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Design of Air Cushion Material Handling System

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Abstract - Advances in material sciences have now made possible a safer, more reliable, and cheaper method of moving heavy loads for material handling i.e Air Cushion Material Handling System. All one needs to do to move a heavy load is put it on a cushion of air like a hovercraft. The reduced friction allows one to move the required load with significantly less amount of force. The compressed air from the blower is filled into the distributor which has nozzles like holes at the bottom, the air seeps through the holes and lifts the platform into air. Due to continuous flow of air the platform stays up in the air and the load put onto the platform can be moved easily.

Key Words: air cushion, material handling, friction, distributor, nozzles

1. INTRODUCTION

Material handling involves the movement of materials, manually or mechanically in batches or 1 item at time within the plant. The movement may be horizontal, vertical or the combination of horizontal or vertical.

Material handling emphasizes upon the need installing efficient and safe methods and equipments for material building. There are number of material handling equipment which works on the electric systems, hydraulic systems and manual operation and so on.

One of the new concepts in material handling is used of Air Power. By using compressed air nowadays material handling is done. For e.g. by using air flow sand conveying can be done to one place to another.Here in this project we have developed one system, which uses compressed air as working media, for material and conveying of bulks and heavy objects or those requiring delicate handling and precise positioning. This system is called as 'AIR CUSION MATERIAL HANDLING SYSTEM' is based on creating a thin film or air between the undesirable of load and floor on which it rests. The air film acts as cushion. It is not traditional type of cushion that absorbs the vibrations but actually it avoids direct contact between two surfaces i.e. load carrying platform and floor under platform.This effect can be compared with effect of oil film in hydrostatic bearing in which two surfaces are in contact are separated by supplied oil, which creates thin film of oil. So that direct contact should be avoided.

2.1 BACKGROUND OF THE STUDY WORK

2.1.1 Air Power

- Air cushion Material handling system effectively uses compressed air as working fluid.
- Industrial processes require equipment using power in various forms such as electric, Hydraulic, pneumatic etc. The use of pneumatic power is not just confined to the traditional air tools but now a day's extends too many other forms such as intensifiers Pneumatic controls and so on.
- As uncompressed air has very less energy as compared to compressed air so it is of very less importance in industrial processes so in industry compressed air used. A typical pneumatic system has an air compressor as its heart. The compressor, which is driven by an electric motor, sucks the air from the atmosphere and compresses it to a higher pressure.
- The air is then contained in specially designed pressure vessels and distributed to the end use point by firm piping. It may be noticed that the electric energy is converted to kinetic energy is in the motor which is transmitted to the compressor where the kinetic energy is converted to potential energy and stored in the air as potential energy
- A small percentage of this energy is used to transport the compressed air through the air piping to the end use point.
- Compressed air is presently used worldwide as one of the best mode of the energy transmission.
- For easy understanding of this source of power transmission one can compare it with electricity.

2.2 BENEFITS

The benefits of Air Cushion Material handling System are felt because of the "Force Equation".

$F = W \times C.O.F.$

Where,

F = force

W = load

C.O.F. = Coefficient Of Friction

This resistance to movement (coefficient of friction) is dramatically reduced when the load is floated on an "Air Cushion".

Air because of its easy availability and general characteristics is an ideal fluid to use for reducing the frictional drag between the load and its supporting surface.

Since air buoyancy is Omni – directional there are no directional restraints (as in the case of trolleys, belt conveyors and roller conveyors) and loads can be rotated and moved in any direction with the same ease. Air cushion Material

handling systems also allow very accurate positioning of the load. The load capacity of the air cushion elements results from the product of their surface area and the operating pressure (F = A * p). Since the air cushions are charged at a pressure of up to 4 bars, an air cushion 1 meter in diameter, for instance, can carry a load of about 25 tons.

Air cushion running gears have a modular structure, i.e. any number of elements can be connected together. This means there is almost no limit on the load capacity. The use of transport pallets allows any number of goods and products to be made mobile and conveyed, cycled or positioned by just one single pallet transporter. In addition, the individual air cushion transporters can be combined into a group of 2, 3 4 or more units, enabling the load capacity to be easily increased and adapted to the particular load. The general principle is that the heavier the load, the greater the cost-effectiveness of the air cushion system in comparison to conventional transport systems. Alongside the high degree of Material handling and flexibility, these benefits make air cushion systems a valuable means of transporting heavy goods.

2.2.1 Other Benefits:

- Transport is smooth and free of vibration
- Small dimensions of the transport vehicles (only slightly larger than the floor area of the load)
- Easy maneuverability thanks to the air cushion principle, allowing optimum use to be made of the available production space
- Low energy consumption because friction is almost completely eliminated
- Distribution of the pressure over a relatively large area means stresses on the floors are less than with traditional means of transport
- Simple operation, clean and ergonomic production facilities
- Provides excellent stability and support

2.3 TYPES OF AIR CUSHION MATERIAL HANDLING SYSTEM

Air cushion Material handling system can be divided into two major types:-

2.3.1 Free path air cushion Material handling system

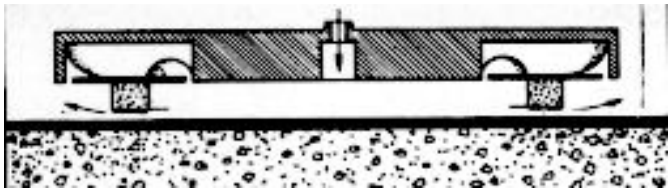

Fig -1: Free path air cushion Material handling system

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.

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2.3.2 Fixed Path Air Cushion Material handling System

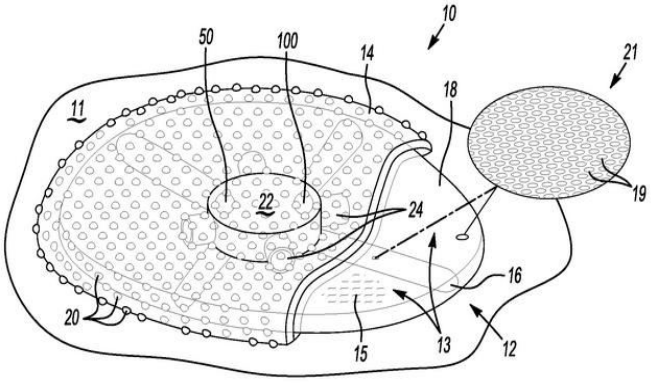

Fig -2: Fixed Path Air Cushion Material handling System

In certain applications for conveying or positioning materials the air cushion principle is utilized is a different manner. 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 air flow is utilized both to 'float' the material as well as convey it in the direction of the inclination of the nozzle due to horizontal component of the force exerted by the escaping air. This method of moving the loads has some advantages, especially for delicate items required gentle handling. Even in case of a 'traffic jam' in the

path of load movement, no excess 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.

Our system i.e. fixed path and free path system we decided our project on free system due to the two reasons explained below:-

- Free path system consumes lesser space, doesn't require any complex floor construction and is more economical as compared to fixed path system.
- So at the student's level speaking in mind the economy, facilities and resources available, it is reasonable to work on free path system.
- 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.
- 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, so as to reduce the air consumption.
- For practical applications, these individual air bearings are usually combined in a number of ways.
- 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.
- 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 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.

2.4 METHODOLOGY USED IN THE WORK

2.4.1 Actual operating system

This system is used for moving around heavy, bulks or awkwardly shaped objects such as machine tools, heavy electrical transformers etc or those requiring smooth and accurate positioning during production assembling or storage, such as aircraft engines, Fuselage parts, or even complete aircraft.

The basic building block of this system is 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 storms 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 thing being equal, the quantity of leakage air is directly proportional to the size of this gap. Thus the smaller the surface of the floor, the smaller this gap can be without introducing friction between the seal and the floor for occasional movement over a relatively rough surface, a thin metal so as to reduce the air consumption. For practical application, these individual air bearings are usual combined in a number of ways. A minimum of three bearing are required to provide a stable platform for the load, but it is usual to combine them in groups of four toned and can be easily be moved around by a single operator. Other sizes and carrying capacities up to 80 tones are in existence. Theoretically, with suitable arrangement there is no limit to the size and, weight of a load that can be moved around on a fluid film.

2.4.2 Principle of Operation

Material handling in the industry requires different toes of equipments 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 rest. Such systems are called as 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 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 horizontal plane.

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 typically 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.

2.4.3 Prime Requirements:

- Continuous supply of compressed air
- Enough pressure corresponding to the load to be lifted
- Sufficiently smooth floor surfaces

2.4.4 Advantages

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 moved around in any direction equally easily, forward , backward, diagonally , sideways, or even completely turned around on its own axis.

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 main source, which is compressed air, as in many industries compressed air is required such as wheel trolleys, belt and roller conveyor.

2.5 FABRICATION

The basic components of the air cushion Material handling system are as follows;

- Air Blowers
- Distributor.
- Platform.
- Pipes.

Now let us study in brief the manufacturing of all those components one by one

2.5.1 Air Blowers

Speed = 13000rpm
Power = 650w
Current = 5.6A
Discharge = $3m^3$/min

Fig -3: Blower

2.5.2 Distributor [Rexine]

As we have taken air distributor as rexine because rexine carries high pressure of air than any other material. The rexine was attached to the wooden plywood by applying hard rexine, crape and staples from 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 this 6 circles the air gets distributed in a perfect manner and the plywood gets lifted and the plywood moves forward.

Fig -4: Distributor

2.5.3 Platform:

The platform of our project is the wooden board of 920mm. The main Reasons for using wooden platform are basically.
1) Light in Weight: - By using wooden platform 3-4h weight is reduced of 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. In order to increase the aesthetic view and ergonomics, we have provided a rubber pad of 5mm thickness over the platform and then in order to prevent change the edges of the wooden board are plated by aluminum plate to four sides. The plates are fixed to the board by nailing.

Fig -5: Platform

2.5.4 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 distributor. The pipeline was directed in 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 -6: PVC Pipes

2.5.5 Lever:

We attach a lever to move in a particular direction. The lever is light in weight as it is made up of fabric material. Due to this lever, we can control the direction of our system known as Air Cushion Material handling System.

Fig -7: Lever

2.5.6 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 centre of the platform. It was done as follows,

1) First the wooden platform was divided equally in two holes and then each half was diagonally mark to get the centre 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 splitter was such that the end having one inlet was facing outside the platform and end having four outlets was faced inside the platform.
3) Then the 2 blowers were fixed to the platform with one end of pipe fixed to the nipple of air blowers and other end of the pipe to the nipple of distributor. Thus four casters with 4 pipes from caster connected to the nipple of air caster connected to 4 nipples of the distributors or the splitter was attached to the wooden board with the help of conical headed screws.
4) Then, we fixed the pipelines which were between the air blowers and the distributor to the wooden board by means of clips and were later on nailed to the wooden board.

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

Fig -8: Assembly of Air Cushion Mobility System

2.6 CALCULATIONS

2.6.1 Observation:
1. Own weight of system = 11 kg
2. Load on system = 53 kg
3. Total Wt. = 11+ 53 = 64 kg

2.6.2 Calculations:

For Wooden Plank
1. Diameter of Plywood: 950mm
2. Width of Plywood: 12.7mm
3. Diameter of two holes at corner on plywood: 35.56mm
4. Distance from centre (Radius): 475mm
5. Distance of centre of semicircle to centre of plywood: 201.90mm
   = 4r/3π
   = 4 x 475/ (3xπ)
   = 201.90mm

For Air Cushion (Rexine)
The air cushion is of 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 circles is an angle of 60^0Each circles are equally sized of radius 12 mm.

2.7 FUTURE WORK

Use of Electronics Devices to make the system automated. This will help the system to be used for longer ranges. Height sensing devices can be used to regulate the uplift of the system. Height sensing will ensure that there is no contact between the ground and cushion. Solenoid valves for direction control. Proper directional stability can be obtained. Also separate mechanism for the forward movement as like in hovercraft can be used. Proper vibration damping devices may be installed to make the system vibration free.

3. CONCLUSION

In conclusion, one may say that air cushion material handling is useful in various industries. Air cushion material handling system used for moving objects in various industries is versatile, safe & cost effective. Air cushion system is based on air power. It can take very huge load as there is continuous flow of air. Hence, the air cushion material handling system is used in heavy equipment industry handling. In the coming years we will thus see there is wider adoption in Indian industries in its innovative & hi-tech sectors.

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