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Design and Prototyping of IoT Based Air Conveyor System

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Abstract: ***The term "air conveyor" refers to a group of systems that use air instead of mechanical belts, rollers, or chains to convey goods and materials. Lightweight goods like empty containers, cartons, and trays can be moved by air conveyors at speeds that frequently exceed system requirements. They might not, however, be confined to lightweight ones. It takes time for workers to move things from one place to another, especially when it involves big items. By moving objects farther away using pressured air and with the use of Internet of Things (IoT) technology, one may save time by employing air conveyor systems.***
Keywords: Air Conveyor system, Prototyping, Pressurized Air, Sensors, Blowers.

I. INTRODUCTION

The Air Conveyor system is a typical mechanical handling device that uses pressurized air to transfer goods from one place to another without the need for a conveyor belt. A cleaner & more effective method of moving raw materials, lightweight goods, or packaging from one location to another may be shown using air conveyors. To make the Air Conveyor system smart & inventive, the use of IoT-based devices & systems may be crucial. In this system, a microcontroller by the name of Arduino gathers data from sensors & provides it to the user based on data analysis and in accordance with user-specified criteria. In a production setting, all forms of solids, plastic materials, metal parts, trash, & trim removal might be transported using an air conveyor system. The types of material being transferred have a significant impact on the vertical & horizontal lengths that are covered. "Transporting items by means of highly compressed air from one position to another" .

II. PROBLEM IDENTIFICATION

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 using Industry 4.0 technology & IoT characteristics to address these issues.

III. ADEPTABILITY OF THE SYSTEM

A. 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. IoT-based 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.

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B. 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 glossy SS 202 sheet with holes punched at precisely specified intervals. Just beneath the metal 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 metal sheet 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 frame supports 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. The scripts are supposedly performed repeatedly based on the needs of the user by an Arduino UNO microcontroller. Arduino can work at 3.3V, and when the supply voltage is reduced from 5V to 3.3V, the current drawn decreases from 4mA to less than 1mA. The Arduino board's power consumption may be reduced in this way. The primary power source for an Arduino UNO Circuit is a 5V DC battery. 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. However, the Bluetooth Module (BT HC05) is also linked to the Arduino UNO. With the use of a mobile application, the input product transport volumes may be changed. This programme connects to the BT Module and provides the user with real-time data. Users are free to modify at any time. 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 CONSIDERATIONS

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.

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3D Model Of Air Conveyor System

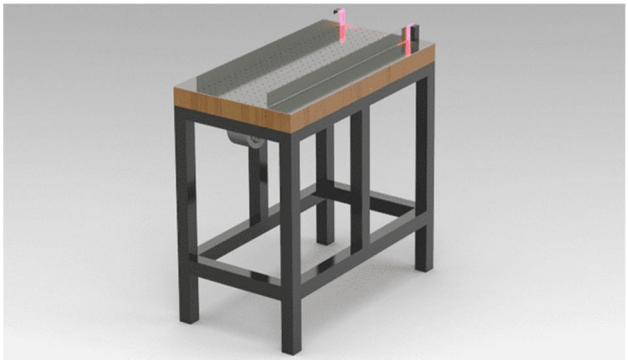


Fig : 1 : IoT Based Air Conveyor System (Isometric View)

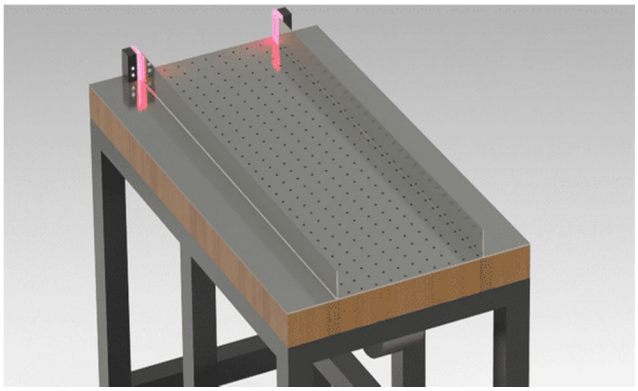


Fig : 2 : IoT Based Air Conveyor System (Top View)

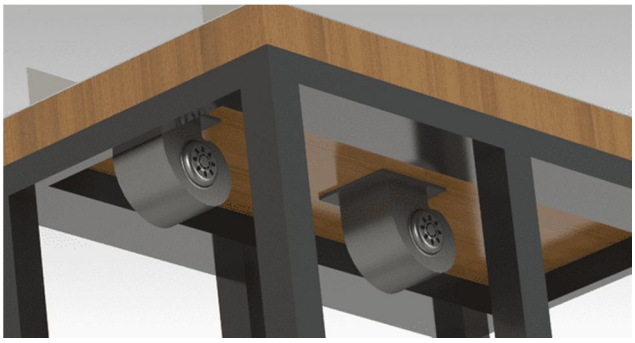


Fig : 3 : IoT Based Air Conveyor System (Bottom View)



Fig : 4 : IoT Based Air Conveyor System (Side View)

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VII. ACTUAL MODEL OF AIR CONVEYOR SYSTEM

Here are some specifications of the Air Conveyor System*;*

Components	*Width*	*Height*	*Length*	*Thickness*
1). *Metal Frame*	*50 cm*	*70 cm*	*90 cm*	••••••••••
2). *Metal Sheet*	*50 cm*	•••••••••	*90 cm*	*0.2 cm*
3). Wooden Bed	*50 cm*	•••••••••	*90 cm*	*7 cm*

Here are some pictures of an actual IoT Based Air Conveyor System;



Fig : 5 : Actual Air Conveyor With Conveying Products



Fig : 6 : Actual IoT Based Air Conveyor System

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Fig : 7 : Sensor Detecting the Conveying Product

VIII. DESIGN AND PRESSURE CALCULATIONS

A. Blower Design & 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 metallic sheet in order to generate enough pressure to make any product slide.

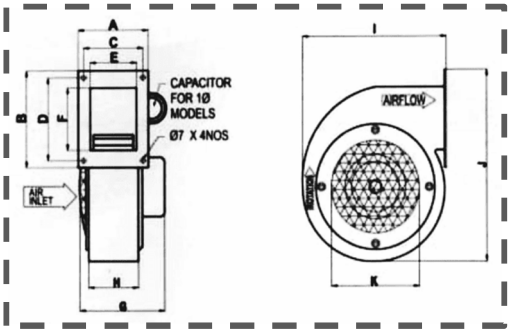


Fig : 8 : Air Blower Design

Area of Blower Duct : 62.05 cm²
Width of Duct (E) : 7.3 cm
Length of Duct (F) : 8.5 cm
Static Pr. of Blower : 294.34 Pascals
R.P.M : 2600 & Power : 120 W
CFM : 241 & CHM : 410

B. Hole Design Calculations

In this system, two air blowers with identical specs, design calculations, and pressure generation are utilized. Each blower can produce 2800 rpm and 241 cfm, respectively.

The Sheet's specifications and associated measurements are as follows:
Rectangle width(w) = 300 mm or 30 cm
Rectangle height(h) = 900 mm or 90 cm
Circle diameter(d) = 5 mm or 0.5 cm
Space between circles and rectangle walls = 2.75 cm

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About Square Pitch Pattern There can be a maximum of 280 circles inside the 30 x 90 rectangle.
Area Rectangle : 2700 cm²
Area Circle : 0.196 cm²
Area all Circles : 54.9 cm²
Circles to Rectangle Area Ratio (%) : 1.51

C. Pressure Generation Calculations

Now for the pressure generation calculations,
We are using the Pressure formula as mentioned below;
P = F/A

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

Here the assumed product parameters are shown below;

Area = 100cm² = 0.01m². (1)
{L= 10cm, B= 10cm}
Mass = 500 g = 0.5kg. (2)



Now applying the pressure generation formula;
P =[(m * g) / A]
P =[(0.5 * 9.81) / 0.01]
P = 491 kg/ m s² or 491 N/m² or 491 Pascals. (3)

For the range aspects we need to ensure the mass and pressure,

i.e. m = 0.3 kg, A = 0.01 m²
Pressure = 294.3 Pascals (4)

i.e. m = 0.2 kg, A = 0.01 m²
Pressure = 196.2 Pascals. (5)

i.e. m = 0.1 kg, A = 0.01 m²
Pressure = 98.1 Pascals (6)

Only when the computed numbers are equal to or nearly equal to the total static pressure produced by the blower is pressure creation achievable. Here, the blower's static pressure is 294.34 Pascal, and according to our calculations about pressure generation, the closest estimate for the lifting pressure at 300 g of product weight is 294.3 Pascal. We may infer from that that our system can lift and move a maximum of 300 g of product weight. If we want to transport heavy products then it's necessary to use high pressure blowers so that they can generate high-compressed air to lift and convey the products.

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D. Measurement of Airflow Through Holes

1) Cross-sectional area of a Hole(A) : $A= \pi r^2$

Where r= radius of a hole.

Here, r= .25 cm. So, $A= 0.19635\ cm^2$

2) Finding the Fluid(Air) Velocity(v): $\sqrt{(2gh)}$

Where h = height of the surface of the fluid below the hole

Here, h=7 cm. So, v = 1.1719 m/s. (7)

3) Finding the Fluid Volume Flow (Flux)(Q): $Q= A \bullet v$

Here, $A = 0.000019635\ m^2$ and v = 1 m/s. So, $Q = .000023\ m^3/s = 0.048734$ cfm for 1 Hole. Square pitched sheet having 280 holes, flux is 12.86 cfm. (8)

IX. RESEARCH LIMITATIONS

A large capital base is needed to build an air conveyor system. Moreover, the body's main structure prevents it from lifting heavier objects. This is a significant restriction that restricts this effort to design only and prevents performance evaluation of the Air conveyor system. Nonetheless, the study effort offers design information for creating air conveyor systems for usage in industries. The cloud-based Internet of Things system can surely be used in industrial settings, although Bluetooth connection is only supported by this prototype.

X. RESULTS

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 300 g may be raised and propelled forward.

The machine can push goods weighing between 1g to 300g. If the product weighs more than 300 gms, 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 300g 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 50 g.

XI. INSIGHTS OF AIR CONVEYOR SYSTEM

A. Accumulation Capability

When it comes to industrial applications, low back-pressure accumulation applications are a natural fit for air conveyors. Back pressure in this context refers to the amount of pressure that items in a line that are behind one another put on one another. The number of items stacked up on a single line directly relates to the back pressure. The exception is pressure buildup in the low back. Back pressure on air conveyors is frequently half that of a regular conveyor. With an air-conveyor system line, if a downstream machine fails, the upstream products on the conveyor automatically start to build up so that other machines on the line may continue operating.

1) Performance and efficiency depend on maintaining a constant air velocity at each louver along the conveyor.

2) Most centrifugal blowers used to power air conveyors only have one moving element, making them safer and easier to maintain.

3) On the infeed sections of standard air conveyors, high-pressure blowers are frequently utilized to accelerate items fast to the line speed of the air conveyor. On the infeed sections of standard air conveyors, high-pressure blowers are frequently utilized to accelerate items fast to the line speed of the air conveyor. Airfoil impeller blowers are sometimes used in transport zones of air conveyors, whereas high-pressure blowers are used in transition zones when a higher pressure is required to fast accelerate the product at the infeed to another conveyor.

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B. Performance Variables

The main factor influencing how well an air conveyor works is air density. To obtain the maximum performance out of air conveyors, you must understand how weather and elevation affect it in turn. As a result, controls, or a global setting, are frequently included with air conveyors so that blowers may be quickly adjusted for variations in air density. Conversely, the blower speed is raised when the air density is low.

1) Centrifugal blowers with airfoil impellers are what power the majority of energy-efficient air conveyors. The airfoil impeller has consistently shown to be the most effective blower component for normal air-conveyor pressure ranges. Different impeller designs are frequently needed for more efficient functioning at higher pressures.

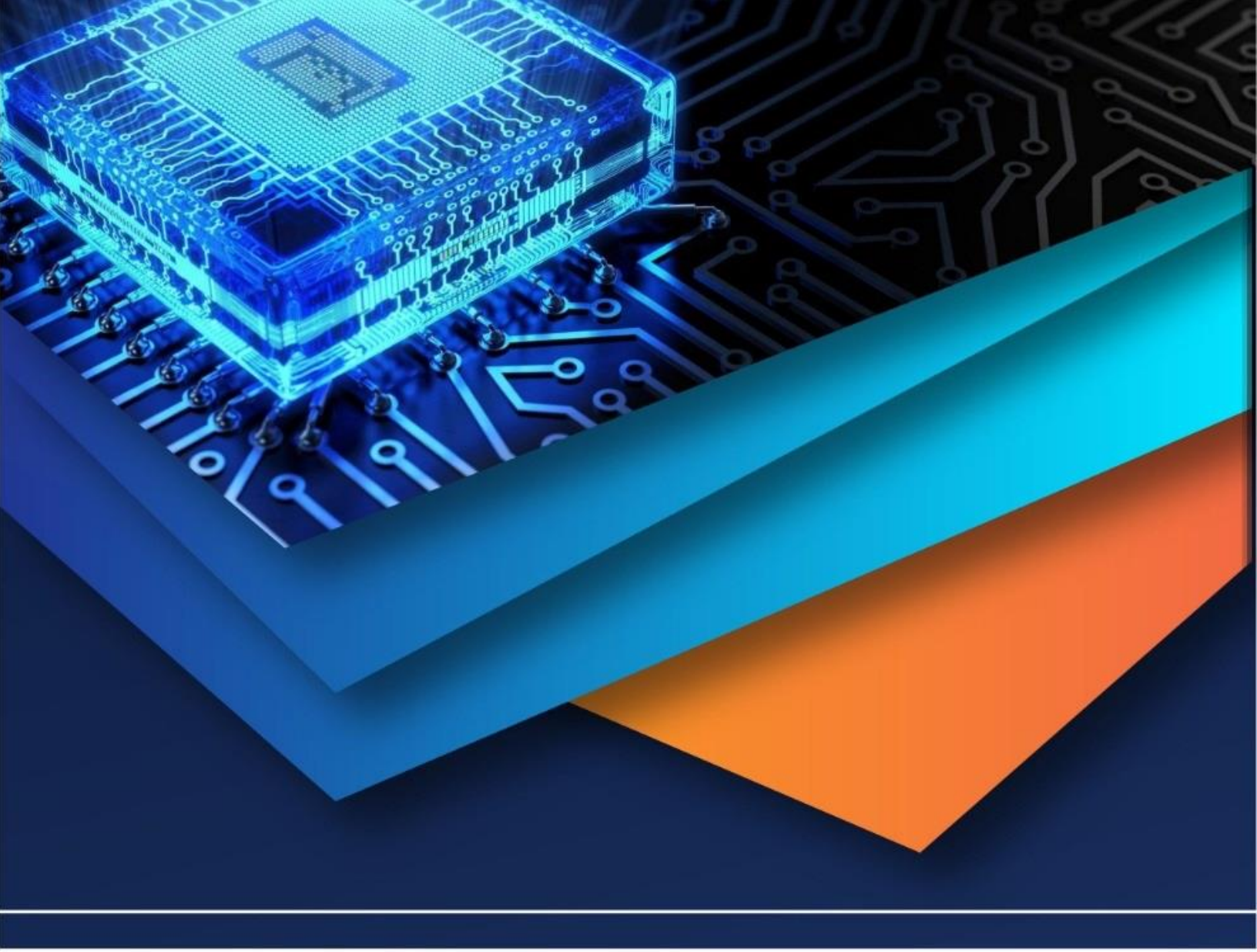
2) The choice of a blower is influenced by several design factors. The most important ones are line speed, plenum length and cross-sectional area, product size and weight, and louver size and number.

XII. CONCLUSION

In this study we conclude how an IoT Based Air Conveyor system could be developed to transport and position planar objects with the help of air Also how it might contradict with the conventional conveying machines. In the end, this machine could share a great deal in the future of Industry 4.0 & easily upgradeable to futuristic technologies. We might save electrical power after implementing the IoT technology in the Air Conveyor System. This is the upgradable innovation in the fourth industrial revolution in the material handling system. In the end, this machine could share a great deal in the future of IR 4 & upgradeable to futuristic technologies.

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