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Structural And Modal Analysis Of Shock Absorber Of Vehicle - A Review

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Abstract: Safety and driving comfort for a car's driver are both dependent on the vehicle's suspension system. Safety refers to the vehicle's handling and braking capabilities. The comfort of the occupants of a car correlates to tiredness and ability to travel long distance with minimal annoyance. Shock absorbers are a critical part of a suspension system, connecting the vehicle to its wheels.

Essentially shock absorbers are devices that smooth out an impulse experienced by a vehicle, and appropriately dissipate or absorb the kinetic energy. Almost all suspension systems consist of springs and dampers, which tend to limit the performance of a system due to their physical constraints. Suspension systems, comprising of springs and dampers, are usually designed for passengers' safety, and do little to improve passenger comfort. To meet the current demands of high speed and safety we must designed and developed such a shock absorber which can sustain more and more vibrations and also improves the safety.

Keywords: Springs, dampers, shock absorber

1. INTRODUCTION

A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. The shock absorbers duty is to absorb or dissipate energy. In a vehicle, it reduces the effect of travelling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. When a vehicle is travelling on a level road and the wheels strike a bump, the spring is compressed quickly. The compressed spring will attempt to return to its normal loaded length and, in so doing, will rebound past its normal height, causing the body to be lifted. The weight of the vehicle will then push the spring down below its normal loaded height. This, in turn, causes the spring to rebound again. This bouncing process is repeated over and over, a little less each time, until the up-and-down movement finally stops. If bouncing is allowed to go uncontrolled, it will not only cause an uncomfortable ride but will make handling of the vehicle very difficult. The design of spring in suspension system is very important.

In the present work, a shock absorber will be designed and a 3D model which will be created is by using Pro/Engineer. The model is also changed by changing the thickness of the spring. Structural analysis and modal analysis

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are done on the shock absorber by varying material for spring.. The analysis will consider the loads, bike weight, single person and 2 persons. Structural analysis will be done to validate the strength and modal analysis to determine the displacements for different frequencies for number of modes. Comparison will be done for two materials to verify best material for spring in Shock absorber.

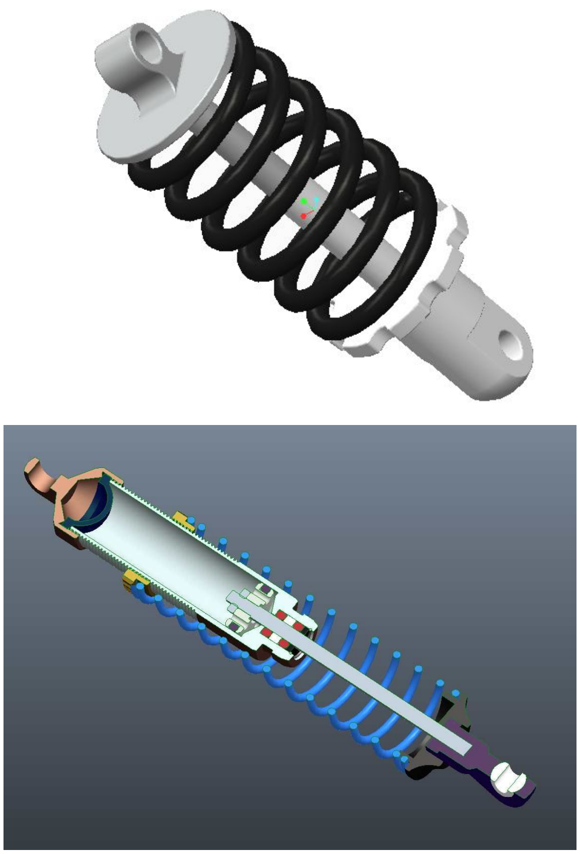

Figure 1.1 Shock absorbers with different dimensions

Shock absorbers dampen the shock the suspension receives when the vehicle is driven over rough or uneven road surfaces.

2.0 PRESENT THEORIES AND PRACTICES

Choon-Tae Lee et al. suggested a new mathematical model of displacement sensitive shock absorber to predict the dynamic characteristics of automotive shock absorber. The performance of shock absorber is directly related to the vehicle behaviours and performance, both for handling and ride comfort. The proposed model of the DSSA has two modes of damping force (1 soft and hard) according to the position of piston. [1] Figure 2.1 shows simulation results of stroke damping force diagram t~r the excitation velocity of 0.1, 0.2, 0,3, 0.6 and 1+0 m/sec, respectively. The damping force changes from soft to hard mode due to the displacement sensitive characteristics around the stroke at _+20 mm,

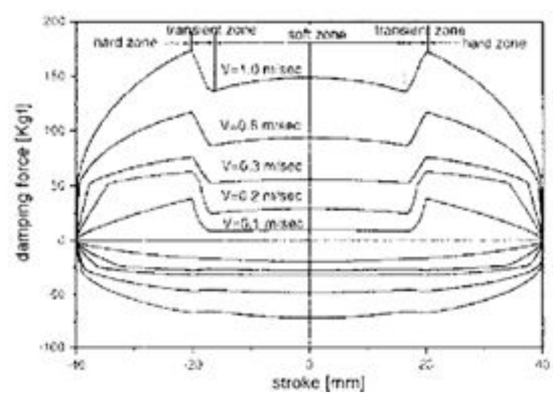

Figure 2.1 Analytical results of the DSSA

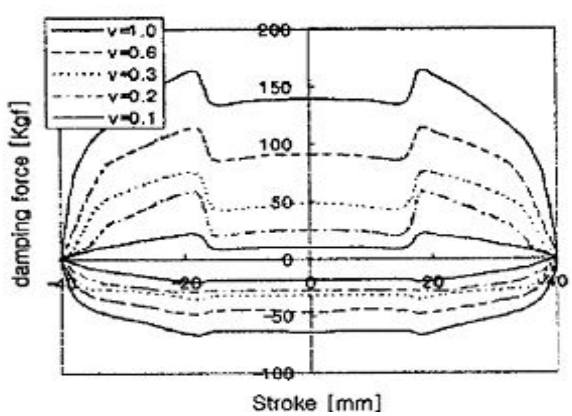

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Figure 2.2 Experimental result of DSSA damping force diagram

P. Polacha, M. Hajˇzman [2] described Verification of the suitability of the designed force-velocity characteristics of the air-pressure-controlled shock absorber. As a criterion for both the design and the verifying of the design of the optimum force velocity characteristics of the semi-active APCSA the maximum similarity of time histories of the relative deflections of the air springs of the SOR C 12 bus multi body models for various vehicle weights to the time histories of the relative deflections of the air springs of the multi body. [2]

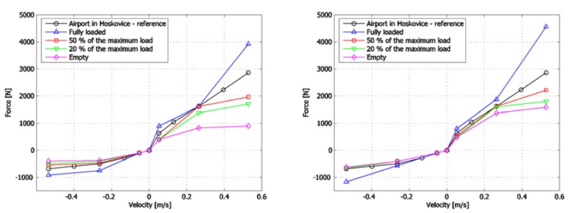


Fig. 2.3 The originally designed and the verified force-velocity characteristics

Piotr Czop, Pawe et al. gives the configurations of a typical valve system including three basic regimes of operation, which correspond to the amount of oil flowing through a valve cavity. The aim of this work was to propose a finite element fluid flow model, which can be used in order to reduce the velocity of fluid flow through a cavity of a shock absorber valve. High flow velocity can cause high-content frequency vibrations and, in turn, audible noise. The model will be used for initial screening of new valve concepts and on the other hand to improve the currently use ones. [3]

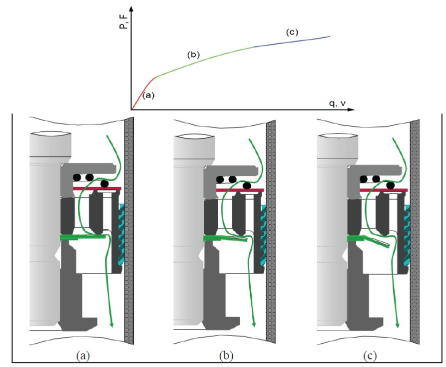
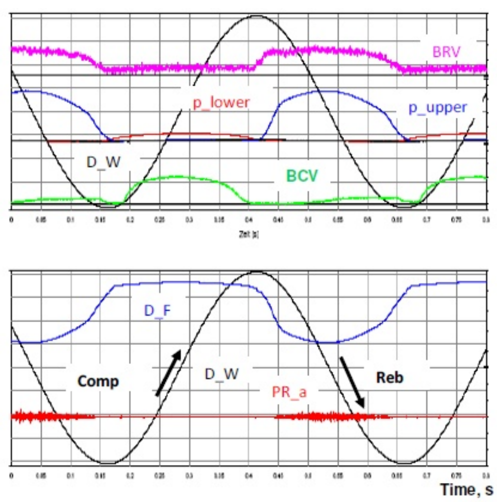


Fig.2.4 Pressure-flow or force-flow characteristics and its regimes: a) bleed operation; b) normal operation high-damping operation

Dr.-Ing. Alexander Kruse, ZF Sachs AG, analyzed the dynamic vibration processes going on in the working chambers of shock absorber. They tested the damping force irregularities and noise at the start of valve opening with the help of experimentations. The improvement of dynamic pressure build-up through valve optimization brought distinct noise reduction. [4]

3.0 Quasi-static" behavior of the shock absorber



Measuring signals at excitation of 2 Hz and velocity of 1,0 m/s

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D_W - shock absorber displacement

D_F - damping force

P R _a - piston rod acceleration

p_ upper - oil pressure in upper working chamber

p_ lower - oil pressure in lower working chamber

p_ ausgl - oil pressure in compensating chamber

BRV - lift of base replenishing valve

BCV - lift of base compression valve

Joseph Phaneuf et al. build and test a model of an active suspension system to minimize the vertical oscillations of a vehicle's body for varying road conditions. The road condition was simulated by introducing an oscillation to the system through an electromagnet. An electromagnet based closed loop control system was established to oppose the vehicle's motion. It was concluded that the vertical oscillations experienced by the vehicle were significantly reduced by the implementation of a proportional control system. [5]

Pinjarla.Poornamohan and Lakshmana Kishore.T, designed shock absorber for 150 cc bike using PROE. The model is also changed by changing the thickness of the spring. They have performed the structural analysis and modal analysis on the shock absorber by varying material for spring, to steel and Beryllium Copper. For analysis loads considered are, bike weight, single person and 2 persons. Modelling is done in Pro/ENGINEER and analysis is done in ANSYS. Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design. [6]

Branislav Titurus et al investigated the possibility of precise experimental identification of steady damper characteristics. The velocity sensitive and nominally symmetric hydraulic dampers were considered. [7]

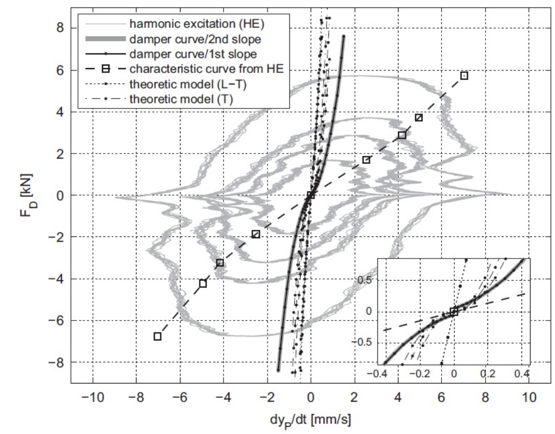

Fig. 13. Comparison of different damper characteristics.

Sudarshan Martande, focuses on to develop new correlated methodologies that will allow engineers to design components of Shock Absorbers by using FEM based tools. The different stress and deflection values in shock absorber components have been obtained using FEA tools and compared with analytical solutions. Percentage error is calculated and it is found that percentage error is less than 15%. Various stress results are below allowable limits of material. Error in FE and analytical results occurs because of various reasons such as assumptions in analytical formulation, approximations in FE formulations, choice of element in FE analysis[8]

Table 4: Comparison of Analytical and ANSYS results

Sr. No	Component	Stress (MPa)			Deflection (mm)		
		Analytical	ANSYS	% Error	Analytical	ANSYS	% Error
1	Spring	649.92	614.92	5.38	82.920	84.060	1.36
2	Piston	132.82	127.80	3.78	0.0901	0.0795	11.77
3	Cylinder	521.41	593.06	12.08	NA	0.1269	NA
4	Assembly	NA	488.80	NA	NA	59.45	NA

Urszula Ferdek, Jan Łuczko, designed a physical and mathematical model for a twin-tube hydraulic shock absorber, using oil as the working medium. To analyze the model,

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methods of numerical integration were incorporated. The effect of the amplitude and frequency of the excitation, as well as the parameters describing the flow rate of oil through the valves, were examined. The basic characteristics of the damping force were also obtained. [9].

Phillip Rodenbeck, done the eyeball optimization. The number of important parameters and the complex ways in which they influence each other will require refined methods. Future work in optimization will be necessary in order to tailor an algorithm to improve the performance of the elastomeric puck component. More modelling and finite element testing is required. This study analyzed a very general, initial design field, but several other modifications can be made to the puck geometry in order to hopefully lessen some of the observed trade-offs. One such modification is a tapered puck design so that contact with the shock wall as the puck is compressed will be more uniform as opposed to starting at the bottom canter and moving upward and outward. [10]

M.S.M.Sani et al. studied and analyzed stiffness and damping of shock absorber system. The stiffness and damping value for shock absorber are strongly related to the capacity of the shock absorber. The results show that good matching with small discrepancy between the experimental and simulation results. [11]

4.0 EXPERIMENTAION

First of all, the original dimensions of shock absorber are achieved from the industries regarding shock absorber. After getting these dimensions, a complete, unique and unambious 3D model of shock absorber will be created by using PRO/Engineer. The Structural and Modal analysis will be performed on this 3D model of shock absorber. The experimentation and repetitive analysis will be carried out for different spring material and spring parameters. The best material will be found out under different loading conditions which are our ultimate goal.

5.0 Finite Element Analysis

The finite element method is a powerful tool for the numerical procedure to obtain solutions to many of the problems encountered in engineering analysis. Structural, thermal and heat transfer, fluid dynamics, fatigue related problems, electric and magnetic fields, the concepts of finite element methods can be utilized to solve these engineering problems. In this method of analysis, a complex region defining a continuum is discretized into simple geometric shapes called finite elements the domain over which the analysis is studied is divided into a number of finite elements. The material properties and the governing relationship are considered over these elements and expressed in terms of unknown values at element corner .An assembly process, duly considering the loading and constraint, results in set of equation. Solution of these equations gives the approximate behaviour of the continuum. Finite element analysis (FEA) has become ordinary in recent days, and is now the source of income in the industry. Numerical solutions to even very complicated stress problems can now be obtained using FEA. The comfort level and durability test can be performed with the help of FEA software's. Finite element codes are less complicated than many of the word processing and spreadsheet packages found on modern microcomputers.

5.1 Principle FEA

In practice, a finite element analysis usually consists of three principal steps:

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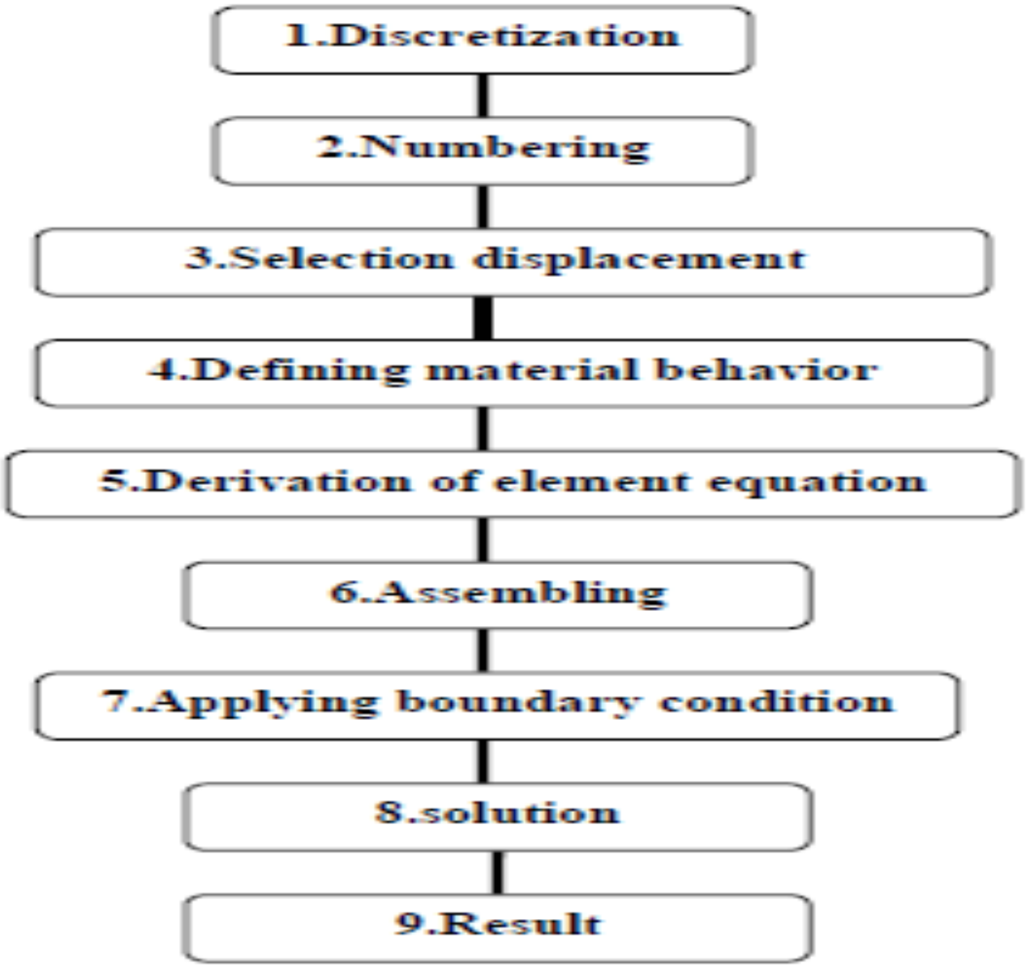

Certain steps in formulating a finite element analysis of a physical problem are common to all such analyses, whether structural, heat transfer, fluid flow, or some other problem. These steps are embodied in commercial finite element software packages (some are mentioned in the following paragraphs) and are implicitly incorporated in this text, although we do not necessarily refer to the steps explicitly. The steps are described as follows.

Conclusion

An intense work has been carried out in the field of shock absorber up till now. Various earlier researchers have also presented their studies regarding the failure and safety design for the same. This project aims towards the FEM analysis of existing shock absorber and checking the failures. Also try to minimise it by suggesting different methodology.

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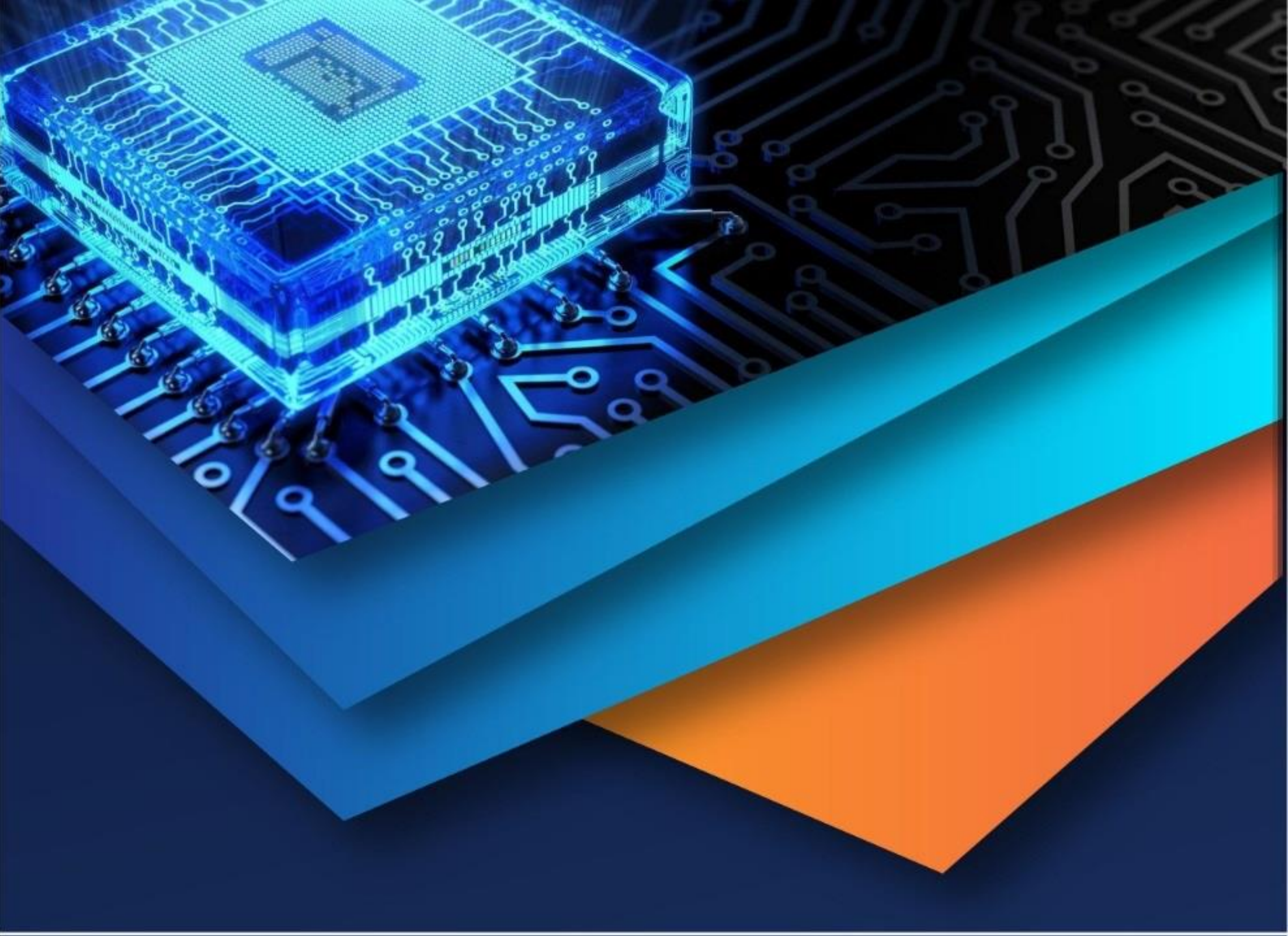

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