Design, Fabrication and Performance Evaluation of Vacuum Operated Grain Collection Machine

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Abstract— A grain vacuum includes a vacuum head supported by wheels for rolling on a substrate. The vacuum head includes a collection chamber having an open scoop like front and an open bottom, for collecting grain and channeling the grain into a vacuum duct. The vacuum head may include a flow control, for controlling air flow through the vacuum, to permit the vacuum to efficiently collect various densities of grain. A method for collecting grain off a substrate by vacuum includes the step of introducing gas supplementary air stream into the vacuum head, to permit the vacuuming up of relatively less dense grain. The supplementary airflow may be choked off to pick up grain having a higher density. In this project we design and develop the vacuum collector with high efficiency. Weight of the grain is also calculated.

Keywords: Frame, Vacuum Pipe, Vacuum Blowing, Weight Sensor

I. INTRODUCTION

Grain vacuum and method for vacuuming grain field of the invention This invention relates to bulk handling of grains, and in particular to an apparatus l0 for vacuuming loose grain from within a bin or otherwise off of surface, for transfer into a storage container or the like. Grain vacuum devices of this type are intended for hand manipulation by an operator .Background of the Invention Grain vacuums are used in grain handling to suction relatively small volumes of grain by hand manipulating a vacuum device. Typical uses include clean out of storage bins and the like. These vacuums consist generally of a vacuum head, which is intended to be manipulated by an operator, connected to a vacuum source and a storage container or the like. Figure 1 illustrates the head portion of a typical 20 prior art grain vacuum. In general, these devices consist of a flared nozzle connected to a vacuum source via a flexible duct, with a handle mounted to the head for manipulation by the operator. A pair of wheels permits the head to roll on a surface. Typically, the flared nozzle has a rectangular opening, which feeds into the generally round duct. The head is tilted rearwardly during use, to permit the operator to scoop grain into the nozzle. Prior art devices are characterized by an opening towards the front of the vacuum head, which serves as both a scoop and as the sole opening in to the interior of the vacuum head. Grain vacuums may be used for bin cleanup applications, in which case a high 30 vacuum force is required. For this purpose, it is desirable for the vacuum head to be capable of being easily rolled across the bin floor and to readily scoop up and vacuum loose grain. However, a grain vacuum may also be used to convey grain of various types to a bin or other reposition for this application;it is desirable to control the airflow in response to different grain densities. Prior art devices suffer in general from several drawbacks. The typical nozzle configuration is relatively inefficient, since individual grain particles are confronted with the vacuum-generated airstream for the brief time it takes for the head to be passed over a particular spot. As well, as the head is tilted rear vardly, a large part of the nozzle is displaced away from the ground. These factors result either in a requirement for a more powerful vacuum source, or alternatively more work on the part of the operator who must then pass the vacuum over the same spot several times in order to effect a complete grain pickup. Prior art devices are also not provided with any means for controlling the force of the suction at vacuum head. Thus, if the operator is using the vacuum to pick up lighter weight grain, the vacuum forcemay be too strong. This can result in difficulty in separating the grain from the air stream at the collection end of the vacuum. It is thus desirable to provide a means for controlling air flow within a grain vacuum head, in a manner that is easy to operate by the operator and is directly associated with the vacuum head. Prior art grain vacuum arrangements typically achieve their "scooping" effect by 2o tilting the head rearwardly, whereby one side of the nozzle forms a scooping surface for either contact with the ground surface, or riding closely above the surface. There are several drawbacks associated with this arrangement. If the underlying surface is bumpy, the nozzle can jam against the bumps. If the operator attempts to avoid irregularities by angling the nozzle upwardly, a gap is formed between the nozzle and the ground and thus not all the grain may be vacuumed and scooped up. This arrangemental requires concentration by the operator to maintain an appropriate angled position which permits the scooping surface to ride above the ground to avoid irregularities, but not by too much. It is thus desirable to provide a grain head which may be simply pushed along the ground surface, without requiring 30 the operator to maintain a particular angle or range of angles of the device. This also can minimize back strain on the operator, and provide for greater ease of use. Summar of the Invention An object of the present invention is to provide a grain vacuum device, having a vacuum head which is easy to operate and effective in comparison with the prior art. In particular, it is an object to permit effective suction pickup of grain. It is a further object to provide a grain vacuum having readily adjustable airflow to easily permit use of the device with different types of grain, without requiring control of the power level of the vacuum power source. A more efficient vacuuming operation is permitted, by providing a vacuum head in which the opening into the collection chamber is both at the front, to achieve a scooping action, and on the bottom, to permit an effective and efficient pickup operation by the vacuum air stream. The invention comprises in one aspect a head portion of a grain vacuum. The head has a hollow interior comprising a collection chamber. Thus, the wheels fully support the vacuum head on the substrate, without any operator assistance. As the vacuum is propelled forwardly, grain is scooped into the open front end of the base, and directed towards the nozzle opening by the converging flanges 30 in cooperation with the flow of air through the vacuum head10.Airflow through the vacuum device is controlled by means of a suction control means associated with the nozzle tube.

II. MATERIAL AND METHODS

A. Conceptual Framework

The traditional sun drying method of a paddy is still widely practiced by most farmers. The practice includes hauling of a paddy in bags to the drying area, spreading out the paddy in the drying floor using wide board, then evened and slightly furrowed with wooden rakes. Mixing and turning the paddy are done regularly to ensure that the paddy is dried evenly. After drying, the paddy is piled using a wooden board. After wards, the paddy is placed into a bag using a metal scoop (Panake). All of the above operations are done manually consuming too much time and effort Collecting and bagging operation is considered one of the difficult tasks in sun drying. This study was then conceptualized by looking into existing designs of pneumatic conveyor from developed, emerging and developing countries that could replace manual bagging and collecting of paddy on concrete pavement during sun drying. Based on the results, good features of the existing design were considered for adoption, adaptation, and simplification to come up with the prototype machine. Design requirements satisfying local condition were identified. Design data then were based on market information of available parts and components of machine. Based on design requirements and design data, a design drawing was prepared. Fabricated prototype was subjected to evaluation to determine its operating characteristics.

B. Power Transmission

System design of power transmission system was based on Philippine Agricultural Engineering Standards. The design data gathered from the literature reviews that were considered in the design were the following: a. Prime Mover Power : 7.5kW[10] High speed engine to match the required rpm of the air mover Engine shaft diameter: 25.4mm Direction of drive shaft rotation: counter clockwise b. Air mover Service factor (Delivery): Direction of driven shaft rotation: clockwise

C. Air Mover

The air mover used in the study was radial flat bladed centrifugal fan. The blade 380 mm Ø is like a paddle wheel with side rims. The blades were perpendicular to the direction of the wheel's rotation and the fan runs at a relatively medium speed to move a given amount of air. The radial blade type was designed for material handling applications, features rugged construction and simple field repair.

D. Suction Nozzle

Assembly Design of the suction nozzle assembly was based on Walinga design. Design data needed in the design were the following: 1) thickness of paddy when drying in concrete pavement, 2-4cm ; 2) diameter of the suction pipe, 80mm; and 3) anthropometric data such as knuckle-to-elbow length, elbow height, and hand grip diameter. Overall length of the suction nozzle assembly was determined using.

III. FANS AND BLOWERS

Fans and blowers provide air for ventilation and industrial process requirements. Fans generate a pressure to move air (or gases) against a resistance caused by ducts, dampers, or other components in a fan system. The fan rotor receives energy from a rotating shaft and transmits it to the air. Difference between Fans, Blowers and Compressors

Equipment	Specific Ratio	Pressure rise (mmWg)
Fans	Up to 1.11	1136
Blowers	1.11 to 1.20	1136 – 2066
Compressors	more than 1.20	-

Fans, blowers and compressors are differentiated by the method used to move the air, and by the system pressure they must operate against. As per American Society of Mechanical Engineers (ASME) the specific ratio- the ratio of the discharge pressure over the suction pressure - is used for defining the fans, blowers and compressors.

A. Fan Types

Type of fan	Peak Efficiency Range
Centrifugal Fan	
Airfoil, backward curved/inclined	79-83
Modified radial	72-79
Radial	69-75
Pressure blower	58-68
Forward curved	60-65
Axial fan	
Vanaxial	78-85
Tubeaxial	67-72
Propeller	45-50

Fan and blower selection depends on the volume flow rate, pressure, type of material handled, space limitations, and efficiency. Fan efficiencies differ from design to design and also by types. Typical ranges of fan efficiencies are given in Table. Fans fall into two general categories: centrifugal flow and axial flow. In centrifugal flow, airflow changes direction twice - once when entering and second when leaving (forward curved, backward curved or inclined, radial)

In axial flow, air enters and leaves the fan with no change in direction (propeller, tubeaxial, vaneaxial).

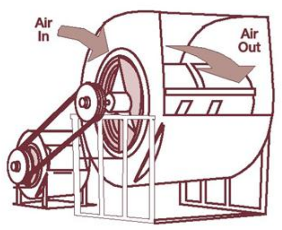

Figure 5.1 Centrifugal Fan

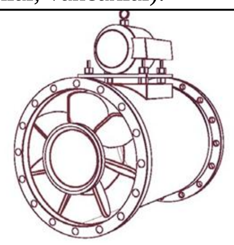

Figure 5.2 Axial Fan

B. Fan Design and Selection Criteria

Precise determination of air-flow and required outlet pressure are most important in proper selection of fan type and size.

The air-flow required depends on the process requirements; normally determined from heat transfer rates, or combustion air or flue gas quantity to be handled. System pressure requirement is usually more difficult to compute or predict. Detailed analysis should be carried out to determine pressure drop across the length, bends, contractions and expansions in the ducting system, pressure drop across filters, drop in branch lines, etc. These pressure drops should be added to any fixed pressure required by the process (in the case of ventilation fans there is no fixed pressure requirement). Frequently, a very conservative approach is adopted allocating large safety margins, resulting in over-sized fans which operate at flow rates much below their design values and, consequently, at very poor efficiency.

Once the system flow and pressure requirements are determined, the fan and impeller type are then selected. For best results, values should be obtained from the manufacturer for specific fans and impellers.

The choice of fan type for a given application depends on the magnitudes of required flow and static pressure. For a given fan type, the selection of the appropriate impeller depends additionally on rotational speed. Speed of operation varies with the application. High speed small units are generally more economical because of their higher hydraulic efficiency and relatively low cost. However, at low pressure ratios, large, low-speed units are preferable.

C. *Installation of Fan*

The installation of fan and mechanical maintenance of the fan also plays a critical role in the efficiency of the fan. The following clearances (typical values) should be maintained for the efficient operation of the impeller.

Impeller Inlet Seal Clearances

- Axial overlap – 5 to 10 mm for 1 metre plus dia impeller
- Radial clearance – 1 to 2 mm for 1 metre plus dia impeller
- Back plate clearance – 20 to 30 mm for 1 metre plus dia impeller
- Labyrinth seal clearance – 0.5 to 1.5 mm

D. *Measurements and Calculations*

Velocity pressure/velocity calculation

When measuring velocity pressure the duct diameter (or the circumference from which to calculate the diameter) should be measured as well. This will allow us to calculate the velocity and the volume of air in the duct. In most cases, velocity must be measured at several places in the same system.

The velocity pressure varies across the duct. Friction slows the air near the duct walls, so the velocity is greater in the center of the duct. The velocity is affected by changes in the ducting configuration such as bends and curves. The best place to take measurements is in a section of duct that is straight for at least 3-5 diameters after any elbows, branch entries or duct size changes

To determine the average velocity, it is necessary to take a number of velocity pressure readings across the cross-section of the duct. The velocity should be calculated for each velocity pressure reading, and the average of the velocities should be used. Do not average the velocity pressure; average the velocities.

E. *Points for Circular Duct*

For best results, one set of readings should be taken in one direction and another set at a 90 ° angle to the first. For square ducts, the readings can be taken in 16 equally spaced areas. If it is impossible to traverse the duct, an approximate average velocity can be calculated by measuring the velocity pressure in the center of the duct and calculating the velocity. This value is reduced to an approximate average by multiplying by 0 .9.

IV. CALCULATIONS

Material – Grains
Surface – Irregular shape,dry
Length – max 5 mm
Width– 25 mm
Thickness – 25 mm

– Weight of Workpiece / Grain

Mass of 1 Grain = L×B×H×ρ
where,
L = length
B = width
H = height
ρ = density

– Force Calculations

1) Case 1 st

Horizontal Suction Pad, Vertical Force
Ft = m×(g+a)× s
where,
Ft = Theoretical Force
m = Mass
g = Accel Due to Gravity
a = System Accel
s = Safety Accel

2) Case 2 nd

For Horizontal Suction Pad ,Horizontal Force
Ft = m×(g+ a/μ)×s
where,
μ = 0.1 for oily surface
= 0.2 to 0.3 for wet surface
= 0.5 for wood, metal, dry surface
= 0.6 for rough surface

A. *Weight Sensing*

A weight machine is an exercise machine used for weight training that uses gravity as the primary source of resistance and a combination of simple machines to convey that resistance to the person using the machine. Each of the simple machines (pulley, lever, wheel, incline) changes the mechanical advantage of the overall machine relative to the weight.

Plate-loaded machines (such as the Smith machine or sled-type leg press) use standard barbell plates instead of captive stacks of plates. They combine a bar-end on which to hang the plates with a number of simple machines to convey the force to the user.

V. DISCUSSIONS

A simple vacuum operated grain collection machine made of locally available materials using local manufacturing technology was designed, fabricated and tested for collecting and bagging the dried grains on concrete pavement. The vacuum operated grain collection machine had the following components suction pad, frame, weight sensor, bag, suction pipe, vacuum system, fibre wheels etc. the following fig shows the actual vacuum operated grain collecting machine.

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