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# Design and Fabrication of Air Cushion Material Handling System

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***Abstract:*** ***The most common methods of moving heavy load across factory floors are cranes, trolleys, belts, conveyors, roller conveyors, etc. All these methods have their uses – however, cranes require that the infrastructure be forced to support the load and in many cases electric power, trolleys, on the other hand, are economical – the flooring however must be built so as to support the weight of the load. Some trolleys need rails, loading and unloading docks, and other infrastructure. Belt and Roller conveyors are directional. In the above cases you either have to build support columns and beams to carry the weight of the load or set up a system of trolleys, rails, rollers, etc. Advances in material sciences have now made possible a safer, more reliable, and cheaper method of moving heavy loads – air! Fragile loads won't break, the load cannot fall, and if you lost power the worst that will happen is that the load will "stay put". All one needs to do to move a heavy load is to put it on a cushion of air (called an air cushion- how simple!) – Like a hovercraft. To harness this "air cushion" what one needs is an "Air Cushion Material handling system".***

***Keywords: Air cushion material handling, Air casting, Rexine, Plywood, heavy loads.***

## I. INTRODUCTION

The material taking care of framework is a vital part of any industry, be it a mechanical assembling industry, synthetic industry, development industry. It assumes a vital part in treatment of the crude materials, semi-completed or completed items. Various types of material handling systems are presently available in different industries and these are based on electronic systems, hydraulic/pneumatic system, mechanical systems, etc. The demand of such systems securing new features is also increasing day by day in view of the new products being developed.

As such, the addition of efficient and effective material handling system meeting the new requirements/challenges is a need of now. Developing a new material handling system is always a challenge as it needs multi-disciplinary knowledge and it's effective application. Here, we have attended to build up a new pneumatic material handling system, which uses compressed air as working media, for conveying materials/equipment requiring delicate handling and precise positioning. The system is called as "Air Cushion Material Handling System" and is based on air power creating a suitable pillow between the object to be moved and the floor on which it rests. The air film acts as cushion an  avoids direct contact between the two surfaces. This minimizes friction between the surfaces and requires very less force for its movement.

## II. LITERATURE SURVEY

### *A. Free Path Air Cushion Material Handling System*

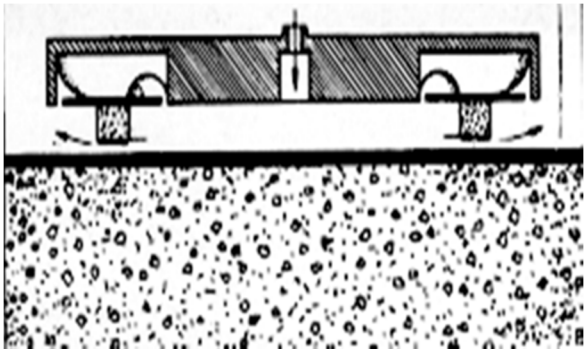

Fig 1.free path air cushion material handling system

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This system is used for moving around heavy, bulky, or awkwardly shaped objects such as machine tools, heavy electrical transformer, etc. or those requiring smooth and accurate positioning during production, assembly or storage, such as aircraft engines, fuselage parts, or even completes aircraft. The basic building block of this system I a load bearing member usually of circular cross-section on its undesirable commonly referred to as air bearing, air caster, etc. by their respective manufacturers. As explained previously, the incoming compressed air first floats the Air caster slightly off the ground and then starts leaking out through the leakage gap between the bottom seal and the floor.

*B. Fixed Path Air Cushion Material handling System*

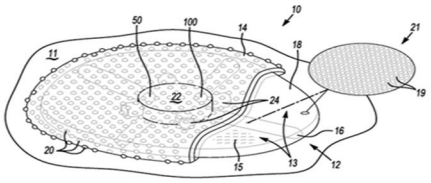


Fig 2. fixed path air cushion material handling system

In certain applications for conveying or positioning materials, the air cushion principle is utilized differently. Here a smooth table surface is laid out over the path which the objects or objects are to follow. Air under pressure is supplied through a plenum which is mounted under this table and this air comes out through the holes provided at regular intervals over its surface. The moving load which should have a fault undesirable such as sheets of paper, glass, metal, etc...Or be of such shape as to prevent the escaping air from the table to pass directly through it. E.g. a rectangular carton or an upturned tumbler.

This escaping air then forms a cushion as explained earlier, and the object which is now literally floating on air can be moved around anywhere on the table surface with but negligible effort and very smoothly too.

The moving load is thus handled very gently as compared to a belt or roller conveyor and thus is popular in industries such as garments' stretching and cutting tables, paper handling equipment, food processing, etc. shows schematically some examples of this type of air conveying system. Materials by giving a slight inclination say 50 degree in the direction in it is required to move. A variation of the air table uses inclined nozzles for exit of the pressurized air instead of vertical openings. In this system, the airflow is utilized both to 'float' the material as well as convey it in the direction of the inclination of the nozzle due to the horizontal component of the force exerted by the escaping air. This method of moving the loads has some advantages, especially for delicate items that required gentle handling. Even the in case of a 'traffic jam' in the path of load movement, no excessive force is exerted on the items being moved. There is however a price to be paid is somewhat longer consumption of air and therefore energy.

The system i.e. fixed path and free path system reasons are explained below:-

*1)* Free path system consumes lesser space, doesn't require any complex floor construction, and is more economical as compared to fixed path system.
*2)* So at the student's level speaking in mind the economy, facilities and resources available, it is reasonable to work on a free path system.
*3)* The basic building block of this system is a load- bearing member usually of circular cross-section on its underside commonly referred to as air bearing, air caster, etc. by their respective manufacturers.
*4)* As explained previously, the incoming compressed air first floats the Air Caster slightly off the ground and then starts leaking out through the leakage gap between the bottom seal and the floor. Since this air must be replenished from the compressed air supply, it is advisable to keep this gap as small as possible, since other things being equal; the quantity of leakage air is directly proportional to the size of this gap. Thus, the smoother the surface of the floor, the smaller the gap can be, without introducing friction between the seal and the floor. For occasional movement over a relatively rough surface, a thin metal sheet can be temporarily laid over the area where the load is required to be moved, to reduce the air consumption.
*5)* For practical applications, these individual air bearings are usually combined in several ways.
*6)* A minimum of three bearings are required to provide a stable platform for the load but it is usual to combine them in a group of four or six or even more.
*7)* The one shown can carry a load of over four tones and can easily be moved around by a single operator. Other sizes and carrying capacities of up to 80 tones are in existence. Theoretically, with suitable arrangements, there is no limit to the size and weight of a load that can be moved around on a fluid film.

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## III. METHODOLOGY

### A. *Actual Operating system*

This system is used for moving around heavy, bulks or awkwardly shaped objects such as machine tools, heavy electrical transformer, or those requiring smooth and accurate positioning during production assembling or storage, such as aircraft engines, Fuselage parts, or even complete aircraft. The fundamental structure square of this framework is a heap bearing part as a rule of the round cross-segment on its unfortunate generally alluded to as air bearing. Air caster By their particular producers. As clarified already the approaching compacted air first buoys the air caster marginally off the ground and afterward storms spilling out through the spillage hole between the base seal and the floor. It is advisable to hold this thing equal because this air must be replenished from the compressed air supply, the amount of leakage air is directly proportional to the size of this gap. Thus, the lower the floor surface, the smaller this distance will be for occasional movement over a comparatively rough surface, a thin metal, without adding friction between the seal and the floor to minimize the consumption of air.

These individual air bearings are typically combined in a variety of ways for practical use. To provide a stable platform for the load, a minimum of three bearings are required, but they are normally grouped in groups of four tons and can be easily moved by a single operator. There are other sizes and capability levels of up to 80 tones. Theoretically, with suitable arrangement, there is no limit to the size and, the weight of a load that can be moved around on a fluid film.

### B. *Principle of Operation*

Material handling in the industry requires different tones of equipment depending on the nature and speed of the movement of the load, its weight and dimensions, space constraints, positioning accuracy required, and so on. One of the most effective system for material handling and conveying of bulks and heavy objects on more requiring delicate handling and precise positioning, is based on creating a thin film of air between the undesirable of the load on the floor on which it rests. Such systems are called air cushion Material handling system. For heavy and lack objects required to be manufactured around in a restricted space and application needing easy and precise positing of the load as also those requiring delicate handling while maintaining a speed of operation, one of the most versatile material handling system is that based on creating a thin film of air between the load and the surface on which it rests. This almost eliminated any friction between the two, i.e. load and surface on which it rests, thus allowing the objects to be moved freely in any direction in a horizontal plane. The effective coefficient of friction goes down to a value as low as 0.001. Put simply a load weighing 10 tons can be moved around by exerting a force of 10kgs only. The system works by introducing air under pressure inside a closed chamber resting on the ground. The load weighing (W) rests on the top of this chamber having an internal area (A) at the base which is in direct contact with the surface on which it rests. Since this air is unable to escape, it raises the air pressure P inside the chamber. When this pressure reaches a value such that P = W/A. The upward force exerted by the chamber balances the load resting on the top. The load now floats clear of the ground slightly. As soon as that happens, leakage of the chamber to the outside takes place due to the pressure difference between the air inside and the atmosphere. This leakage air is replenished by the pressurized air which is being continuously supplied to the chamber. The load is now floating frees of the floor and thus can be easily moved in any direction by applying a very small force. This force is typical of the order of one or two kg per ton of the load. The hovercraft is one well-known example of passengers and cargo movement based on the above principle.

### C. *Prime Requirements*

*1)* Continuous supply of compressed air
*2)* Enough pressure corresponding to the load to be lifted
*3)* Sufficiently smooth floor surfaces

### D. *Advantages of Air Cushion System*

The advantages of Air Cushion Material handling Systems over other alternatives used for similar work such as wheeled trolleys, belt and roller conveyors, etc. are as follows:

*1)* *Low Unit Pressures:* Due to the large supporting area under the load, the unit pressures in this system are far lower than those produced by wheeled vehicles, being typically of the order of 1.5 bar (20 PSI) and rarely exceeding 3.5 Bar (50 PSI). This reduces wear and tear on the shop floor.
*2)* *Omni- directional Material Handling:* Unlike wheeled vehicles, or roller conveyors a load supported on an air cushion can move around in any direction equally easily, forward, backward, diagonally, sideways, or even completely turned around on its axis.

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3) *Safety of Operation*: Since the load is lifted just a few millimeters off the ground, and the gap between the bottom seal and the supporting surface a less than a millimeter, it results in enhanced safety, both for operating as well as other personnel in the vicinity.
4) *Economical:* This method requires the main source, which is compressed air, as in many industries compressed air is required such as wheel trolleys, belt and roller conveyor.

## IV. DESIGN OF AIR CUSHION MATERIAL HANDLING SYSTEM

### A. Introduction

The beginning of design of air blowers or air cushion Material handling system was done by keeping in mind similar design or air bearing used in computerized co-ordinate measuring machine [C.M.M]. The air bearing of a coordinate measuring machine can only be used over a very highly polished surface. Because of the unavailability of the design procedure and design Parameter of an air bearing in co-ordinate measuring machine, probable design of the air bearing of coordinate.

A measuring machine was made and based on that further designing of air caster in air cushion Material handling system was preceded. So, we can say that the probable design of the air bearing of the coordinate measuring machine was the first step in designing the air bearing of the cushion Material handling system.

In case absence of any reference design parameter, a hit and trial method was used. While proceeding towards the final design of the air caster, total of four models were proposed and tested under various conditions. For a reference, we name these models as model 1, model 2, model 3, and model 4.

In a further report, we will discuss the conditions that led to the origin of these models, their behavior under various conditions finds of failures, and probable reasons for their failure.

### B. Model -1

During the trial of Model 1, we first made 3 holes on the distributor (rexine). Then the blowers were attached to the plywood through one small piece of pipe. Then a weight of 80kg was put on the plywood and the blowers were switched on. The plywood didn't give a satisfactory result as it didn't go much up.

### C. Model -2

During the trial of Model 2, we first made 4 holes on the distributor (rexine). Then the blowers were attached to the plywood through one small piece of pipe. Then weight of 80kg was put on the plywood and the blowers were switched on. The plywood didn't give satisfactory result but it was much better than the Model 1. As it did go up at a small distance from the ground level. And this was achieved successfully in our next modified design that is Model 3.

### D. Model -3

During the trial of Model 3, we previously made 6 openings on the merchant (rexine). At that point the blowers were appended to the pressed wood through one little piece of line. At that point weight of 80kg was put on the pressed wood and the blowers were turned on. The pressed wood gave an agreeable outcome and it was excessively acceptable in tallness at that point model 2. As it went up at a stature of 15cm from the beginning.

In spite of the fact that there was very little contrast between the aftereffects of Model 2 and Model 3, yet model 3 was picked as the last plan for "AIR CUSHION MATERIAL HANDLING SYSTEM.

### E. Sketch of Assembly of Material Handling System

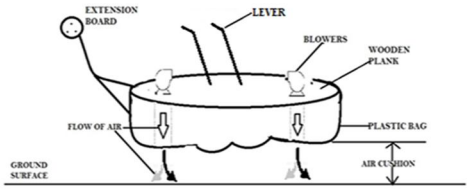


Fig 3. assembly of material handling system

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## V. EXPERIMENTATION AND ANALYSIS OF WORK

1) Own weight of system = 10kg
2) Load on system = 80kg
3) Total Wt. = 90kg

### A. For Wooden Plank

1) Diameter of Plywood: 950mm
2) Width of Plywood: 12mm
3) Diameter of two holes at corner on plywood: 36mm
4) Distance from a center (Radius): 475mm
5) Distance of center of the semicircle to a center of plywood: 201.90mm

$= 4r/3\pi$
$= 4 \times 475/ (3x\pi)$
$= 201.90mm$

### B. For Blower

1) Voltage/Frequency: 220V/50hz
2) Input Power: 150W
3) No Load Speed: 16600Rpm
4) Blowing Rate: 2.8$m^3$/min

### C. For Air Cushion (Rexine)

The air cushion is a circular shape.
Then, we made 6 equal circles on the air cushion for equal distribution of air pressure which has been inserted from air blowers.
Each circle is an angle of 60 degrees
Each circle is equally sized with a radius of 12 mm.
The weight that can be handled by equipment can be find by
Cushion Pressure= Gross weight / Cushion Area
Therefore, the load on a system is 90 kg
(load includes self weight and load on the system)

Gross Weight = $m \times g$
$= 90 \times 10$
$= 900N$

Cushion Area = $\pi /4 \times d^2$
$= \pi /4 \times (0.95)^2$
$= 0.7089\ m^2$

Therefore, Cushion Pressure
$= 900/0.7089$
$= 1269.57$ pa
$= 1.26957$ Kpa

Therefore, the average pressure of a blower ranges between 1.2 – 3.3Kpa.It will lift the load.

Volume flow rate of blower
$= 2.8\ m^3/\ min$
$= 2.8/60\ m^3/sec$
$= 0.0466\ m^3/sec$

Now to find, Power required to run blower
= Cushion Pressure × Volume flow rate
$= 1.26957 \times 0.0466$
$= 0.0592$ KW

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Stress on Plywood

$\sigma$ = Force/Area

F = 900N A = 0.7089 $mm^2$

$\sigma$ = 900/0.7089 = 1269.57 $N/mm^2$

Stress max = 7$N/mm^2$

( From Mechanical properties of Wood )

Therefore, $\sigma < \sigma_{max}$

Therefore, Design is safe.

## VI. FABRICATION AND BOUGHT-OUT ITEMS

As per the design of the Air Cushion Handling System, this system consists of the following items,

*1)* Air Blowers
*2)* Distributor
*3)* Platform
*4)* Pipes
*5)* Handle
*6)* Fasteners
*7)* Extension Board

Except for the Air Blowers and Extension Board which are bought-out items, all other items as mentioned above are fabricated in the workshop. The details of the same are illustrated below.

### *A. Air Blowers*

Speed = 16000rpm
Power = 150w
Current = 5.6A
Discharge = 2.8m3/min

Fig 4. air blower

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*B. Distributor*

The air distributor is made of rexine because its capacity to withstand high pressure of air than any other material. The rexine was attached to the wooden plywood by applying hard rexine, crape, and staples from a staple gun. Then we made 6 small circles of equal radius at a certain distance so as for the perfect balancing of the objects. Because of these 6 circles, the air gets distributed perfectly and the plywood gets lifted and the plywood moves forward.

Fig 5. air distributor

*C. Platform*

The platform of the project is the wooden board of 950 mm diameter &

The main reasons for using wooden platform are basically.

1) *Light in Weight:* By using a wooden platform 3-4h weight is reduced of the whole apparatus.
2) *Economically Feasible:* It is an also economical because if we use mild steel plate will be more costly and also the machining problem will be there. So we have used a wooden platform.

A round plate of 250 mm diameter & 12 mm thickness was also used for proper air distribution.

To increase the aesthetic view varnish is applied over the platform and then to prevent change the edges of the wooden board are covered with insulation tape.

Fig 6. Platform

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*D. Pipes*

The pipe used for the apparatus is the pressure pipe, which can withstand the pressure on the line, which is supplied to the apparatus. The pipelining is made in a specific manner as shown in fig.

Both the ends of pressure pipes are connected to the nipples of air blowers and distributors. The pipeline was directed in a particular manner and was fixed to wooden board because the pipelines were suspending and because and critical path to air caster as shown in fig of assembly.

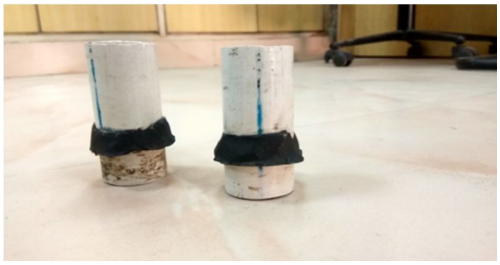

Fig 7. pipes

*E. Handle*

The handle is attached to move the entire system in a particular direction. The handle is light in weight as it is made up of mild steel material. Due to this handle, it can be used to control the direction of the system. It is joined to the distributor by T-sections, which is drilled and joined to the platform.

Fig 8. Handle

*F. Fasteners*

An M16 Bolt was used for attaching the small round plate with the platform. 8 CK screws of 3mm diameter & 10mm length were used for attaching lever assembly with the platform. The One-half thread was also used in lever assembly.

Fig 9. fasteners

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*G. Extension Board*

An extended board is used to extend the reach of our project. The blowers are plugged into the extension board.

Fig 10. extension board

*H. Final Assembly*

After manufacturing and fabricating all the components we assembled the manufactured and fabricated components. The assembly was done as follows.

First of all, the entire wooden platform was taken and it was marked in order to get four centers of the platform. It was done as follows:

*1)* First the wooden platform was divided equally into two holes and then each half was diagonally mark to get the center and similarly four centers were obtained.

*2)* Then the splitter was attached to the platform using clips which were further fixed by nails to the wooden platform. The position of the splitter was such that the end having one inlet was facing outside the platform and the end having four outlets was faced inside the platform.

*3)* Then the blower was fixed to the platform with one end of pipe fixed to the nipple of air blowers.

*4)* Then, the pipelines were fixed between the air blowers and the distributor to the wooden board using clips and were later on nailed to the wooden board.

Thus the assembly of our Air Cushion Material handling System is completed.

The following is the picture taken after its assembly.

Fig 11. Air cushion material handling

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## VII.EXPECTED RESULT

*A.* It should be able to move the material anywhere in the plant.
*B.* It should require minimum effort for moving the material.
*C.* There shall be no floor wear.
*D.* It should carry out the operation with minimum requirements.

## VIII. SCOPE FOR FUTURE MODIFICATION

*A.* We can use electronic devices, for example electric blowers for starting the system.
*B.* With the help of sensors the accurate positioning can be achieved.
*C.* Solenoid valves can be used for better handling with accuracy.
*D.* Separate mechanism for a forward moment of the system for example used in hovercraft to give forward push.

## IX. CONCLUSION

In conclusion, one may say that AIR CUSHION MATERIAL HANDLING SYSTEM is useful in various industries. AIR CUSHION MATERIAL HANDLING SYSTEM used for moving objects in various industries is versatile, safe, and cost effective. In the coming years, we will thus see there is wider adoption in Indian industries, more so in its innovative and Hi-tech sectors.
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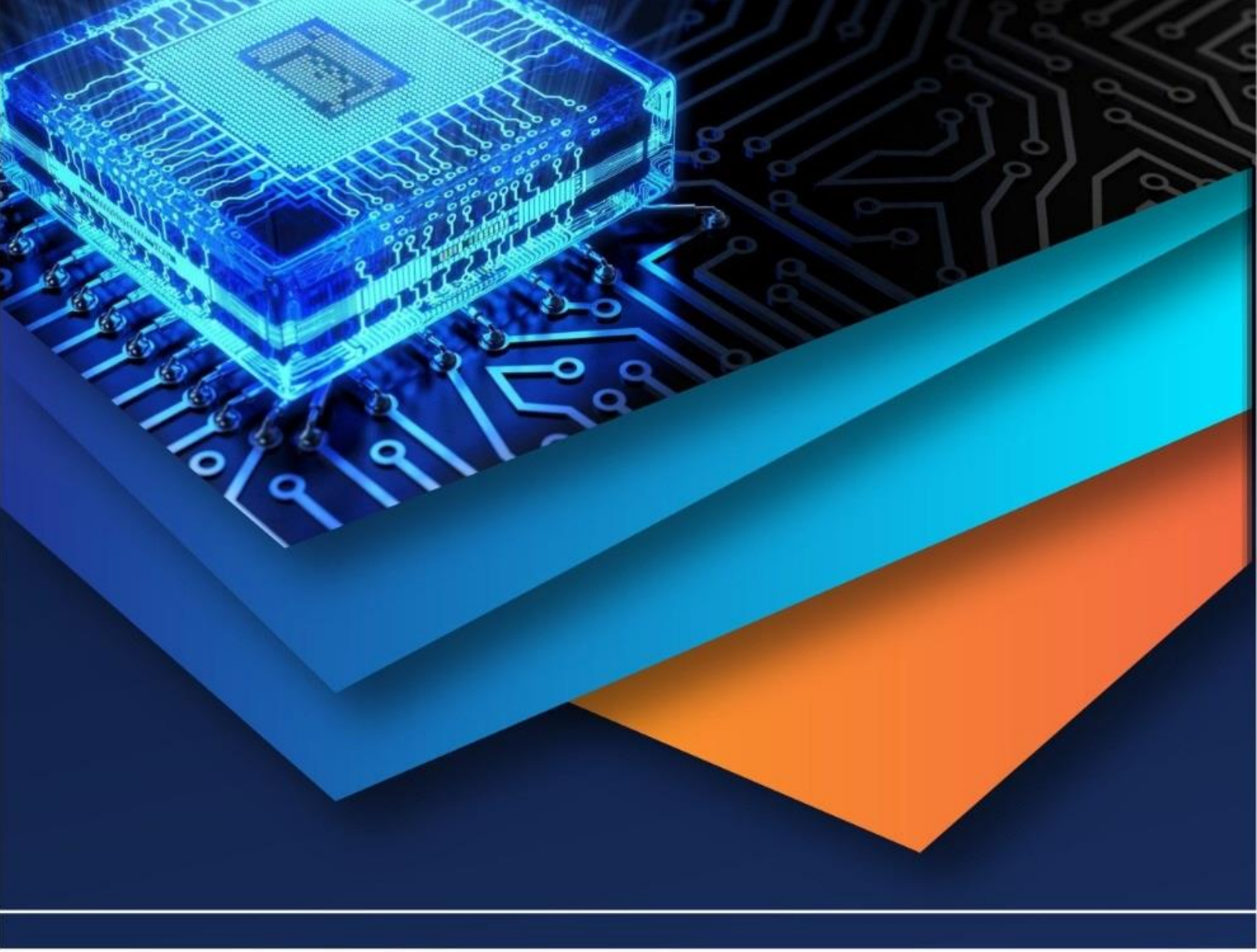

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