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An Analysis of Solar Energy Operated Cotton Ginning Machine for Sustainable Development of Rural India

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Abstract: ***Cotton Ginning is a fundamental process in any cotton textile industry whose major purpose is to clean and gin the cotton seed. The aim is to develop a machine which can be operated using multiple power sources (preferably solar and wind energy) at the same time keeping it portable, so that the operators can move it anywhere easily. The design is potentially help us to counteract the shortage of electricity. The primary aim is to demonstrate the possibilities of incorporating the renewable resources like solar and wind energy to effectively run a Ginning machine. The machine will primarily be used in rural domestic household instead of industrial segment. It is planned to design and fabricate the single roller cotton ginning machine which is multiple power operated using on grid electricity as well as off grid electricity like solar, wind etc.***
To utilize the vast amount of solar energy available in India along with the wind to run the ginning machine especially in rural areas where there is always the scarcity/shortage of on-grid electric supply. It is proposed to employ the photovoltaic cell panels, wind turbines and other techniques to harness the solar and wind energy and convert it into electric energy to run the prime mover i.e. an electric motor to perform the ginning operation. The major advantages are that it is a very clean form of energy. It is inexhaustible as well as free of cost, available all-round the year .
Keywords: Solar powered ginning machine, renewable energy, rural India.

I. INTRODUCTION

Ginning is the process of removing the seeds from raw cotton and cotton gin is a machine that quickly and easily separates cotton fibers from their seeds allowing much greater productivity than manual technique. Cotton ginning is a primary process in any cotton textile industry whose major function is to clean and gin the cotton seed.

More than 75 countries grow cotton on a commercial scale. The primary producers being USA, China and Uzbekistan, followed by India and Pakistan. Cotton is one of the most important commercial crops grown in India and is grown primarily in 9 states which are Punjab, Haryana, Rajasthan, Maharashtra, Andhra Pradesh, Karnataka and Tamilnadu etc. Indian Cotton Ginning Industry is the second largest in the world. Cotton ginning plays very important role of separation of fibers from seed of cotton and converts field crops into a marketable commodity i.e. lint.

Ginning acts as a bridge between cotton farmer and textile industry. In India, cotton is ginned on double roller gins manufactured domestically and industrially. Indian Ginning Industry has been transformed into profitable business enterprise and has achieved world-wide leadership in supply of quality cotton to domestic as well as international markets by implementing of efficient ginning, pre and post cleaning and material handling machinery along with application of skill development.

Ginning of cotton can be performed by people who reside in remote locations like farms and villages where even today there is a severe scarcity of on-grid electricity. However, this problem can be effectively tackled by making suitable arrangements that can help the residents to harness electricity from renewable and almost free natural resources like solar energy and wind energy. The major advantages of harnessing electricity from such sources are 1) Free of cost, 2) abundant in nature, 3) Eco-friendly, 4) subsidized equipment by govt.

These steps can make these people independent and empowered and will significantly boost the economy of the country.

In India, the present ginnery can be categorized into three major groups: -

Conventional Ginnery -In conventional ginnery, ginning, pressing or both operations are carried out mechanically, but the handling of seed cotton, lint, cottonseed and bales are done manually.

Semi-automatic Ginnery -This is a composite unit where all the unit operations of material handling except 1) Unloading and heap making of seed cotton 2) Feeding of seed cotton to the gins from central platform 3) Feeding of lint to press box and handling of bales in the press house are done automatically.

A. Manufacturing Process & Technology

Ginning process is illustrated in the flow chart figure 1. Seed cotton is fed to grading system where grading is done followed by pneumatic conveying. Further it passes through preparatory cleaning process followed by saw gin and lint cleaner and finally through pre-bale press and cotton bales.

Ginning Process involves two cleaning stages

1) Pre- Cleaning
2) Post Cleaning

The primary process of separating seeds from cotton is done by saw gin. In the gin house after ginning process is completed the cotton lint and cotton seeds are separated and the lint passes out through pneumatic system to the Post cleaner. (Lint Cleaners in which small impurities such as dust particles including small fibers are carried out and cotton becomes free from contamination.)

3) Rapid and easy separation of cotton fiber from their seed occurs and it enables much greater productivity than manual cotton segregation. The fibers are then processed into various cotton goods such as linens while any undamaged cotton is used typically for textiles like clothing. Seeds may be used to grow more cotton or to produce oil from seed of cotton.

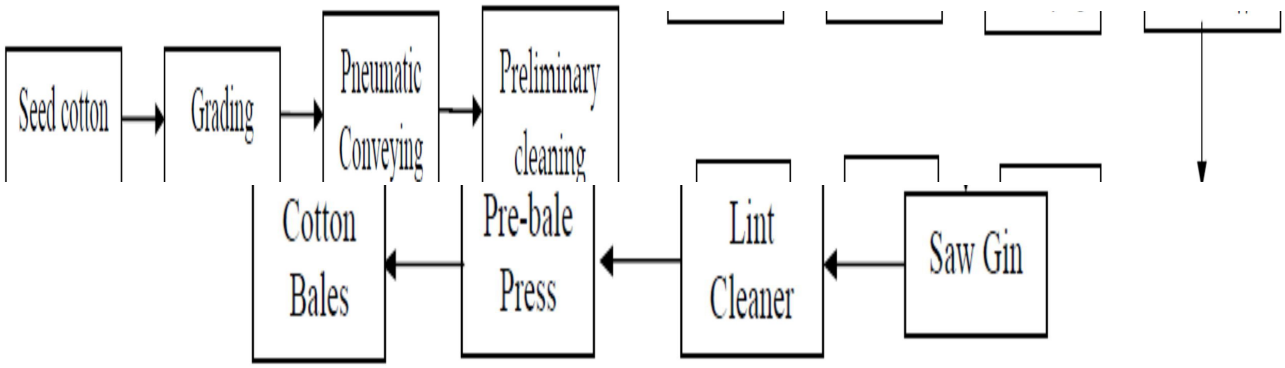

Figure 1 Flow diagram of the ginning process

II. PROPOSED CONCEPT

To implement solar/wind energy as an alternate source to enable the operation of cotton ginning machine in the absence of or non-availability of on-grid electric supply.

III. PV PANEL POWERED GINNING MACHINE

The method is to employ the vast amount solar energy available in India to run the ginning machine especially in rural areas where there is always the scarcity/shortage of on-grid electric supply. To employ the photovoltaic cell panels to harness the solar energy to convert it into electric energy to run the prime mover i.e. the electric motor to perform the ginning operation. The major advantages are that it is a very clean form of energy. It is inexhaustible as well as free of cost, available all-round the year except the rainy seasons.

The setup will consist of PV panels installed over the roof in such a way that they point towards the sun most of the time.

Along with the mechanism installed to change its alignment if needed. The electrical output of PV panels is passed through the regulator and to the storage batteries which are optional just in case of need of backup power (night operation).

It is sent to main inverter which performs the operation of converting the DC supply from the PV panels to AC supply suitable for AC motor along with stepping it from 24V DC to 230V AC. The process is explained in the figure 2.

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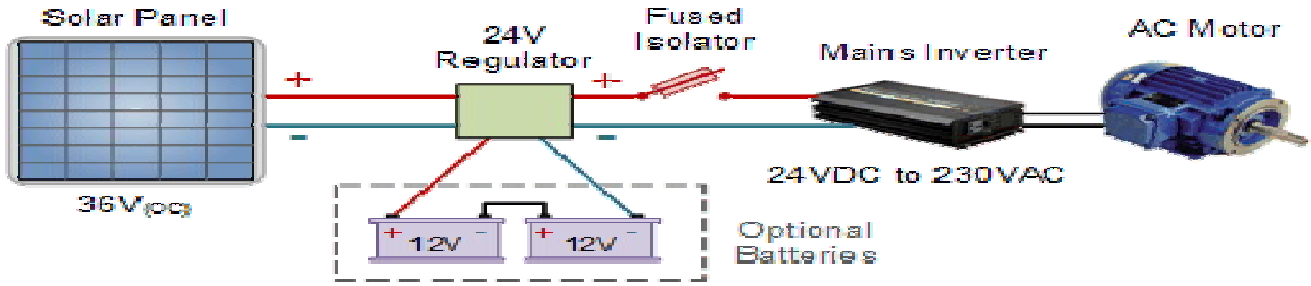

Figure 2 Solar panel assembly

A. Salient Features and Benefits of System

1) A clean, silent and eco-friendly source of power
2) Solar modules convert sunlight into electricity without Pollution
3) Negligible maintenance as there are no moving parts and Maximum reliability
4) Long life span of solar modules
5) Modular design and easily expandable
6) installation: can be mounted on roof top or groun
7) Can be installed at point-of use to avoid transmission losses
8) Energy Independence, subsidized equipment.
9) Protection against future escalation of energy costs
10) Available throughout the year

B. Working Principle

Except for the source of the power is Solar Radiation Solar photovoltaic(PV) system is like any other electrical power generation systems in terms of the output. This conversion of Solar radiation to the electrical power is based on the photovoltaic principles. However, the principles of operation of the connected load and interfacing with other electrical systems remain the same. A number of other components are required to properly conduct, control, convert, distribute, store and transform the energy produced by the array for solar PV array produces power when exposed to sunlight.

Solar power generating system supplied for this project shall be utilized for powering motor for specified hours of sun shine operation.

This system is designed to generate the energy in an eco friendly manner with the source from solar radiation which is abundant. This may incorporate a storage system for standby power. These modules will be connected in series / parallel combination through Optimizers to the desired string configuration as per the design parameters of the load. The load is of 0.5 to 1.5 horse power single phase AC motor. Grid power supply is provided to support the load and to reduce the Grid power consumption when solar power is available.

When the grind power is available the PV Panels will automatically switch to charging mode and charge the battery up to a certain limit. Once the grid power goes off the PV panels will power the machine during the period of sunshine, and during the dark hours the machine will rely on battery supply. In case if the electricity production is excess the framers and villagers can send to the grid and the govt. will pay these people an equivalent amount. This will in turn help to recover the invested cost in a shorter period of time.

C. Calculation of PV panel lighting system

The load of One horsepower (or 746 watt),

Total Wh rating = connected load * operating hours ---(1)

The normal number of operating hours be 8 hours,

(1) => Total Wh rating = 746 * 8 = 5968 Wh

Assuming 100Wp as the Watt-Peak or peak wattage developed by the panel as per design-

Actual power o/p of panel = peak power rating *

Operating factor

= 100 * 0.75

= 75 W

Power at end use = actual power * comb. Efficiency
= 75 * 0.81
= 60.75
Energy produced by one 100Wp panel in a day = power at end Use * 8h/day
= 60.75 * 8
= 486 Wh
Number of panels required = total Wh rating/daily energy produce by the panel
= 5968/486
=12.27~13 Panels are reqd.

Now, to find out battery requirements-

Battery capacity (Ah) = $\frac{\text{Total Wh * Days of autonomy}}{\text{Battery combined eff. * voltage}}$

$= \frac{5968 * 1}{0.8 * 0 .9 * 12}$
= 690.75 Ah
No. of batteries required = Total Ah rating/ Battery rating
= 690.75/120
= 5.75~ 6 batteries are reqd.
In parallel to get reqd. Ah with constant DC voltage of 12V.

IV. SOLAR POND TO POWER THE GINNING MACHINE

The solar pond is another efficient and cost-effective technique to harness solar energy and convert it into solar energy. Technique is especially suitable in rural areas and in farms where there is availability of vacant patch land plenty of water throughout the year.

A. The solar pond has two types

1) Convective solar pond
2) Non-convective solar pond

A solar pond is a huge solar thermal collector with an inbuilt arrangement for storage of heated water.
A solar pond is, just, a pool of saltwater which collects and stores solar thermal energy as shown in figure 3. The saltwater naturally creates a vertical salinity gradient, in which low-salinity water floats above high-salinity water. The concentration of the salt solution and in-turn its density increases with increasing depth.
A high uniform concentration of salt solution can be found after a certain depth. When the sun's rays strike the bottom of a shallow pool-which is coated with a special material generally black in color to optimize heat absorption- they heat the water adjacent to the bottom. When water at the bottom of the pool is heated, it becomes less dense than the water above it, and this temperature difference initiates convection. Solar ponds heat water by using this convection. Salt is added to the water (about50 gm/m^2) until the lower layers of water become completely saturated. The low salinity water at the top of the tank does not mix easily with the high salinity water solution at the bottom of the tank, so when the lower layer of water is heated, convection occurs separately in the lower and upper layers, with only mild mixing among the two. This greatly reduces heat loss and allows for the high-salinity water to get up to 95 °C while maintaining 25 °C low-salinity water. This hot, saline water can then be pumped out for use in electricity generation, through a turbine or as a source of thermal energy.
Also, this heated water can be directly converted into electrical energy by using Thermoelectric converters.

B. Advantages and Disadvantages

1) This approach is attractive for rural areas in progressing countries.
2) Gigantic collectors can be set up for just the cost of the clay or plastic pond sheet.

3) The accumulating salt crystals have to be removed and can be a valuable by-product and a maintenance expense.
4) No need for a separate/extra collector.
5) The extremely-large thermal mass means power is harnessed night and day.
6) Relatively low-temperature operation means solar energy conversion is less than 2%.
7) Due to evaporation, non-saline water is constantly required to be topped up to maintain salinity gradients.

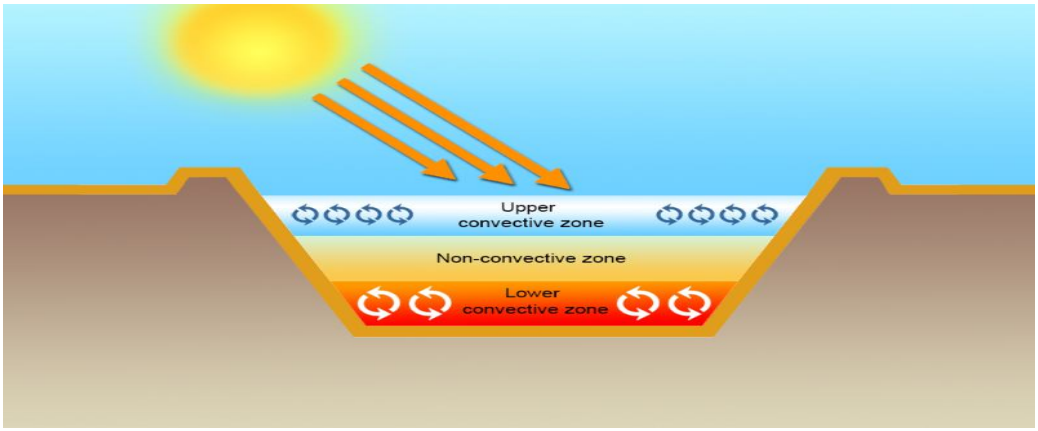

Figure 3 Solar Pond (Convective Type)

V. WIND POWERED GINNING MACHINE

Wind energy is the kinetic energy associated with the movement of large masses of air. These motions result from uneven heating of the atmosphere by the sun, creating density, pressure and temperature differences.
In contrast to active availability of direct solar radiation, wind energy can be available continuously throughout a 24-hour day for much longer periods though it can vary to a great extent including no wind periods. It is a clean, cheap and ecofriendly renewable source.
Wind energy is harnessed as mechanical energy with the help of a wind turbine.
The necessary wind speed for the wind turbine to be in generating mode is anywhere between 5m/s to 25 m/s.
The turbine is coupled to an electric generator which converts mechanical energy of the turbine to electrical energy which can be conditioned to use directly or can be stored in a suitable storage device.

A. There are primarily 2 types of turbine

1) Horizontal axis
2) Vertical axis

Horizontal axis turbines are simple in construction but consume a lot of space, whereas vertical axis turbine is compact in their construction.

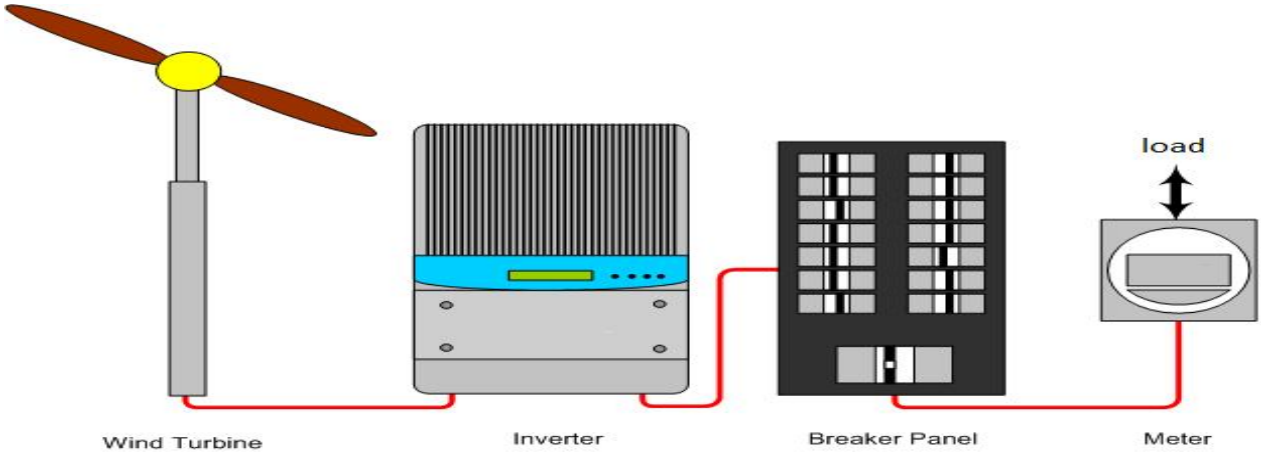

Figure 4 Wind turbine powered load

VI. RESULT

If the electricity is not available the machine can also be driven by using power harnessed from solar energy as well as wind energy. The concepts brought under the light are about utilizing PV panels, Solar Ponds and wind turbine to power a ginning machine along with a design for PV panel powered load.

VII. CONCLUSION

The concept to employ the photo-voltaic cell panels, solar Ponds and wind turbines to harness the solar/wind energy to convert it to electrical energy to run the prime mover i.e. the electric motor to perform the ginning operation has been successfully discussed. The major advantages are that it is a very clean, inexhaustible as well as free of cost, available all-round the year.
It is a very advantageous system for the people living in remote areas like farms and villages. This system certainly has a potential to uplift the current scenario of the rural India.

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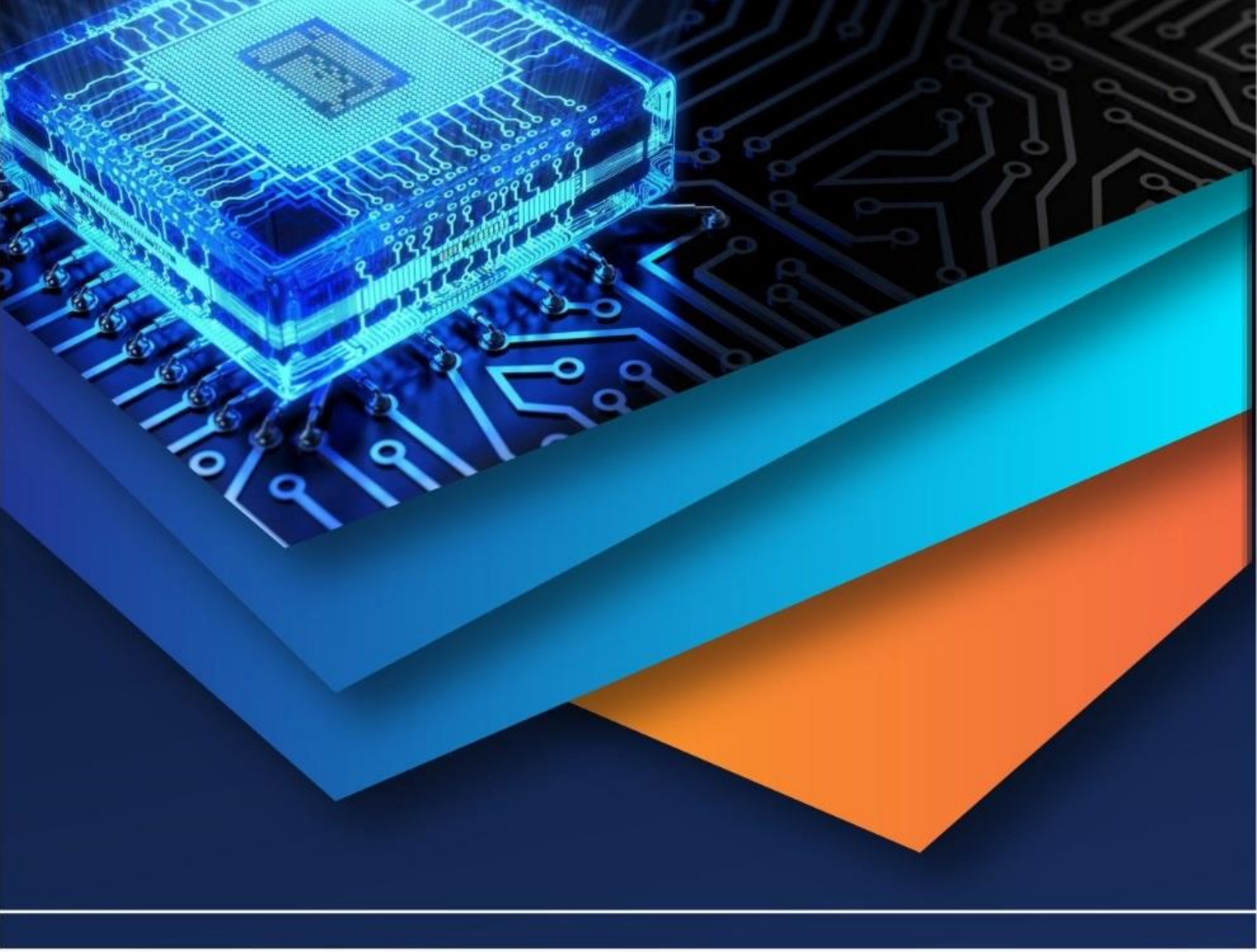

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