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Design and Development of Solar Operated Fodder Cutting and Collecting Machine

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Abstract: ***This paper describes the design, manufacture and performance evaluation of a small modified forage cutter and harvester built with a very simple mechanism that is cheap and simple. Harvesting fodder is a necessary farming activity that requires considerable work. Labor costs and availability pose significant challenges during the cutting season. Due to shortage of labor and unpredictable weather during harvesting, farmers must use mechanized methods to ensure speed of harvesting and collection. We have used various techniques to analyze and design a very low-cost fodder cutter and harvester with solar system and battery. This machine is designed for small farmers who have less than 2 acres of agricultural land. This small machine can cut up to two stacks of fodder at once. The feed is cut by reciprocating blades that cut it like scissors. It uses a 12V electric motor for propulsion. This power is supplied to the cutter by an electric motor. After sowing, the feed is collected in a storage tank using a collection system. Because it was built using spare parts readily available in the area, this small machine is easy to maintain and operate. Small farmers can find this machine the answer to their labor and implementation cost problems.***

Keywords: Productivity, scissor mechanism, production, forage cutter and picker, chain and chain mechanism, performance evaluation, gear mechanism, solar system and battery.

I. INTRODUCTION

Indian economy is highly dependent on agriculture. In India, agriculture faces major challenges such as labor shortages during the busiest times of the year and at other times. The main reasons are the increasing number of well-paid non-agricultural jobs, the movement of population to cities and the lower social status of agricultural workers. In India, manual labor is mainly used for collecting and cutting fodder. Harvesting fodder is the basic stage of farming. Currently, Indian farmers harvest and harvest fodder using a traditional approach that involves cutting the crop by hand and employing laborers to harvest it. However, this process is very laborious and time consuming. Therefore, the aim is to design and research a forage harvester to help Indian farmers run small farms. It will reduce the cost of collecting and cutting fodder in the field. It will help in raising the economic standards of India. AutoCAD software will be used to present the construction model of the forage cutter and harvester. In India, manual labor is generally used to cut and collect fodder. "Forage and harvest approach to agriculture" is what we want to give to farmers. This machine is made up of a simple mechanism that can be powered by a 12V battery electric motor, which is also used as a solar battery system. Farmers will save money and speed up the process of cutting and collecting fodder.

II. LITERATURE REVIEW

Balaji A [1] The design and construction of a cutting machine and the disassembly process require a lot of time and money. The lead screw, pin bearing and knife blade form the mechanical part of the machine. Farmers want to find the most economical techniques for growing their banana trees due to the rising cost of inputs like fertilizers, pesticides and farm implements. They focused on the needs of small farmers and provided them with an automatic, affordable banana tree cutting machine. They conduct research that leads to regular intervals of cutting banana trees into pieces. Any change in the distance between the wire and the base material is immediately corrected by a significant change in current, the arc length being kept constant in this operation.

Mahesh Kadam [2] worked on the development and construction of crop cutters. In 2011, India was one of the top five producers of meat from cattle and poultry in the world with the fastest growth rate. Because traditional harvesting requires more labor and increases the cost of crop cutting, they create crop cutting machines to achieve their goal of offering a low-cost solution that solves these problems. Problem Statement India is an agrarian country that imports various crops. Solution To solve this problem, we offer a completely new, progressive idea that is mainly applied in the agricultural sector: the design and manufacture of crop cutters.

Pravin Garal [3] invented a multi-purpose crop cutting machine. They were looking for a small farmer who was interested in labor-intensive physical work that included crop cutting, weeding and other labor-intensive manual work.

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They make a machine that can perform tasks like spraying, planting, weeding and harvesting in one unit at an affordable price for small farmers. These machines reduce labor costs and operating costs for tasks like harvesting, weeding and seeding. What we do is build machines that can spray, seed, weed and cut crops in one operation. With the help of this cutting-edge machine, they aim to speed up the agricultural process and significantly reduce labor costs.

Ferdows Nipa Jannutal [4] Straw crushers have continuously evolved from a very basic tool to industrial standards that can be operated at different speeds and produce different sizes of chaff as the animal chooses (Mohamed et al. 2001). To cut paddy straw smoothly, intelligently, quickly and efficiently, you need the right machine at the lowest possible price. The V-belt drive has a number of advantages, including the fact that it needs no maintenance, is extremely efficient, generates little noise, has a long life, is easy to install, and acts as a "safety fuse" by refusing to transfer power in the overload setting for the experiment. In this study, various performance indicators were tested using forages such as dried and stored Sharna rice straw, Napier grass and seasonal maize leaves. At the 5% level of significance, Duncan's multiple range test was used to evaluate the mean values of chopping efficiency, machine productivity and energy consumption between different forage feeding methods.

Mohd. The research of Shahid Hayat [5] on the design and performance evaluation of wheat cutting machines is represented. Agricultural organizations rent or sell these machines hourly on the market, although small farmers do not need such fully equipped or super equipped combine harvesters. The aim of the project is to develop a portable, small, user-friendly, cheap and mini harvesting machine that can cut and harvest crops at the same time. Lack of education, overall socio-economic backwardness, slow implementation of land reforms, and insufficient or ineffective financing and marketing services for agricultural products. Due to the low transmission of cutting power, friction on the rotating yoke, and the possibility of failure of this mechanism when the crop cluster collects on the piston cutter, this idea was abandoned. However, if the reel speed was too high or moved too fast, the fingers would break the head violently, causing more loss. When evaluating machine performance, field capacity and efficiency are very important factors to consider.

Dengale Suhas Annasaheb [6] designed and manufactured machines for crop cutting and harvesting. It will be beneficial to save labor costs as this equipment offers both cutting and collecting capabilities. Obtaining information about conventional techniques and machinery for cutting crops from local people who run small and large farms Gasoline engines are used because they are efficient and available in rural areas. Each machine part that is being prepared must have the right type of material selected with regard to construction and safety. By doing all the research, it is clear that the mower and harvester is very simple to assemble and is also relatively simple and cheap to operate.

Vilas S. Gadhave [7] designed and developed the Multi Crop Cutter concept driven by an electric motor. This machine is useful for small farmers with less than 100 acres. It is powered by a 1.5 HP electric motor, which is connected to the cutter by a system of pulleys and gears. Considering the fact that 2/3 of Indians are dependent on rural employment, the WHO (World Health Organization) states that policy makers are interested in the slow growth of agriculture. Indian economy is primarily based on agriculture. However, small farmers who have less than 2 acres of land usually do not need fully equipped combines. The goal of this research is to develop and manufacture machines that will reduce our dependence on human labor, which will benefit our nation by increasing agricultural income. Construction and operation of the Multi-Crop Cutter It is a mobile harvester with a 1.5 HP electric motor that rotates at a speed of 2000 rpm.

Usha C. Thomas [8] was the Multi-Crop Cutter machine operator. The pulley arrangement provides the power to this machine. This small combine is easy to repair as it was built from local spare parts. This combine can be the answer to the problems that the small farmer has with the implementation of work and costs. Because of their high price, these harvesters are available for purchase, but they are not affordable; however, agricultural organizations hire them by the hour. Since power outages and load disconnections are the biggest problem at present, the machine will be idle under certain circumstances. The same thing happens throughout the day when the person is overworked but the machine is not. So using multi crop cutter can also save 80% of your time. The device was found to be the most cost effective.

III. PRESENT STATUS OF FORAGE CUTTING AND HARVESTING PROCESS AND ITS SHORTCOMINGS

There are two methods of forage cutting and harvesting:

1) *Manual processing by hand or sickle:* Cutting feed by hand with knife or rotary machine is extremely laborious. It has certain limitations, some of which are listed below;

- This process may result in hand fatigue and damage.
- Since the process is continuous, it requires tedious work.

- Because it is a long and laborious process, no one wants to do it in the modern world.

2) Mechanical motor processes:- Some limitations of this process are as follows:

- only motorized cutting equipment or tools are currently available for cutting feed; However, collecting fodder still requires work.
- Heavy equipment is relatively expensive, so its purchase is not affordable for rural dwellers and small farmers.

IV. AMENDMENTS TO THE PRESENT STATE OF THE ART ARE PROPOSED

This article explains the proposed amendment to the current state of the art. One approach is the development of special "forage cutters and pickers" that will be operated by manual push, even solar systems for batteries. An actual CAD model of this machine is shown in the following section along with design calculations, operating principle and material selection. This machine has two basic mechanisms: a crank cutting mechanism for cutting and a chain mechanism for collecting fodder. Both of these mechanisms are powered by a 12V electric motor, which is recharged by a 12V battery.

V. DESIGN CALCULATIONS

(a) Landing gear or main frame:-

¯ Material: - square inch = 1 inch * 1 inch = 25.4mm * 25.4mm (mild steel)

~ Frame size

 Length =5 feet =1554m m

 Width = 2 feet

= 629.76 mm

 Height = 1 foot

= 324.40 mm

(b) Claw:-

- Overall length = 12 inches = 304.8 mm
- Height = 10 inches = 254 mm
- Effective working area = 9 inches = 228.6 mm

(c) Sprocket:-

- Number of teeth = 25
- Pitch = 1/2 inch = 12.7mm
- Diameter of drive gear = 3 inches = 76.2 m
- Diameter of driven sprocket = 3 inches = 76.2 mm
- Number of teeth on the drive sprocket= (Z2)= 25
- Number of teeth on the driven sprocket=(Z1)= 25
- Center distance=a= 457.2 mm= 18 inches= 457.2 mm
- Gear ratio= Z2/Z1= 15/15= 1
- Standard pitch (maximum pitch)= a/30= 457.2/30 =0.6 inch= 15.24 mm

- Minimum pitch = a/50 = 457.2/50 = 0.36 inch = 9.144 mm
- Final standard pitch = 0.625 inch = 15.875 mm

(d) Sprocket Shaft: - - Diameter = ¾ inch = 19.05 mm

- Length = 24 inches = 609.6 mm

(e) Round:-

- Diameter = 20 cm = 7.87 inches = 199.89 mm
- Shaft diameter = 1 inch = 25.4 mm

(f) Chain:-

- Center to below distance
- Horizontal = 13 inches = 330.2 mm
- Slope = 18 inches = 457.2 mm

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- Chain length = 45 inches = 1143
mm
- Chain type = Simplex
- Actual chain length (Ap)= a/p= 457.2/15.875= 28.8mm
- Number of links(Lp)= (2×Ap)+[(Z1+Z2)/2]+[(Z2-Z1)/2π^n 2/Ap]
= (2×28.8)+[(15+15)/2]+[(15-15)/2π] × 2/28
Lp = 2.85 inches = 72.6 mm
- Chain length (L) = Lp × PL = 72.6 × 15.87 = 45 inches = 1152.16 mm

(g) Engine:-
-Motor torque (T)= f × r .....(Assume f=10 kg), (r=sprocket radius=38)
= 10 × 9.81 × 38
= 3.727 Nm
-Motor power (P)= 2πNT/60= 2×3.14×1500×3.7/60= 514.96 = 0.69 HP

VI. COST ESTIMATION AND COMPONENTS SELECTION

Sr.no	Required Components	Quantity	Price/Part (Rs)	Total Cost (Rs)
1.	Main frame	1	3000	3000
2.	DC Motor (250 watt)	2	3500	400
3.	Shaft bright bar (Mild steel)	3	600	600
4.	Runner wheels	4	1600	1600
5.	Pedestrial Bearing	4	1600	1600
6.	Cutting blades	2	1200	1200
7.	Collector	1	1400	1400
8.	Toothed Roller Drum	1	800	800
9.	Chargeable Dry battery (12V)	2	1200	1200
10.	Solar Panel (12V 60W)	1	3000	3000
11.	Fabrication Cost	1	2500	2500
12.	Chain Sprocket	1	600	600
-	Total Cost:-	-	-	20,100

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VII. CONSTRUCTION

A forage harvester and picker is a simple mechanized machine. It is battery powered, eco-friendly and economical, consists of several components like 12V battery, 12V DC motor, simplex chain, main frame, travel wheels, bearing, reciprocating cutting knives, collection tank, sickle and cylinder mounted on gear chassis. All the components are arranged on the main frame and supported by rubber wheels to move the vehicle. It is a trolley machine with slide drive which is used for cutting and collecting feed. The detailed functions of some components are as follows:

1) Main frame: Mild steel is generally used for the primary frame because it contains less carbon and because it is a ferrous metal for both iron and carbon. This supports the entire body part of the model, which is the most important role in almost any project design.
2) DC Motor: The primary purpose of a DC motor is to convert electrical energy into mechanical energy. Direct current electrical energy is used as a source of mechanical power in a direct current motor. DC motors are smaller than AC motors and more suitable for domestic applications.
3) Mild steel shafts, bright bars: Conveyor shafts are made of bright bars. Due to its exceptional mechanical and dimensional properties, bright steel bars are widely used in the manufacture of mechanical parts. Clearer machining improves physical and mechanical properties, reduces component manufacturing waste, and increases straightness and dimensional accuracy.
4) Casters: When used in conjunction with an axle the wheel reduces friction by smoothing the rolling motion. A moment is required to be applied by gravity or some other external force or torque to the wheel about its axis to turn the wheel. Using the concept of mechanical advantage, a simple machine that simplifies the handling task is a machine with a wheel and axle.
5) Bearing: Pillow block bearings are often used to support rotating shafts using various accessories and suitable bearings. Plummer block or pillow block are other names. Used on long shafts that require moderate support
6) Cutting Blades: Cutting blades are one of the oldest tools used by humans. They are part of the equipment of machines used for cutting grass and fodder
7) Collection tank: The collection tank is used to collect the chopped fodder that falls on the ground after cutting with the cutting knife. The feed can then be collected using the jaws of a cylinder mounted on the chassis and placed in a storage tank.
8) Sprocket: A sprocket is a wheel with a profiled design and teeth that drive a chain, belt or other material that has holes or grooves. Any wheel with radial lugs that attach to a rotating chain above it is called a sprocket. A sprocket is used in machinery to transmit linear motion to a track or to transmit rotary motion between two shafts when the gears are not suitable.
9) Rechargeable Battery: A device that stores chemical energy and converts it into electrical energy is a battery. Acts as a voltage stabilizer for the charging system and provides additional current when the charging system is unable to cover the electrical power consumption. The positive pole and the negative pole are the two electrical connectors of the battery.
10) Solar Panel: A device powered by electricity through batteries and a cooling system combined with polycrystalline panels and accessories to stabilize the battery. There is also a movable frame at the top of the machine where the panels are mounted to adjust the direction or angle of the panels.

VIII. ACTUAL DESIGN OF CAD MODEL

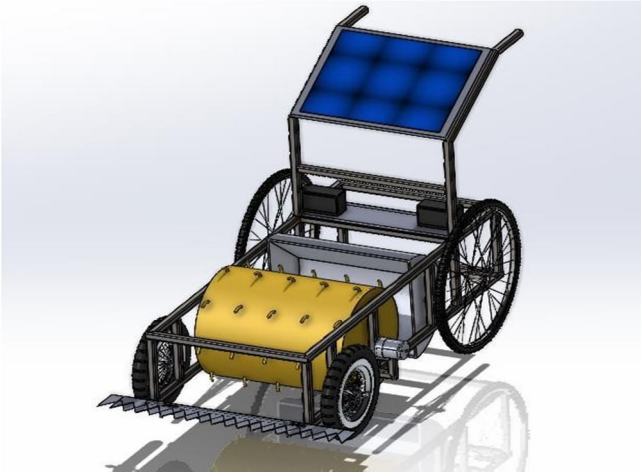

Fig.(1):- CAD model of Modified Fodder Cutter and Collecting Machine

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IX. WORKING

This machine has two mechanisms. A mechanism that converts rotary motion into linear motion is a crank cutting mechanism to reciprocate the cutting blade on a stationary cutting blade. The second part is the collection system, which consists of a roller with claws and an attached motor. After cutting the feed, the direction of the roller in the forward direction to collect the feed through the claws of the roller on the surface and collect it in the tank. This device runs a 200 RPM motor on a 12V battery. The power output is transmitted to the crankshaft and sprockets via a V-belt. This output shaft has a crank attached at one end which causes the crank to rotate to move the cutter blade back and forth. In agriculture, a reciprocating cutting blade slides on a stationary blade and provides a shearing effect that is responsible for cutting the forage, while another motor is used to drive the harvesting device. In this mechanism, the motor rotates the chain shaft by passing rotary motion through the V-belt and also rotates the motor, causing the movement of the chain conveyor having collection forks on it and helping to collect the feed cut by it. Next transfer it to the storage tank by chain conveyor. "Forage Mower and Harvester" uses both its simple mechanics to cut and collect fodder in the field, thus reducing the difficulty and effort of working.

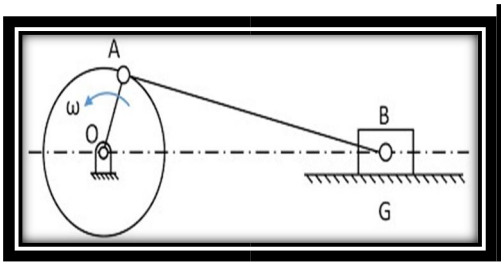

Fig.(2):- Crank-cutter mechanism

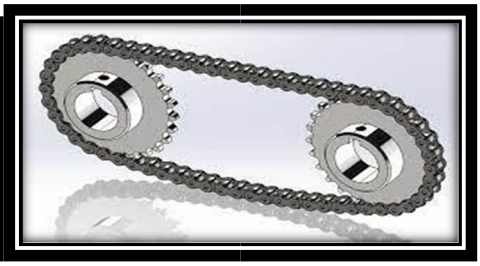
Fig.(3):- Sprocket and chain mechanism

X. PERFORMANCE EVALUATION

1) Manual operation:-

- A laborer is paid Rs. 300 for one day's work.
- The total number of workers needed for a 1 acre farm is 5.
- The total amount paid for the work is 5 x 300 or Rs. 1500 per acre in one day.

2) Actions of our cutter and picker:-

- Assuming it is a 12V, 150AH lead acid battery, the charging voltage is usually 13.8V.
- Battery charging efficiency (ah) is 0.8 while 12V charger efficiency is 0.7.
- Kilowatt hours from an AC source equals 13.8 V times 150 AH times 1000 (0.8 x 0.7) units, or roughly 3.7 units.
- The total charge is 3.7 units times 8 rupees or 29.6 rupees.
- Salary for the job is Rs. 300 per day.
- Total cost = total fees + labor + maintenance.

= 29.6 + 300 + 100

= Rs.429.6/-

XI. ADVANTAGES

1) Reduces the need for human effort – This machine is primarily designed to be operated or operated by only one operator. No more work will be required during machine start-up.

2) Reduces costs – In agriculture, it eliminates the need for labor implementation costs, and since it is battery operated, the farmer can operate it for less money.

3) Time saving - With a simple mechanism, it can simultaneously cut and collect fodder, saving both the farmer's time and the time required for these tasks.

4) Ease of use – As this machine is easy to use, anyone can start and operate it.

5) Does not require skilled labor – can be operated and handled by unskilled labor; No special training is required.

6) Utility Safety – Prevents injuries to farmers while cutting fodder which is caused by manual sickle cutting.

7) Interchangeable Shearing Mechanism:- This mechanism can be quite easily removed, repaired, replaced with another mechanism or used one after the other for different operations.

8)

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XII. CONCLUSION

A. For Machine:-

- Machine works on 1 acre area = Battery consumption is 12V/-
- Fuel cost Rs. 29.6 + labor cost Rs. 300 + maintenance cost Rs. 100 = Rs. 429.6/- - 1 acre of land to be cut in 3 hours.

B. For work:-

- The cost of hiring a laborer in 1 acre farm is Rs. 1500.
- It takes 10 hours to cut 1 acre of agricultural land with 2 workers.

Hence, it is clear from the above comparison that using forage harvester and picker in the field for the above application is cheaper than using manpower. The combined forage cutter and collector is designed to cut forage quickly and efficiently. This machine can be an ideal option for farmers with small plots of land, as forage harvesters in the market are now designed for larger farms. How farmers view this machine as a companion will determine its success. Before the finished product goes on sale, the machine must go through several changes.

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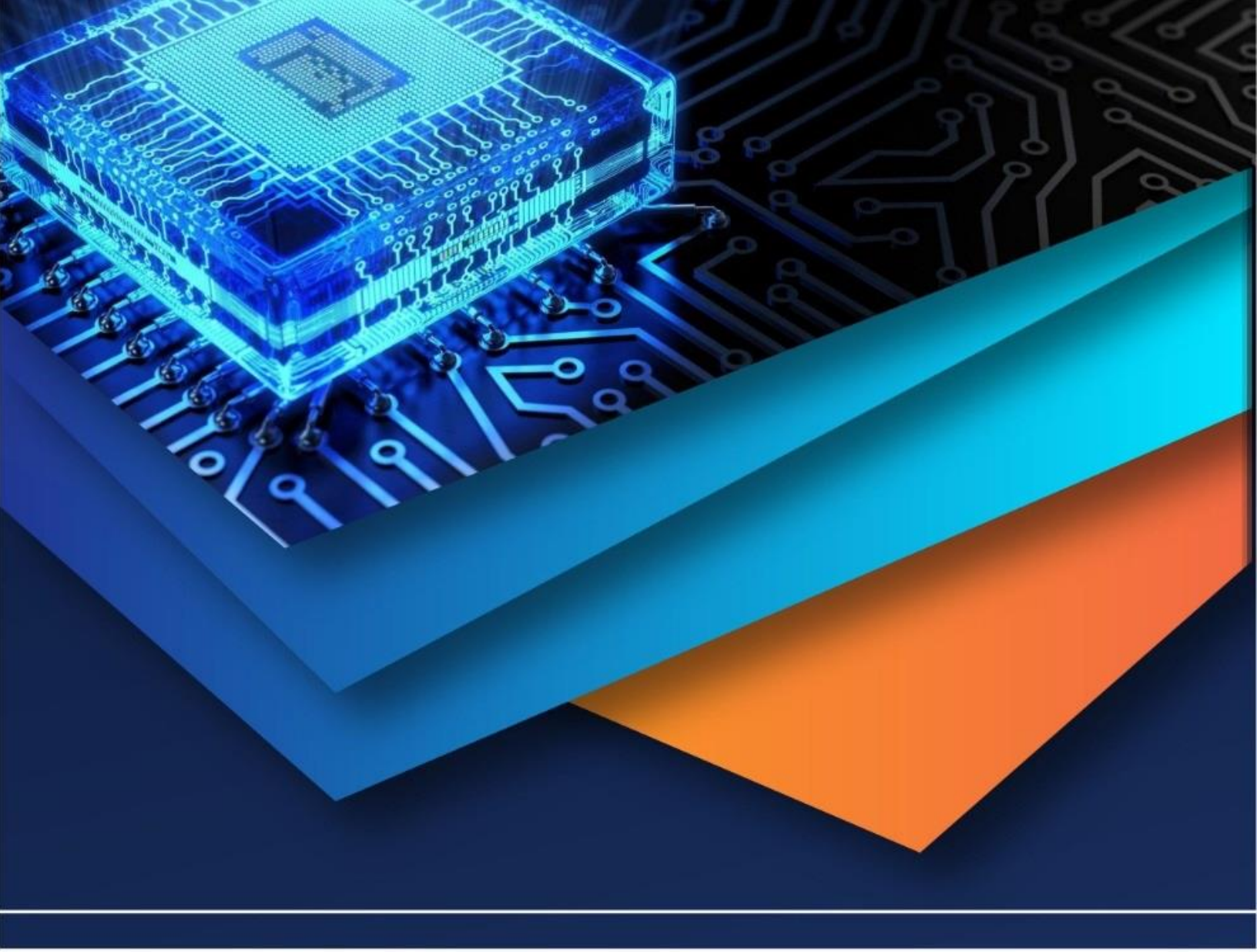

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