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DESIGN AND FABRICATION OF CONTACTLESS AIR CONVEYOR

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Abstract: In this study, we developed a completely contactless air conveyor system for transporting and positioning planar objects. The air conveyor forms a thin film underneath the object for support and simultaneously generates a controlled airflow that results in viscous traction. It is potentially applicable in the manufacturing process for semiconductor wafer or flat foodstuffs, where mechanical contact is expected to be avoided during transportation of the products to minimize contamination. The air conveyor employs duplicated arrays of actuating cells that are square pockets with a surrounding dam. A simple model is proposed to characterize the viscous force. The theoretical analysis reveals that the total force is the composition of an actuating force generated in the pocket areas and the side areas and a drag force generated in the dam areas. Experimental investigations are conducted on the basic characteristics of the film pressure distribution and the viscous force. The results show that the air film pressure is symmetrically distributed in the width direction but non- symmetrically distributed in the length direction. The viscous force increases if the suction flow rate is enlarged or the gap thickness is narrowed. Comparison of the experimental results and the calculated results indicates that the model can provide an accurate prediction. A proportional–integral–derivative (PID) controller is applied for 1D-position control and position tracking. The actuating direction is selected using fast switching valves and the amplitude of the actuating force is adjusted using a control valve to vary the suction flow rate. The simulated and the experimental results verify the feasibility of the air conveyor system and the control method.

IndexTerms **– Contactless Conveyor, Problem Statement, Construction and working, Design considerations, Modeling, Blower, Accurate, Load Capacity.**

I. INTRODUCTION

Many industries require contactless transport of delicate or clean products such as silicon wafers, flat foodstuffs, and freshly painted objects. Transport by means of pneumatics technology is widely used in practical applications since it is clean, free from magnetism, and generates little heat. Noncontact vacuum grippers and air-cushion conveyors are the most commonly used methods to avoid mechanical contact. The vacuum grippers generate an upward lifting force and thereby can pick-and-place a planar object. However, an object handled in this way is very likely to drop when tilted and thus locating pins or rubber friction pads are generally equipped on the grippers. The air-cushion conveyor uses arrays of bearing elements which supply pressurized air to form an air film under the object.

II. PROBLEM STATEMENT

In comparison to current conveyors, an air conveyor that moves items from one end to the other without the need of a mechanical belt, chain, or roller mechanism might be speedier. Because of the high-power consumption needed for product transfer, other conveyor systems like belts and chains may require longer time to make runs and have higher maintenance costs as well. One of the advantages of an air conveyor system is that it is a clean and efficient way to transport products. Because there are no physical contact points, there is less risk of product damage, contamination, or jamming. Additionally, air conveyor systems can be designed to accommodate a wide range of product geometrical shapes and sizes, making them a versatile solution for many industries. It would have less maintenance & a high transmission rate in this air conveyor system. Some of the problems witnessed with the present mechanical conveyors are as follows:

1) There is a maximum motor speed since going over that diminishes torque.
2) Belts, motors, and moving parts are quite expensive.
3) Rollers and bearings are expensive and necessary for gravity conveyors.
4) Moving components require regular maintenance and lubrication.
5) These conveyors suffer wear and tear as a result of contact and friction.

We developed a new prototype called the Air Conveyor System to address these issues.

III. Adaptability of the System

3.1 Compatibility

It should be simple for the operator to operate the machine from the machine's point of view. The machine itself must work with the system's connected items and gadgets. During operation, the machine should also adjust to the working environment. This air conveyors can be user-friendly if they have an acceptable design and rapid haptic feedback while in use. It demonstrates its expertise in moving lightweight goods while upholding the accuracy of its requirements.

3.2 Availability

The Air Conveyor System is currently only being used by a few businesses. Not a single sector in India has chosen such a method. Companies from countries like Japan, Canada, and the United States are investing a lot of money to create systems that can be employed on a wide scale. The air conveyor system effectively achieves superior results from several aspects, such as in power consumption, speediness in moving the items, material safety and handling, based on the numerous researches accessible and the R&D done by few.

IV. Construction & Working

Lightweight objects may be moved at extremely high rates without the aid of a conveyor belt using a smart contactless Air conveyor. To complete this purpose, this technology creates compressed air. The conveyor's top surface is made of a fiber glossy plate with holes punched at precisely specified intervals. Just beneath the wooden covering is a hardwood bed with a hollow hole that serves as a compressed air tank. There, in the hollow area between the sheet and the wooden bed, high pressure is created. Little holes bored on the fiber plate at the top allow the compressed air to escape. Based on the variety in size and weight of the articles to be conveyed on the conveyor, the hole size and distance are established. The choice of the proper air blowers is essential because they emit the compressed air needed for pressure creation after the hole size and location on the sheet have been fixed. There are two Air blowers mounted on the bottom of the wooden bed, the air flows through the duct of the Air blower and enters into the gap between Metallic sheet bottom and top of the wooden bed where pressure is generated. This pressurized air will come out from the holes and move the products with the help of the bottom thrust.

This is how an Air Conveyor prototype works. Installation of a more potent air blower is required for lifting big items. A sturdy metal and wooden frame support the whole system. To guarantee product security during shipping, guide vanes are fitted on either side of the top surface. After the object is in motion, it moves smoothly and without any resistance across the conveyor while moving in the specific predefined direction. As a result, this system offers a cutting-edge, contactless method of transporting objects that is low-maintenance and has minimal moving components. For product counting, photoelectric IR proximity sensors are added. At a finite range, such sensors could detect both metallic and nonmetallic objects. The major component of our execution method is a two-channel relay, to which the blower wires are linked via the terminal block and the primary power supply via the input connections. The machine will automatically shut off and conserve electrical energy from the power supply when a user-defined value is reached. Relay is responsible for the power cut off when desired products are reached.

V. Design Consideration

The following guidelines are typically followed in the design of an effective and efficient material handling system, which will increase productivity and reduce effective cost:

1) The system should be designed to have zero idle time and a continuous flow of material.
2) Choosing standard equipment ensures low investment and flexibility.
3) Gravity flow is incorporated into the material flow system.
4) Ensuring that the ratio of material handling equipment's dead weight to its payload is as low as possible.

VI. Material Selection & Consideration

The choice of material for an air conveyor system is quite important, especially for the top surface of the conveyor where the product will be transported from one end to the other. To transfer the product or material, a material with a low air friction ratio and maximal tangential airflow through the perforations is needed. For this conveyor system, three metallic and nonmetallic materials have been taken into consideration. A metallic surface may be achieved with steel (CS, SS, MS) and aluminum. The ideal material for a nonmetallic surface is acrylic. Stainless steel (SS 202) is now ready to be used to create metallic sheets. The system's chassis, which is built of stainless steel, features a metallic frame (SS 304). To create the wooden bed, it is suggested to use high-quality hardwood plywood.

3D Model of Contactless Air Conveyor

Fig: 1: Contactless Air Conveyor (Isometric View)

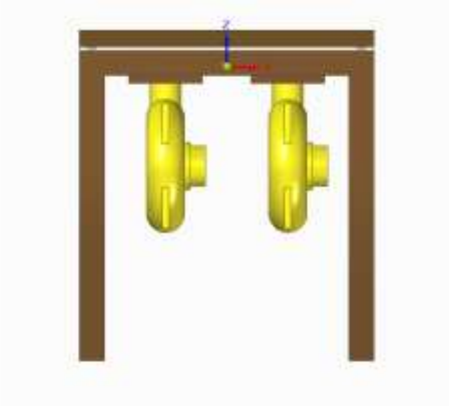

Fig: 2 : Contactless Air Conveyor (Front View)

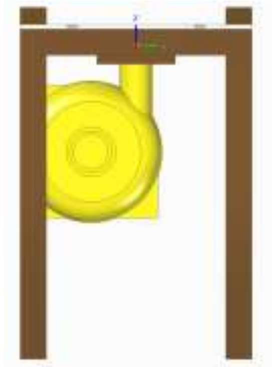

Fig : 3 : Contactless Air Conveyor (Side View)

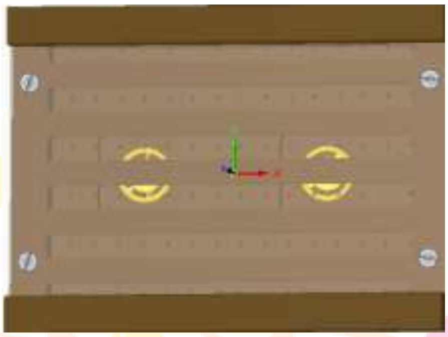

Fig: 4 : Contactless Air Conveyor (Top View)

VII. ACTUAL MODEL OF CONTACTLESS AIR CONVEYOR

Table 7.1: Specifications of the Contactless Air Conveyor;

Components	Width	Height	Length	Thickness
1. Metal Frame	270 mm	400 mm	370 mm	•••••••••••
2. Fiber plate	270 mm	•••••••••••	370 mm	4 mm
3. Wooden Bed	270 mm	•••••••••••	370 mm	40mm

Here are some pictures of Contactless Air Conveyor;

Fig: 5: Contactless Air Conveyor's Blower & with Conveying Product

VIII. DESIGN AND PRESSURE CALCULATIONS

8.1 Blower Specification

According to the research, the entire area of the rectangular output duct of the blower should be bigger than the total area of the complete number of holes present on the fiber plate in order to generate enough pressure to make any product slide.

230 volts, 300 watts & speed 5000 rpm
Power of blower: P = 300 watts x 2 = 600 W
P = 0.6 KW
Time = t= 60 min = 1 hour
Power Consumption = power x time = 0.6 x 1 = 0.6 KWh
Static Pr. of Blower: 1177.36 Pascals

8.2 Pressure Generation Calculations

We are using the Pressure formula as mentioned below;
P = F/A

P = Pressure Generation, A = Area of Product
F = Force Acting on the product (Here F = m*g ; m = mass of the product, g = gravity)

Here the assumed product parameters are shown below;
Area = 10000mm² = 0.01m² (1)
(L= 100mm, B= 100mm)
Mass = 1000 g = 1kg (2)

Now applying the pressure generation formula;
$P = [(m * g) / A]$
$P = [(1 * 9.81) / 0.01]$
$P = 981\ kg/\ m\ s^2$ or $981\ N/m^2$ or 981 Pascals (3)

For the range aspects we need to ensure the mass and pressure,
i.e. m = 1.2 kg, A = 0.01 m²
Pressure = 1177.2 Pascals (4)
i.e. m = 1 kg, A = 0.01 m²
Pressure = 981 Pascals (5)
i.e. m = 0.8 kg, A = 0.01 m²
Pressure = 784.8 Pascals (6)
i.e. m = 0.6 kg, A = 0.01 m²
Pressure = 588.6 Pascals (7)
i.e. m = 0.4 kg, A = 0.01 m²
Pressure = 392.4 Pascals (8)
i.e. m = 0.2 kg, A = 0.01 m²
Pressure = 196.2 Pascals (9)

The blower's static pressure is 1177.36 Pascal, and according to our calculations about pressure generation, the closest estimate for the lifting pressure at 1200 g.

8.3 Measurement of Airflow

Finding the Fluid (Air) Velocity(v): $v = \sqrt{(2gh)}$
where h = height of the surface of the fluid below the hole
Here, h=30 mm. So, v = 0.767 m/s. (10)

Finding the Fluid Volume Flow (Q): Q = A*v
Here, A = 0.000007068 m² and v = 0.767 m/s.
So, $Q = 5.894 \times 10^{-6}\ m^3/s$ for 1 Hole. (11)
where A= cross sectional area of conveyor in m²
v = air velocity in m/s

8.4 Hole Design Calculations

Formula: $D = \sqrt{((4 * Q) / (\pi * v))}$
Based on the principles of fluid mechanics and the conservation of mass equation for flow through an orifice.

where Q = Fluid volume flow in m³/s
v = air velocity in m/s

$D = \sqrt{((4 * Q) / (\pi * v))}$
$= \sqrt{((4 \times 5.894 \times 10^{-6}) / (\pi \times 0.767))}$
$= 0.03127$ m (12)

∴ The Diameter of hole can be considering as 3 mm

The Sheet's specifications and associated measurements are as follows:
Rectangle width(w) = 200 mm
Rectangle height(h) = 300 mm
Circle diameter(d) = 3 mm
Space between circles and rectangle walls = 1.5 mm
Area Rectangle: (200 x 300) mm = 60000 mm²
Area Circle: 7.0685 mm²
Circles to Rectangle Area Ratio (%) : 1.13%
Area all Circles: 678.58 mm²
About Square Pitch Pattern There can be a maximum of 96 circles inside the 200 x 300 rectangle.

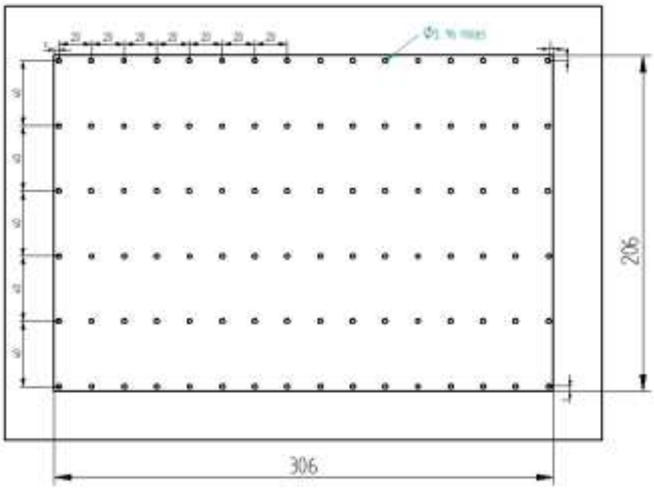

Fig: 6: Hole plate draft

IX. RESULTS AND DISCUSSION

Only when the computed numbers are equal to or nearly equal to the total static pressure produced by the blower is pressure creation achievable. We draw the conclusion that via pressure creation, a product with a weight of up to 1200g may be raised and propelled forward. The machine can push goods weighing between 1g to 1200g. If the product weighs more than 1200 grams, the machine may not be able to levitate it and may instead push it forward. In this case, a blower with a large capacity is necessary. Each of the two configurations might provide pressure and lift products with the same amount of force. Any product's width that is less than the sheet with the lighter weight will move from one end to the other with significantly more momentum. Items with a maximum weight of 1200g and a square, round, or rectangular cross-section can easily move on the bed. The range of Conveying Products during operations is around 1g to 500 g.

X. CONCLUSION

In conclusion, the design and fabrication of the contactless air conveyor project marks a significant leap forward in material handling technology. By harnessing the power of air to transport items without physical contact, this innovative system not only enhances efficiency but also minimizes the risk of product damage and contamination. Through meticulous design and precise fabrication, our team has brought to life a solution that streamlines processes across industries, from manufacturing to logistics. The seamless integration of advanced sensors and control systems ensures smooth operation, while the versatility of the conveyor accommodates a wide range of materials and environments. As we look to the future, the potential applications of this contactless air conveyor are boundless. Whether revolutionizing assembly lines, optimizing warehouse logistics, or enhancing cleanroom operations, its impact will be felt far and wide. With ongoing refinement and adaptation, this technology promises to reshape the way we transport goods, paving the way for safer, more efficient, and more sustainable practices in the years to come.

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