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Study and Analysis on Compressed Air Powered Vehicles

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Abstract: ***It is hard to believe that compressed air can be used to drive vehicles. However that is true, and the compressed air operated car, as it is popularly known, has caught the attention of researchers worldwide. It has zero emissions and is ideal for city driving conditions every automotive industry is looking to reduce the weight of the vehicle as it helps in the better handling of the vehicle and increases the efficiency of the vehicle. Today, the heavy vehicles are known for producing a large amount of harmful gases like CO2, SO2 etc. Although it seems to be an environmentally- friendly solution, one must consider its well to wheel efficiency. The electricity requirement for compressing air has to be considered while computing overall efficiency. Nevertheless, the compressed air vehicle will contribute to reducing urban air pollution in the long run.***

Keywords: pneumatic propulsion vehicle, pneumobile, optimization, air consumption, mathematical modeling, pneumatic propulsion system

I. INTRODUCTION

The first compressed air vehicle was established in France by a Polish engineer Louis Mekarski in 1870. It was patented in 1872 and 1873 and was tested in Paris in 1876. The working principle of engine was the use of energy stored in compressed air to increase gas enthalpy of hot water when it is passed through hot water. Another application of the compressed of the compressed air to drive vehicles comes from Uruguay in 1984, where Armando Regusci has been involved in constructing these machines.

He constructed a four-wheeler with pneumatic engine which travelled 100 km on a single tank in 1992. The Air Car was developed by Luxembourg-based MDI Group founder and former Formula One engineer Guy Negre is which works on compressed air engine (CAE).

He developed compressed air- 4- cylinders engine run on air and gasoline in 1998 which he claims to be zero pollution cars. It uses compressed air to push its pistons when running at speeds under 35 mph and at higher speeds of 96 mph, the compressed air was heated by a fuel (bio fuel, gasoline, or diesel), due to which the air expanded before entering the engine. A fuel efficiency of about 100 mpg was observed. Light weight vehicles are the next advancement in the development of automobiles. Reducing the weight of the vehicle has many advantages as it increases the overall efficiency of the vehicle, helps in improving maneuverability, requires less energy to stop and run the vehicle.

The latest researches are going on around the world in order to come up with innovative ideas. But global warming is also one of the problems which is affecting the man. A compressed-air vehicle (CAV) is powered by an air engine, using compressed air, which is stored in a tank. Instead of mixing fuel with air and burning it in the engine to drive pistons with hot expanding gases; compressed-air vehicles use the expansion of compressed air to drive their pistons. Compressed- air propulsion may also be incorporated in hybrid systems, such as with battery electric propulsion. This kind of system is called a hybrid pneumatic electric propulsion.

Additionally, regenerative braking can also be used in conjunction with it It seems to be an environmentally-friendly solution, one must consider its well to wheel efficiency. The electricity requirement for compressing air has to be considered while computing overall efficiency. Never the less, the compressed air vehicle will contribute to reducing urban air pollution in the long run . The temperature of the earth is increasing drastically and this in turn is causing climatic changes. The fossil fuels are widely used as a source of energy in various different fields like power plants, internal & external combustion engines, as heat source in manufacturing industries.

II. REVIEW & RESEARCH

The Pneumatic vehicle is a new technology developed that allows a car to be powered by compressed air.

1) Venkatesh Boddapati [1] says compressed air storagetanks built with carbon fibers will carry high amount ofpressure with minimum volume space which obviouslymeets the requirement with the conventional engines with zero emission. Air powered Vehicle is realization of most advanced technology in the field of Automotive. It eliminates the use of Non Renewable energy fuels. We can develop this type of vehicle into Multi-fuel Engine that runs on both compressed air and/or Fuel (Gasoline) mode.
2) Gaurav sugandh [2] says that this paper describes the working of a four stroke single cylinder Engine which can run on pneumatic power as by compressed air. Since it is an old technique which can attracted many scientist as well as Engineer's for many years. This paper describes on the same with some new modification which is main objective of this research paper . Since engine is operated by Compressed air which contribute to reducethe air pollution and tend to zero pollution level of atmosphere and making a great a environment. While developing it some parameters as like temperature , density, input power, emission control have be masteredfor development of safety. Since the Gasoline is a thingof past so the main advantage of CAE is no hydrocarbon fuel is required i.e. No combustion is occur during this process.
3) S. S. Verma. [3] says that Compressed air as a sourceof energy in different uses in general and as a nonpolluting fuel in compressed air vehicles has attracted scientists and engineers for centuries. Efforts are being made by many developers and manufacturersto master the compressed air vehicle technology in all respects for its earliest use by the mankind. The presentpaper gives a brief introduction to the latest developments of a compressed air vehicle along with anintroduction to various problems associated with the technology and their solution. While developing of compressed air vehicle, control of compressed air parameters like temperature, energy density, requirement of input power, energy release and emission control have to be mastered for the development of a safe, light and cost effectivecompressed air vehicle in near future.
4) Pramod kumar [4] studied In this project, an SI engine is converted into a compressed air engine. A four stroke single cylinder SI engine is converted to twostroke engine which operates using compressed air because of its design simplicity. As we converted the already existing conventional engine into an airpowered one, this new technology is easy to adapt. Another benefit is that it uses air as fuel which isavailable abundantly in atmosphere.
5) Gopal sahu [5] says that Compressed air as a source of energy in different uses as a nonpolluting fuel in compressed air vehicles has attracted scientists andengineers for centuries. Compressed air filled by electricity using a compressor. The electricity requirement for compressing air has to be considered while computing overall efficiency. Compressed air vehicle will contribute to reducing air pollution andtend to zero pollution. No combustion process is occurring there. Light utility vehicles are becomingvery popular means of independent transportation for short distances.
6) Andrew papson [6] studied characterized thepotential performance of CAVs in terms of fuel economy, driving range, carbon footprint, and fuel costs and examines their viability as a transportation option as compared with gasoline and electric vehicles. Subjects of analysis included energy density of compressed air, thermodynamic losses of expansion, CAV efficiency on a pump-to-wheels and well-to-wheels basis.
7) A.H. Ingle [7] This paper deals with the study of compressed air as a fuel for running a 3- wheeler vehicle wherein the compressed air is stored in tank& supplied to the air motor from where rotational motion is obtained .In this project a preliminary investigation is carried out to run a vehicle on compressed air. Using this study we were able to develop a 4 wheeler compressed air vehicle integrated with remote control and a steering mechanism for industrial use.
8) Mihai Simon [8] described the research, design and construction of a viable experimental pneumaticdriven vehicle. Their main goal was to find ways todrive efficient by using alternative energy, not necessary cheaper, but more environmental friendly in increasing polluted metropolis. This was done by developing an experimental pneumatic vehicle running on compressed nitrogen gas. Here the technology used was not much cheaper because of compressed nitrogen we decided to overcome this by using regular compressed air as fuel.

A. Study of Compressed Air Storage System asan Energy for 21st Century

The power conversion system (PCS)is a vital part ofall energy storage systems. It interfaces the energystorage device and the load (the end-user). PCS costis significant and it can be greater than 25% of theoverall energy storage system. PCS cost rangesfrom Rs.4500/kW for UPS markets to Rs.55000/kWfor standalone market.

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Some of the major PCS markets include Motor drives Power supplies UPS (uninterrupted power supply) Electric vehicles Inverters/Converters for solar-hybrid systems, Micro-turbines, Fuel cells, Wind turbines Power conversion system technology has been evolving slowly due to the limited distributed energy resource (DER) market. As a result, Energy Storage System cost has been high with low profit margins and the manufacturing volume has been low impacting reliability and quality of the PowerConversion System designs

CAES is not a simple energy storage system, like otherbatteries. It can be viewed as a hybrid of an energy storage and a gas turbine power plant. Unlike conventional gas turbines, which consume about two- thirds of their input fuel to compress the air at the timeof power generation, CAES pre compresses the air, using low-cost electricity from the power grid at off- peak times, and utilizes it with some gas fuel to generate electricity when required]. The compressed airis stored in appropriate underground caverns oraboveground air vessels. The schematic of a modern CAES facility is presented

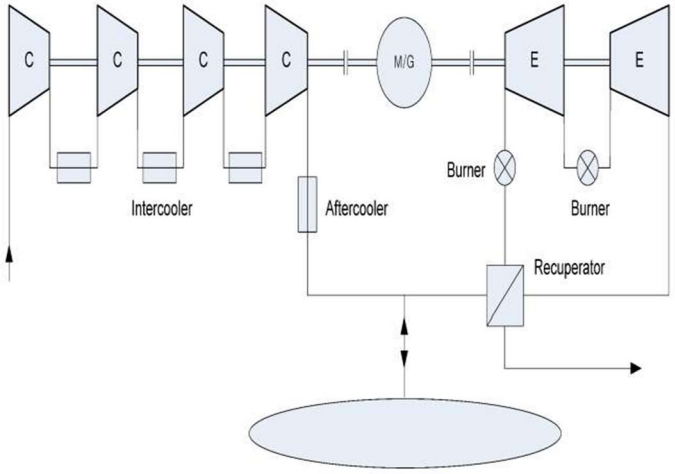

Fig 1: Conventional CAES system: Schematic of the McIntosh plant

Since the CAES system can be considered to be a combination of an energy storage system and power plant,and all processes are accompanied by a significant amountof heat transfer, understanding the electrical energy flow in the CAES system is very difficult using the first law ofthermodynamics, which deals with heat and work equally;therefore, we can use exergy flow, which is based on the second law of thermodynamics, to better understand the characteristics of the CAES system. Exergy can be defined as the maximum useful work possible that isaccomplished during a process that brings the system intoion equilibrium with the environment. Assuming that potential and kinematic energy effects are negligible and no chemical reaction occurs, the exergy of an air stream can be expressed

$$\dot{E}_a = \dot{M}_a\,[h - h_0 - T_0\,(s - s_0)]$$

Where *h* and *s* are specific enthalpy and entropy, respectively, and the subscript 0 indicates that the properties are taken at the environmental temperature andpressure

(T_0 = 20° C, P_0= 1 bar).

In the case of perfect gas flow:$_0$=cp$(T-T_0)$

$|-s|s_0$=cp ln(T/T_0) r ln (P/P_0)

where c_p is isobaric specific heat at average temperature and *r* is the specific gas constant.

The exergy in Equation

$$\dot{E}_a = \dot{E}_{a(M)} + \dot{E}_{a(T)}$$

$$\dot{E}_{a(M)} = \dot{M}_a r T_0 \ln \frac{P}{P_0}$$

$$\dot{E}_{a(T)} = \dot{M}_a c_p \left(T - T_0 - T_0 \ln \frac{T}{T_0}\right)$$

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Although the compression work varies according to various compression processes, e.g., isothermal, adiabatic compression, and two-, three-, and four-stage compression with intercooling, the compressed air is cooled and stored at the same environmental temperature (T_0) and storage pressure (P_S). This means that only the mechanical energy of the compressed air is stored in the air storage, and the thermal energy of the compressed air is dissipated by the cooler or can be stored in the thermal energy storage and reused during the discharging process.

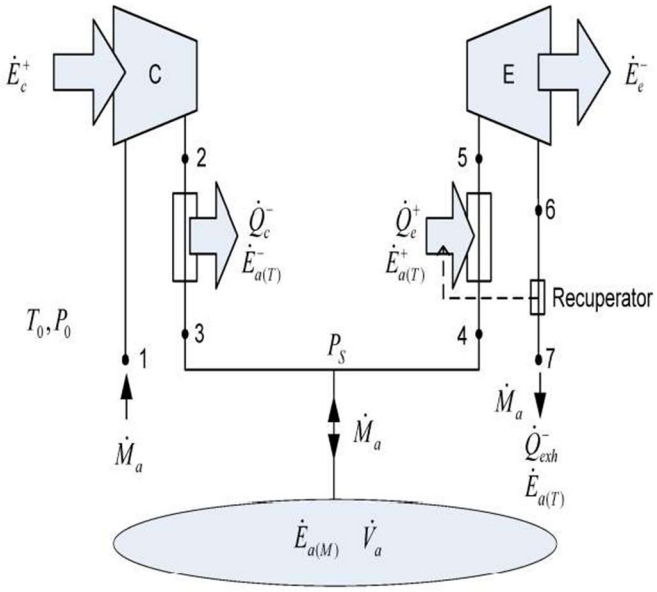

Fig 2: Energy and energy flow of simplified CAES system.

Comparison Chart

COMPARISON CHART	INTERNAL COMBUSTION VEHICLE	ELECTRIC VEHICLE	COMPRESSED AIR VEHICLE
Fuel type	Diesel/Petrol	Batteries	Compressed Air
Annual fuel cost (Rs.)	137400	10871	8850
Annual green house gas emissions	4.6	4.1	–
Top speed	180km/hr	140km/hr	129.2km/hr
Engine characteristics	80.90kw	32.2kw	Compressed air {estimated around 2.04kw@80psi)
Recharge time	Instantly	8 hr	–
Price	7.69-14.18 lakhs	14.99-17.50 lakhs	10 lakhs

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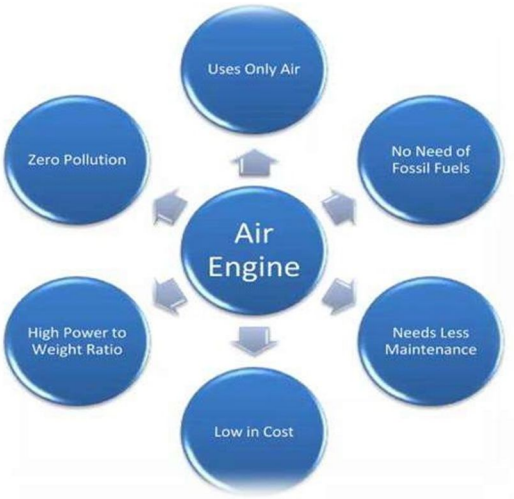
III. PRINCIPLE

Battery Powers the air compressor starts pressurizing the air and transmits it to valves via tubes. The AC 220V supply is provided to the transformers pair to convert it into 24V AC Supply. The 24V AC supply isconverted to Dc using rectifier and the supply is fed tothe DC Motor. The DC Motor rotates and runs the switch rod over the switch plate. The switch plate has4 divisions and each division is a conducting surface connected to 1 relay switch. When the switch rod rotates over the switch plate, it powers the relay switches and in-turn powers the solenoid valves in phase due to the construction of the plate. As the valves turn On, it transmits the air through its opening to the pneumatic cylinder and actuates the piston. Simultaneous switching of each of 4 valves produce continues actuation of each piston which transmits of its linear motion to the shaft. The shafts rotates continuously due to the cylinder movement and drivesthe wheels of the car.

IV. APPLICATIONS

1) It can be used by Car Manufacturing Companies.
2) It can be used as Family car.
3) It can be used as Van.
4) As Taxi Purpose
5) Personal use
6) Industries by workmen



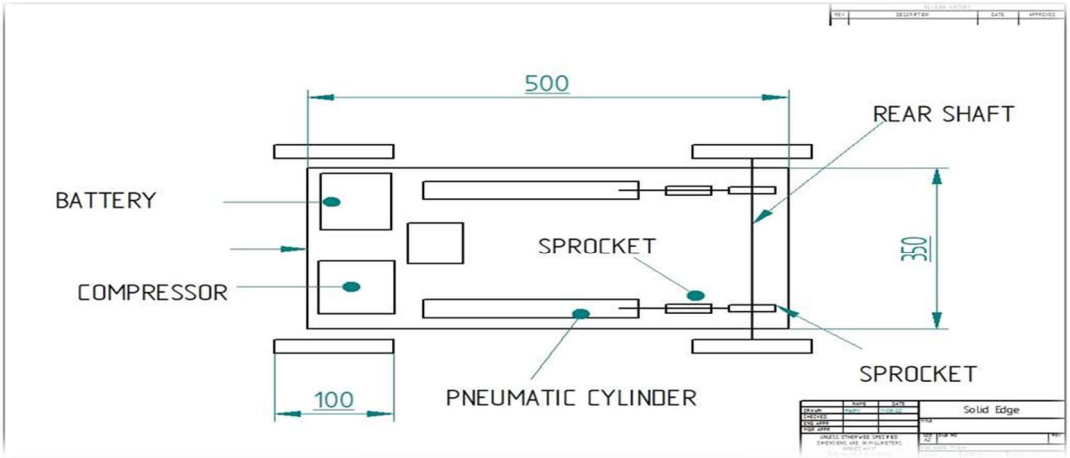


Fig 3: Basic design of vehicle

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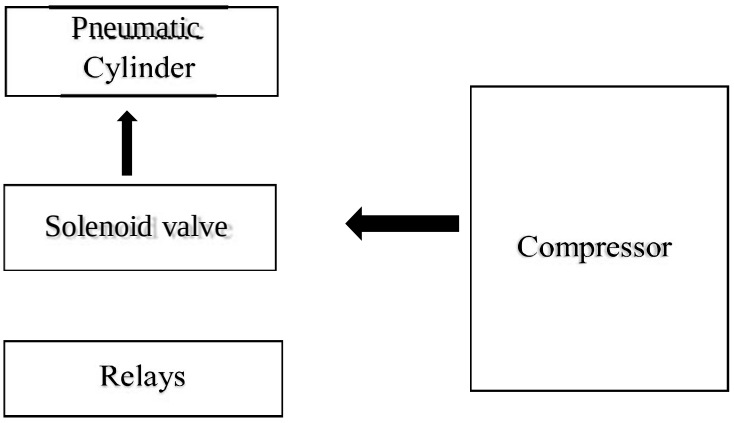
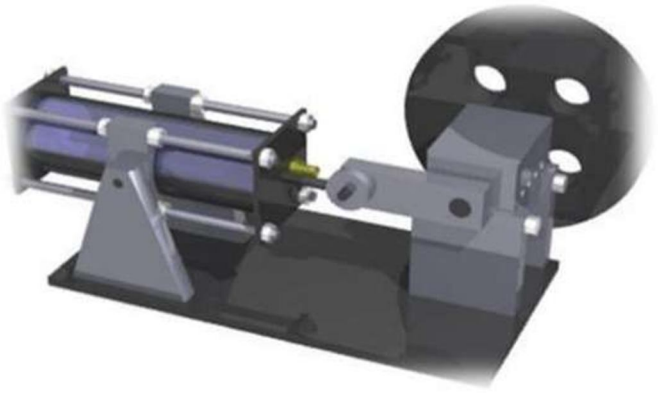
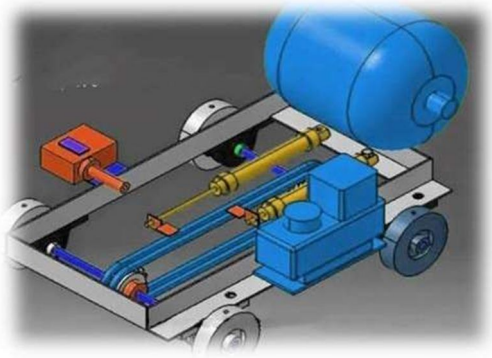
V. CONCLUSION

The technology of compressed air vehicles is not new. Infact, it has been around for years. Compressed air technology allows for engines that are both nonpollutingand economical. After ten years of research anddevelopment, the compressed air vehicle will be introduced worldwide. Unlike electric or hydrogen powered vehicles, compressed air vehicles are not expensive and do not have a limited driving range. Compressed air vehicles are affordable and have a performance rate that stands up to current standards. To sum it up, they are non-expensive cars that do not pollute and are easy to get around in cities. The emission benefitsof introducing this zero emission technology are obvious. At the same time the well to wheels efficiency of these vehicles need to be improved.







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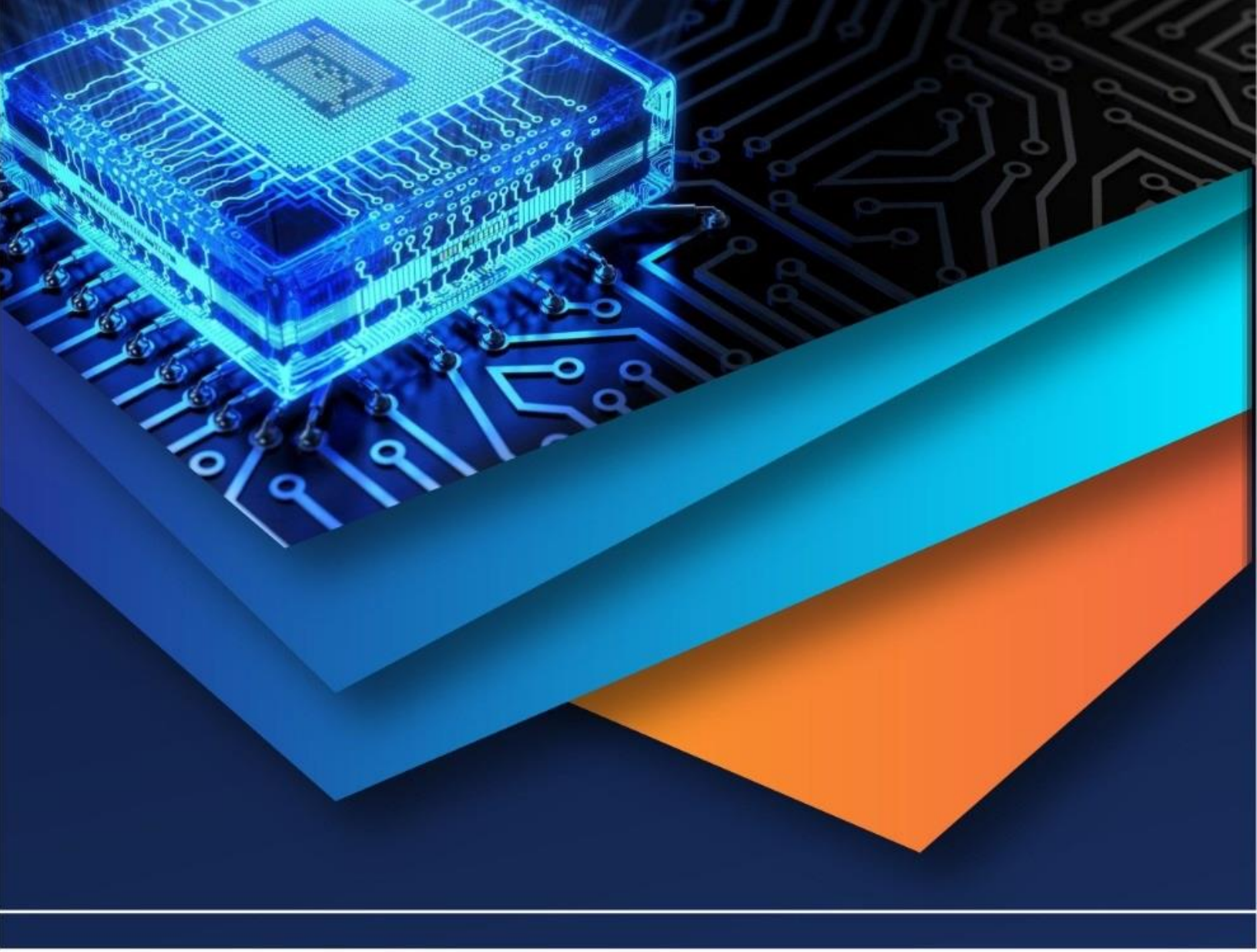

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