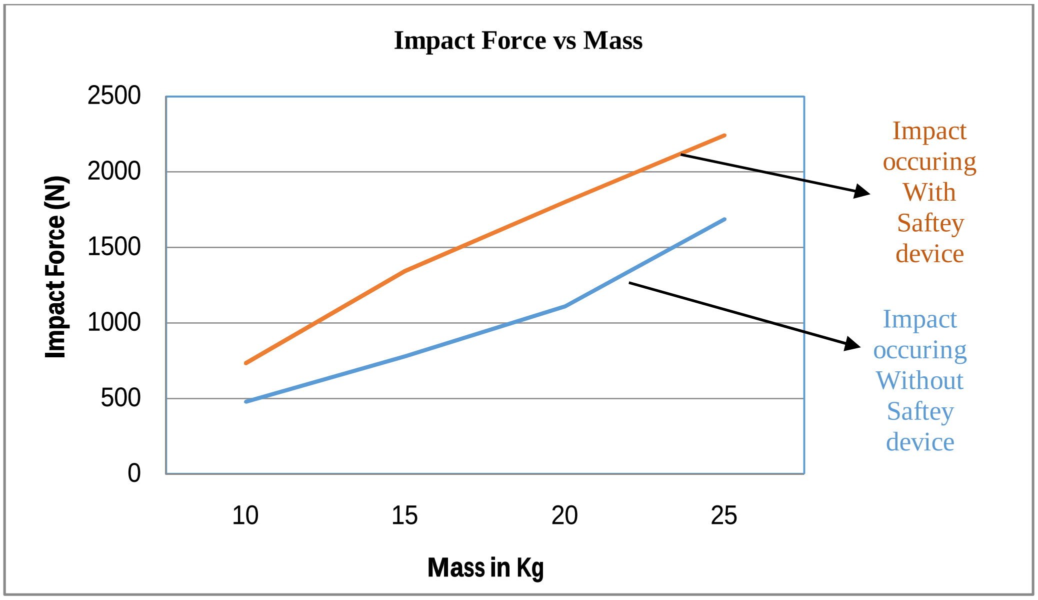

Fig 6.2: Impact force vs Mass (with 'series 1' & without 'series 2' safety system)

The above graph shows the impact force occurring with the safety device and the impact forces occurring without the safety device and gives a brief idea about the reduction of impact force with and without the proposed system. And it's evident that there is a significant reduction on impact force. Comparing the values obtained, percentage reduction in impact force is given below:

Table 6.4: Percentage reduction of impact forces

Mass Kg	% Reduction in Impact
10	34.84
15	42.02
20	38.45
25	24.93

Thus through this project we were able reduce a maximum of 42 % impact. This could be improving the design. This project is mainly focused for accident reduction. It can be implemented to any type of vehicles which is produced world-wide. This project is limited to 2 wheelers. Its low investment and maintenance result in better feasibility and reliability.

VII. CONCLUSION

This Project covers the working of our new impact absorbing safety system which is added to the basic framework of a car that helps reducing the impact caused due to the head on head collision in automobiles. It is generally agreed that during a high speed collision, the impact crosses over the crumbling zone which may take away the valuable lives of the passengers inside the car. The purpose of this project is to increase the safety of the passengers by providing a new safety system that absorbs the very sudden impact during a crash. In addition to this, our safety system not only for the passenger's safety, it also helps to reduce the damage of the automobile engine itself during a crash which helps to save the automobile repairing cost. The cars which contain this safety system would be more expensive than normal cars; however this will helps to reduce the losses during a car collision and also helps to develop more safety cars.

VIII. ACKNOWLEDGEMENTS

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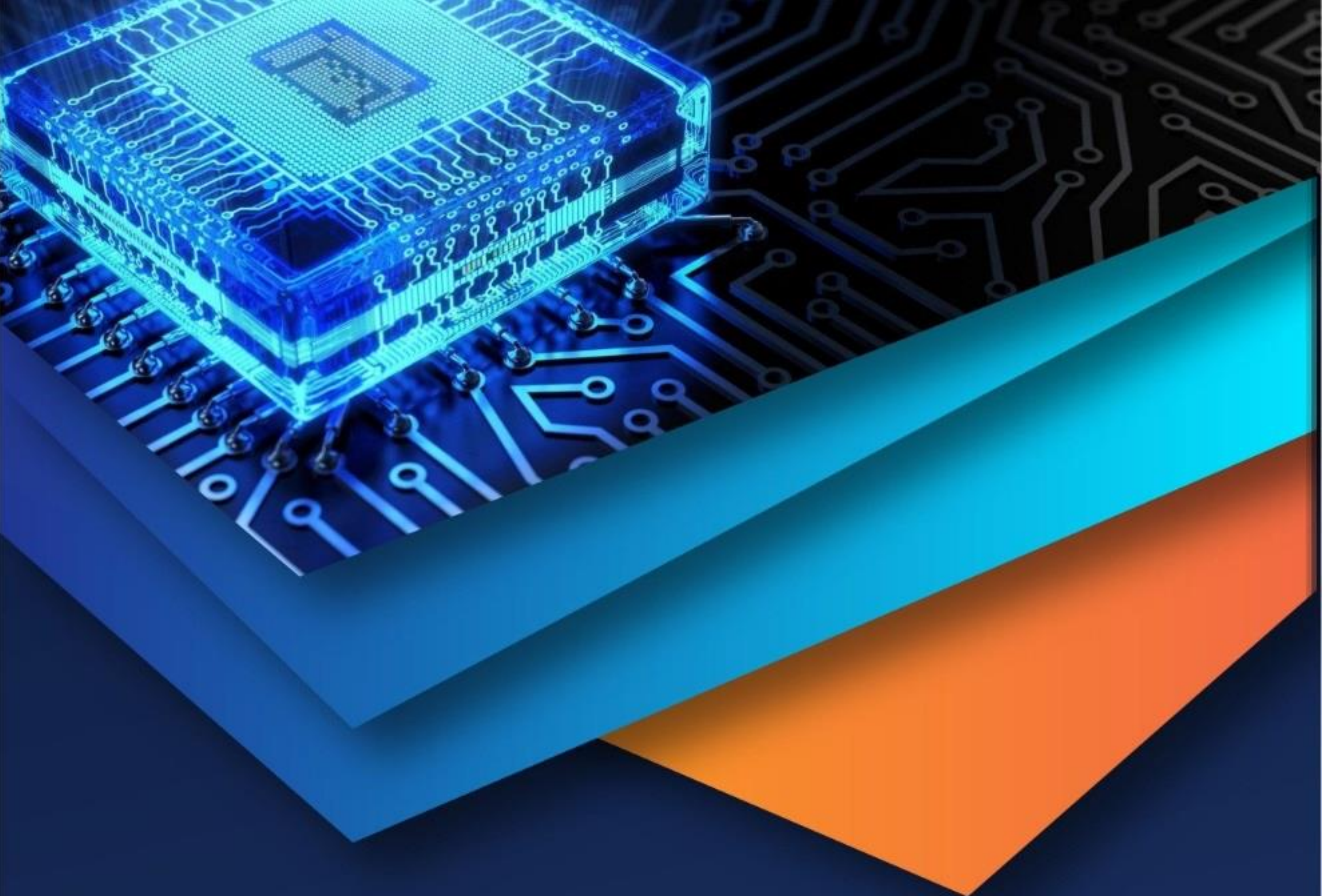

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