iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VII Month of publication: July 2021

DOI: https://doi.org/10.22214/ijraset.2021.36506

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VII July 2021- Available at www.ijraset.com

Design and Development of Braking and Wiring Systems in Go-Kart

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Abstract: This paper is aimed to calculate and numerically analyse the effectiveness of Disc brakes before and after manufacturing of full scale Go-kart. Disc brakes are developed over time to time for being a reliable method of decelerating and stopping a vehicle. There are different designs of disk brake systems for various applications. This review gives an in depth description of various geometries of the components and therefore the materials utilized in a disk brake system. In spite of all the involvements, there are still many operational issues associated with disc brakes that need to be understand during operations and resolved. There has been tons of research happening about these issues and at an equivalent time different methods are being proposed to eliminate or reduce them. One major purpose of this paper is to provide a comprehensive overview of all such developments.
Keywords: Disc brakes, Go-kart, Racing, Friction, Weight

I. INTRODUCTION

Every vehicle requires a kind of brake system to stop or adjust its speed and acceleration with changing road and traffic conditions. The basic principle utilized in braking systems is to convert the K.E. of a vehicle into another sort of energy. For example, in friction braking it's converted into heat, and in regenerative braking it's converted into electricity or compressed gas etc. During a braking operation not all the K.E. is converted into the specified form, e.g. in friction braking some energy could be dissipated within the sort of vibrations. In a quick description of various brake systems utilized in a vehicle is given.

Two sorts of friction brakes, drum brakes and disc brakes, are widely used. Disc brakes as compared to drum brakes cool faster, thanks to larger swept area and comparatively higher exposure to air flow, and show self-cleaning ability thanks to centrifugal forces. Due to these improving reasons and some other extreme advantages disc brakes have become the universal choice for front brakes on cars and are also expected to dominate the truck market in the near future.

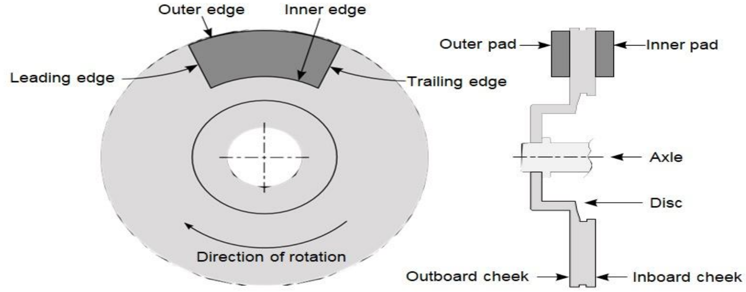

Fig. 1 Disc brake system

A. About go-kart

Karting is that the safest, cheapest and, arguably, best avenue into motorsports for those with the will to compete. Karts could seem like little cars, but there are some defining characteristics that separate them from ATVs or other tiny conveyances. Obviously, size may be a big factor, but one major aspect of a kart is its complete lack of a standard suspension; here the axle is firmly affixed to the frame, there's no differential (both rear tires turn at an equivalent speed), and while things like camber and caster could also be adjustable, there are not any dampers or springs. Overall kart layout tends to feature a driver sitting beside a coffee capacity engine (generally 125cc or less) that uses either chains or gears to drive the rear axle. Traditionally, a kart features a single brake disc on the rear and zip on the front (though that's not always the case), and therefore the pedal is situated to the left of the kart, with the throttle on the proper , forcing the driving force to either learn left-foot-braking or go hurtling astray .

B. Future Scope Of The Project

Go-kart is basic of racing or start line , there's not one during all one amongst one in every of one of the present crop of F1 drivers who hasn't started his Motorsport career in a go-kart. Karting helps you get your basics. Karting also gives you some idea about the level of fitness you need to become a racer Now that go karting in India has become a popular choice of sports, there are tracks laid in every major Indian city. Along with the turns and bends of the tracks, the speed of the kart and therefore the power of the engine one should also confirm the place has taken safety measures and therefore the karts are in fitness.

C. Goals

1) To design a braking system that is simple to use and ensures safety of the driver with most effective way.
2) To design a braking system this can take minimum time to bring the vehicle to stop.

D. Purpose

1) To deduce the speed of a moving vehicle using kinetic friction force and secure it from rolling when stopped using static friction force.
2) To design and develop a braking system which take minimum time to bring the vehicle to stop.
3) To ensures safety of the driver.

II. THEORY

In a disk brake system, a group of pads is pressed against a rotating disc with help of friction; heat is generated at the disc-pad interface. This heat ultimately transfers to the vehicle and environment and therefore the disc cools down. A simplified disk brake is shown in figure 1 with the terminology which is in common use. The pad which is nearer to the middle of the vehicle is named the inboard pad while the one that's away is named the outboard pad. Similarly friction surface of the disc which faces towards vehicle is named inboard cheek and therefore the one which faces away is named outboard cheek. The edge of the pad which comes into contact with some extent on disc surface first is named vanguard while the sting which touches that time last is called trailing edge. The edge of the pad with smaller radius is named inner edge while the one with larger radius is named fringes.

A disk brake assembly consists of following major components: brake disc, pad, under layer, back plate, shim and calliper. Now these components are going to be described in additional detail.

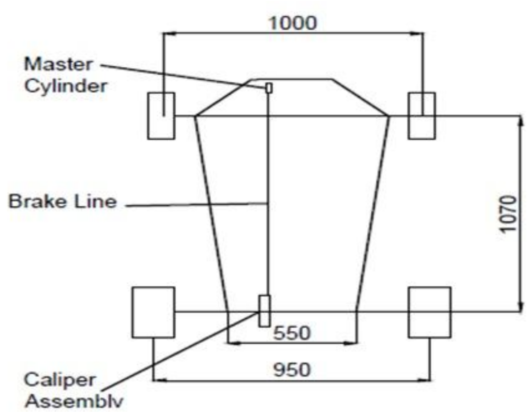

Fig.2 Brake circuit diagram

A. Brake Disc

Brake disc, also called brake rotor, is fixed to the axle, so it rotates with the same speed as the wheel. Braking power of a disc brake is determined by the rate at which kinetic energy is converted into heat due to frictional forces between the pad and the disc. For an efficient brake design, it is also important that heat is dissipated as quickly as possible otherwise the temperature of a disc might rise and affect the performance of a disc brake. So to get an optimum performance in demanding applications, ventilation is introduced in the brake discs which increase the cooling rate. Brake discs could be divided in two categories:

1) Solid brake discs
2) Ventilated brake discs

B. Brake Pad

A brake pad includes a friction material which is glued to a stiff back plate. Mostly the friction material and back plate combined are called a brake pad. A brake pad usually penetrated slots on its face and chamfers at the ends. Figure shows different configurations of pads. A pad can have quite one slot and it might be arranged in several orientations. One purpose to include chamfers and slots is to scale back squeal noise. Relatively higher temperature at the pad surface than the inside will end in convex bending of the pad. A slot will allow the fabric to bend and help avoid cracks. Furthermore it facilitates to scrub the dust collected between disc and pad surfaces by offering an escape.

Fig.3 Brake pads

C. Brake Caliper

A brake caliper is an assembly which houses the restraint. In addition it also includes the pistons and provides the pathway for the brake fluid which actuates the pistons. There are two sorts of calipers, fixed and floating. A fixed caliper does not move relative to the brake disc and houses the pistons on both sides of the disc as shown in figure. When pressure is exerted both pistons move and push the restraint . A floating caliper includes the piston only on one side of the disc as shown in figure. When pressure is implemented, the piston moves and forces the inner brake pad forward. When the pad contacts the disc surface, caliper moves within the other way in order that outer pad also contacts the disc surface. In this design, inboard pad is additionally called piston-side pad and outboard one is named finger-side pad.

In general, the inner and outer pads show different contact pressure distributions and wear behaviors because of different support and actuation systems and difference in thermal deformations of inboard and outboard sides of a disc.

Fig.4 Brake Caliper

D. Materials

A variety of materials are used for the different parts of the disc brake assembly. The choice of materials mainly depends upon the applications and characteristics required.

1) *Disc Materials:* Grey forged iron with a predominantly pearlitic matrix is that the widely used material for brake discs. The advantages of using it as a disc material are good cast-ability and machinability, high thermal conductivity and heat capacity, resistance to brake fade and lower cost. There is an interest within the industry to use lighter materials for the disc in order that it contributes less to the general weight of the vehicle and ultimately improves the fuel Consumption. One more reason for lighter disc is that the brake discs are a part of the unsprung mass of the vehicle, so its reduction also adds to driving comfort. One way to scale back the load is to use aluminium mounting bell and forged iron braking ring during a hybrid brake disc. These two parts are often connected with either integrally casted grey iron braking ring with aluminium bell or by mechanical connections e.g. integrating radial steel inlays. Friction ring is formed of forged iron to require advantage of its superior friction and thermal properties while mounting bell is formed of aluminium to scale back the general weight

2) Friction Materials

From functional and safety point of view following considerations are required on the behaviour of friction materials.

a) High coefficient of friction
b) Stable coefficient of friction regardless of temperature, velocity, pressure, humidity, wear, corrosion and water spraying
c) Slow wear rate of the friction material and long lif
d) Slow wear rate of the disc
e) Smooth braking without noise and vibrations
f) Regain the original properties after severe braking and with aging
g) Environment friendly raw materials
h) Low cost

This puts tremendous demands on the fabric selection process. To fulfil numerous demands friction materials are made up of many constituents and hence are termed composites.

III.DESIGN

A. Design Calculation

Parameters: Mass of vehicle = 150 kg
Maximum speed of vehicle (s) = 80kmph (22.22m/s)
Tire radius (r_{tire}):= 139.70mm
Height of C.G from ground surface (h) = 200mm

1) Calculation Of Stopping Distance And Time

u=initial velocity in m/s;

v=final velocity in m/s;

a=deceleration rate in m/s2;

s=stopping distance; t=braking time;

v=0; u=80 kmph (22.22m/s)

Assuming deceleration a=1 x g=9.81m/s2
(i.e. a=µxg; µ=the coefficient of friction between road and tire Assuming µ=1 for asphalt and slick tires)
Using Newton's 3rd Kinematic equation,
v2=u2+2as s=25.17m Using Newton's 1st Kinematic equation
v = u + at t=2.56sec The stopping distances and braking time while stopping the kart to rest from various speeds are listed in following table: 2 Dynamic weight transfer:
Dynamic weight transfer is the amount of change of vertical loads of the tires due to longitudinal acceleration imposed on Centre of Gravity of the car. Total static mass of vehicle including driver =150 kg (Static weight distribution is assumed to be 40%front and 60% rear) Height of C.G from the ground surface (h) =200mm Wheelbase (b) =1070mm
(Fs)F =Static weight on front wheels = 150 x 9.81 x 0.4 = 588.6N
(Fs)R =Static weight on rear wheels = 150 x 9.81 x 0.6 = 882.9N
F_d = Force due to dynamic weight transfer

$$F_d = \frac{m\,a\,h}{b}$$

$$= \frac{150 \,X\, 9.81 \,X\, 200}{1070}$$

= 275.05 N

Total dynamic weight on Front axle $(F_d)_F=(F_s)_F+F_D$ = 588.6 + 275.05 = 863.65N
Total dynamic weight on Rear axle $(F_d)_R=(F_s)_R-F_D$=882.9 - 275.05=607.85N

2) Master Cylinder & Caliper Selection

As only one disc is used on rear rigid driving axle weight on only rear wheels is considered. Maximum driving torque without slipping condition is:

$T_f = (F_d)_R \times \mu \times r_{tire}$ = 607.85 x 1 x 0.1397

=84.9N-m

Single piston caliper is suitable for required braking torque. Available single piston caliper in market is rear Brake Caliper of Bajaj Pulsar 220. The diameter of that Caliper is 32mm.

As there is only one disc used for braking the rigid driving axle, Master Cylinder (MC) is preferred over Tandem Master Cylinder (TMC) to avoid blocking extra outlet port.

Fig.5 Master Cylinder

3) Design of Braking Circuit

We found the force applied by foot of driver by using spring balance to be 150N on an average. We have assumed a pedal ratio of 6 :1 to achieve an optimum pedal travel and minimum driver effort.

Table no .1. Braking circuit

Pedal force applied by driver (F_a)	= 150N
Brake Pedal Ratio	= 6 : 1
Force applied to master Cylinder (F_1)	= 900N
Diameter of Master cylinder piston (D_1)	= 12mm
Area of master cylinder (A_1)	= 11.31×10^{-5} m^2
Brake fluid Pressure (P) = F_1 / A_1	= 79.57bar
Diameter of caliper piston(D_2)	=32mm
Brake caliper piston area (A_2)	= 8.042×10^{-4} m^2

According to Pascal's Law, Assuming pressure is transmitted without any loss to the Caliper Force Transmitted to Brake caliper (F_c) = PxA_2 =6399.02N

Total force transmitted to brake pad(F_p)=$2\times F_c$ =12798.038N

Braking Torque (T_b) = $F_p \times \mu_{pad\&disc} \times r_{effective}$

=12798.038×0.33×(0.07)

Where $r_{effective}$ = radius at which pad apply force on disc

Tb = 295.63 N-m

Hence braking torque is greater than the required frictional torque So wheels will get locked. The brake pedal has an adjustment of 2 pedal ratios as 4.5:1 and 3:1.

Hence, according to driver feedback, pedal ratio can be adjusted, depending upon the track conditions and dynamic events.

4) Rotor Specifications

We are going to manufacture disc of our own design. Specifications of disc are:

Material = EN8

The reason behind selecting EN8 is to obtain high strength, specific heat, better heat transfer and good thermal conductivity of the disc.

Outer dia. = 150 mm

Effective radii = 75 mm

Thickness =4 mm

PCD= 80mm (3 bolts of dia 8)

Fig. 6. Brake rotor and Hub

5) Design of Rotor Hub

Material: EN8

For EN8 σ_{yt}=323.23 MPa

Torque to be transmitted (M_t)= Torque due to traction

= μ x m x g x 0.6 x radius of tire

= 123.3411 N-m

=123341.1 N-mm

Fixing the hub length as 30mm,

Shaft diameter = 25mm

Hub diameter (d_h) = 41mm

Thickness of flange (t) = 6mm

Force on hub=M_t / radius of hub

=123341.1/20.5

=6016.64N

Shear stress=F / A

=6016.64/ (π x d_h x t)

=6016.64/(3.14 x 41 x 6)

6) Brake Pedal

Pedal Calculation

The force applied by foot of driver while braking is assumed to be 150N. The value is found out by taking a number of readings of force actually applied by our driver on spring balance and taking the average.

Force applied by foot of a driver on pedal (N) = Average reading in spring balance x 9.81 Now the pedal ratio is assumed to be 5.5 : 1

Force on master cylinder = Pedal ratio x Force on pedal by foot of driver

= 5.5 x 150

= 825 N

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VII July 2021- Available at www.ijraset.com

This force generates a pressure of 41.65 bar and a braking torque of 154.77Nm in the respective hydraulic circuit to lock the wheels. Required force on pedal for generating 123.34 Nm torque to lock the wheels is 120N. So, from above calculations application of braking force is in comfort of driver.

Selecting FOS = 2 D^3 = 4329.638

D = 16.253 mm

Calculation by Torsion for finite life S_{se} =0.577 x S_e

S_{se} = 99.643

$D^3 = 16 \times M_t / (\pi \times S_{se} / FOS)$

= 12606.804

D = 23.2007

Hence by using design for fluctuating load, the diameter obtained is 23.2007mm

IV. WIRING SYSTEM

A. Introduction

The electrical system of a kart is a closed circuit with an independent power source the battery. It operates on a little fraction of the facility of a household circuit. A typical electrical system aside from the most charging, starting and ignition circuits, there are other circuits that power lights, electric motors, the sensors and gauges of electrical instruments, heating elements, magnetically operated locks, the radio then on. All Circuits are opened and closed either by using switches or by using relays - remote switches operated by electromagnets. Current flows along a single cable from the battery to the component being powered, and back to the battery through the kart's metal body. The body is connected to the world terminal of the battery by a thick cable. Earth-return system during a negative (-) earth-return system, the present flows from the positive (+) terminal to the component being operated. The component is earthed to the kart body, which is earthed to the negative (-) terminal of the battery. This type of circuit is called an earth-return system any part of it connected to the kart body is said to be earthed. The strength of the present is measured in amperes (amps); the pressure that drives it around the circuit is named voltage (volts). Modern karts have a 12-volt battery. Its capacity is measured in amp/hours. A 56 amp/hour battery should be ready to deliver a current of 1 amp for 56 hours, or 2 amps for 28 hours. If the battery voltage drops, less current flows, and eventually there's not enough to form the components work. Current, voltage and resistance the extent to which a wire resists the flow of current is named resistance and is measured in ohms. Thin wires conduct less easily than thick ones, because there's less room for the electrons to travel through the energy needed to push current through a resistance is transformed into heat. This can be useful, for instance within the very thin filament of a light-weight bulb, which glows white hot. However, a component with a high current consumption must not be connected using wires which are too thin, or the wires will overheat, blow a fuse, or blow out.

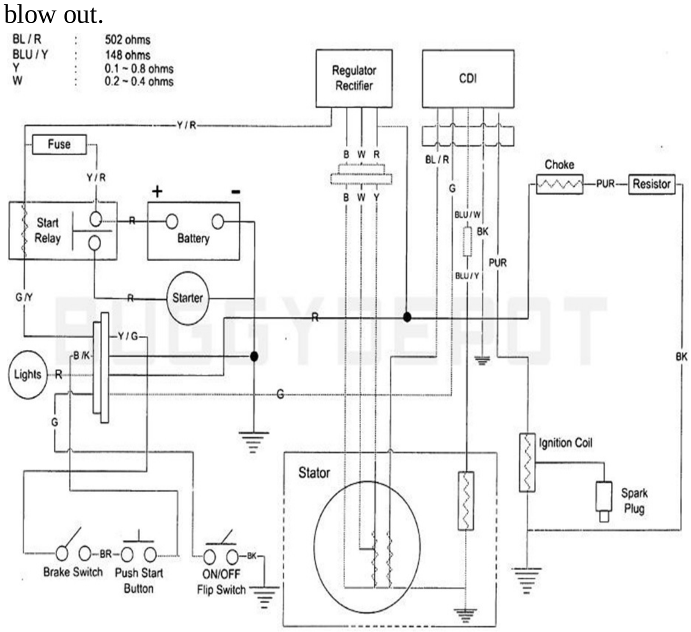

Fig. 7 Electrical wiring system

B. *Components of Wiring System*

1) *Battery:* A battery is employed to supply the facility to start out the kart. It also used for diminishing electrical energy. Most of the motorcycle batteries are the traditional 'lead-acid' batteries. These batteries are often either of 6 volts or 12 volts. If the batteries are in fitness, then the particular value of voltages isn't these values. When the battery is fully charged, and it's current level is at peak, the terminal voltage of every cell is 2.1v. These cells are connected serial combination to supply required voltage. A 6v battery consists of three cells which can give total terminal voltage 3 * 2.1v = 6.3v. Likewise, a 12v battery is formed from six cells having a terminal voltage of two .1v, which can provide a total terminal voltage of 12.6v. A 12v battery gives energy starting from 10.5v when connected to load with dimmed lights to 14v when charged fully. There will be voltage deflections as per the battery has undergone charging or discharging states. This depends on electrical loads. They lower the voltages temporarily. The buffering charge reduces usual operating voltage
2) *Relay Switch:* One of the foremost common electro-mechanical switches during a vehicle, the most job of a relay is to permit a coffee power signal (typically 40-100 amps) to regulate a higher-powered circuit. It also can allow multiple circuits to be controlled by one signal—for example during a police kart where one switch can activate a siren and multiple warning lights at the same time. Relays are available a number of styles , from electromagnetic relays—which use magnets to physically open and shut a switch to manage signals, current, or voltage—to solid-state, which use semiconductors to control the flow of power. Because solid state relays haven't any moving parts, they're generally more reliable and have a extended service life. Unlike electro-magnetic relays, solid state relays aren't subject to electrical arcs which will cause internal wear or failure.
3) *Rectifier:* In motorbike, rectifier is an electronic unit which converts 12 volts DC out of the 11 to 14 volts AC the generator/alternator within the engine components. Other than karts most bikes do not have a separate alternator which is belt driven and sits beside the engine. Many bikes have their alternator within the engine housing near the crankshaft. An rectifier regulates the voltage of the alternator mainly by burning the amount of electricity which is too much. Therefore, rectifiers get hot - and are attached to the frame at an exposed position rather than inside the engine where it's hot anyway.
4) *Ignition Switch:* An switch, starter switch or start switch may be a switch within the system of a vehicle that activates the most electrical systems for the vehicle, including accessories. In vehicles powered by internal combustion engines, the switch provides power to the starter solenoid and the ignition system components (including the engine control unit and ignition coil) and is frequently combined with the starter switch which activates the starter
5) *Kill Switch:* Kill switch is a red colour safety mechanism button on the right side of the handlebar of the steering wheel to quickly shut down the engine and switch back on without reaching for the keys. Kill switches aren't limited within the definition. The kill switch or the engine cut off' switch or emergency switch on a kart is made to optimize the rider, as it helps to switch the engine on and off' without lifting hands from the throttle. It's particularly helpful just in case of emergencies and also in saving fuel which can be discussed below but before jumping into that. The kill switch is installed to chop the facility supply from the engine as quickly and safely as possible. Of course, this relies on the sort of kill switch that's installed, but the foremost common way it works is by involving the sparking plug.
6) *Ignition Coil:* An ignition system generates a spark or heats an electrode to a high temperature to ignite a fuel-air mixture in spark ignition internal combustion engines, oil-fired and gas-fired boilers, rocket engines, etc. The widest application for spark ignition combustion engines is in petrol (gasoline) road vehicles like karts and motorcycles.
7) *CDI Unit:* Capacitor discharge ignition (CDI) or thyristor ignition may be a sort of automotive electronic ignition which is widely utilized in outboard motors, motorcycles, lawn mowers, chainsaws, small engines, turbine-powered aircraft, and some karts. It was originally developed to beat the long charging times related to high inductance coils utilized in inductive discharge ignition (IDI) systems, making the ignition more suitable for higher engine acceleration (for small engines, racing engines and rotary engines). The capacitive- discharge ignition employ capacitor discharge current from the coil to fireside the spark plugs.

V. CONCLUSION

Disc brake may be a complex system and understanding different issues associated with its design and operation require expertise from different disciplines e.g. tribology, material science, fluid dynamics, vibrations etc. Disc brakes have evolved tons over the decades thanks to extensive research and development. There are still many points which aren't understood fully. For realistic computational analysis of disk brake systems, it's crucial to further develop non-linear finite element models which could simulate realistic evolution of contact interface. Such models should be capable, at least, to incorporate a realistic friction and wear model, and temperature dependent material properties. We calculated all the planning parameters and analysed the brake layout, brake disc, etc. Thus in any case the test and calculation we've concluded that our design is safe for fabrication.

VI. ACKNOWLEDGEMENT

We express our deep gratitude towards our guide and mentor Prof. A.P.Patil who helped us and supported us throughout the project. We are also thankful to our college management and Staff who gave us opportunity to make this concept made into reality. We are grateful to AIRC to educate us.

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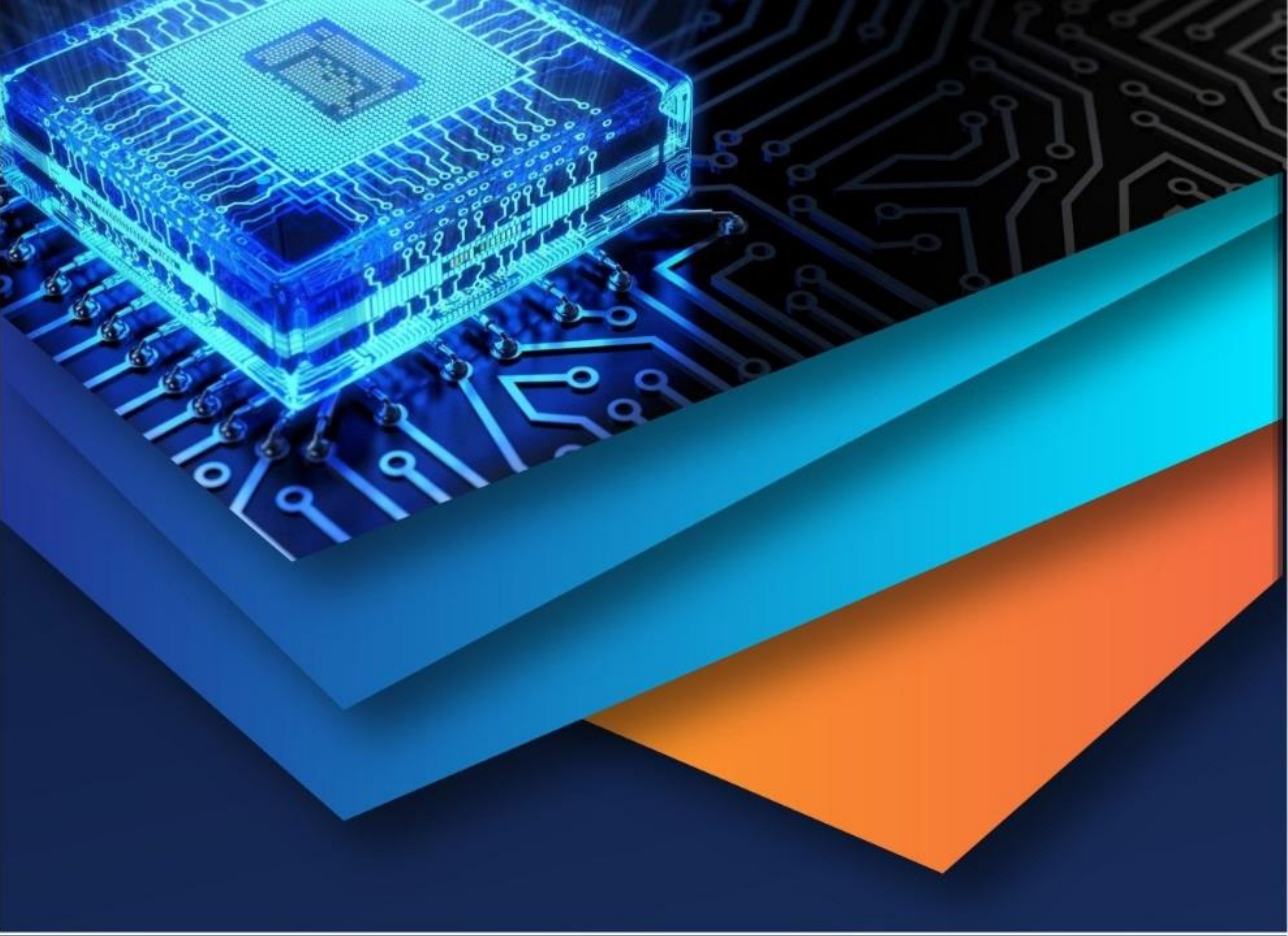

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