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Fabrication of multiple discharge type slurry feeder with single motor

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Abstract
Fabrication of multiple discharge type slurry feeder with single motor, Handling of slurries is done in many industries like chocolate manufacturing, power plant ash disposal system, cement factories, chemical factories etc., To meet increased demand and supply, multiple processing or disposal streams of slurries are required and hence multiple discharges of slurries is very much essential. As in most of the industries, multiple motors are being used to operate multiple discharge valves, which is an expensive process and also requires a lot of installation and maintenance work. As a part of our project dissertation, we are planning to fabricate and test multiple discharge type slurry feeder which can be operated using a single motor. The Advantages of using a slurry feeder with single motor are Low initial cost, low installation cost, needs comparatively low maintenance, can handle acidic materials like food slurries, ash slurry, etc.

Keywords: multiple discharge, slurries, specific gravity, centrifugal pump, Abrasive, Newtonian fluids

1. Introduction

The manufacturing industry is expected to experience significant growth in the near future due to product innovations in established markets such as the US and Western Europe and rising disposable incomes in developing markets such as India and China.

Hoppers differ in terms of applications, some hoppers are designed for chemical, pharmaceutical, food processing, or material handling applications. Others are suitable for processing, recycling, or handling hazardous materials.

The steady flow of slurry material from a hopper plays a critical role in many industrial and process engineering applications. During hopper discharge, various problems such as unsteady and erratic flow, rat-holing, blockage, dead zones, and wear of the hopper walls are often encountered. Many researchers and industrial engineers have been long interested in designing a hopper to achieve steady, smooth and reliable mass flow rate for a specific material.

Feeders or Silos are sometimes required in locations where space is very limited. Under these conditions, a rectangular cross-section or planform provides a good economic solution, and multiple silos can be tessellated as shown in figure (1). However, the structure of a rectangular planform silo must be designed to sustain both bending and stretching (membrane) actions [1, 2], whilst those of a circular silo are predominantly designed for membrane forces [3, 5]. Where a rectangular silo is constructed with steel, the walls may be made relatively thin if the pattern of pressure on the wall is well understood, and a thin wall itself reduces the pressures at the mid-side of the wall [6].

Fig 1: Industrial feeder

Jacob R. Sensibar When hydraulically unloading free-flowing material, Such as sand, from the hopper, a water carrier is employed to move the sand from the hopper, wherein each hopper element has surrounding sidewalls sloping toward the bottom and disposed at an angle from the horizontal which is at least slightly greater than the angle of repose of the wet free-flowing material to be emptied from the hopper [7].

JIN, Baosheng *et al*. The effect of hopper cone angle and hopper opening size determines the increase in the angularity of a particle decreases the mass discharge rate and flat bottom hopper (hopper cone angle zero) increases the residual in the hopper after discharge [8].

D. Peckner *et al*. Stainless steels are most notable for their corrosion resistance, which increases with increasing chromium content. Additions of molybdenum increases corrosion resistance in reducing acids and against pitting attack in chloride solutions. stainless steel is an ideal material for many applications where

both the strength of steel and corrosion resistance are required [9].
Chen, J.F *et al*. It is widely acknowledged that the flow pattern has a strong influence on the pressures exerted on hopper walls. The flow pattern determines how the fluid is flowing and which type of is to be used [10].
Bosley *et al*. in 1969 examined in a photographic study that, the effects on hopper shape article size particle density hopper size on velocity profiles on discharge. The velocity profile were mainly depends on hopper shape [11].
There are several problems that have been identified through research study on industrial feeders and also in order to re-create or if possible, to improve the efficiency of the feeders.
Usage of multiple motors for operating multiple discharges involves higher initial investment.
Fabrication of a user-friendly slurry feeder to enhance its efficiency by using multiple discharges in a hopper and a single motor for low power consumption.

1. Use of stainless-steel material for hopper to reduce the weight and for specific applications such as handling of food slurries and acidic substances without corrosion.
2. Use of multiple discharge type slurry feeder with a single motor.
3. To increase the output and Reduce personal hazards.
4. It needs low installation cost and comparatively low maintenance.

2. Working principle

Slurry feeder works on the principle of multiple discharges through hopper with single motor rotating a spindle to pour the slurry. Slurry is a mixture of solid and liquid (semiliquid) which is poured in a hopper. A hopper is a large, pyramidal shaped container used in industrial processes to hold slurry that has been collected from expelled air, proposed hopper has six discharges which are drilled into a hopper with the spindle itself. A 12 watts and 300rpm speed motor is used to rotate the spindle which in turns rotate in the hopper to allow the flow of slurry from the hopper. As hopper and spindle are fabricated from SS 304 material it can handle the slurries of food-grade and acidic substances without corrosion as shown in figure (2).

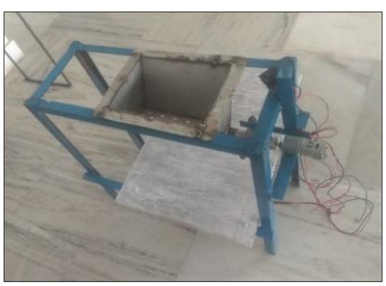

Fig 2: Assembled slurry feeder

As the spindle rotates left side with the help of motor it starts pouring 1 litre of slurry into the containers and as the spindle rotates into the right side to its original position it stops feeding the slurry. A limiting disc is attached to the spindle which comes in contact with the stopper. A stopper is welded to the structure to stop the movement of spindle to avoid any damage and spillage of slurry. In the industrial automation, feeders work with different motors but with this proposed model it works on a single motor with multiple discharges thus saving electricity, labour and time, to increase the output.

2.1 Components

Table 1 : list of components

s.no.	Components
1	Structure
2	Motor mounting
3	Stopper
4	Hopper
5	Spindle
6	Limiting disc
7	DC powered motor
8	Two-way switch
9	Wooden plank

2.1.1. Structure

The material used to fabricate the structure is IS 2062 grade (A) mild steel angles which are in 'L' shaped with 90 degrees angle as shown in figure (3).it have strength and good weldability.

Table 2: Properties of mild steel

properties	Is 2062 mild steel
Yield’s strength [MPa]	250
Ultimate strength [MPa]	410
Carbon [max %]	0.14-0.23
Young’s modulus [GPa]	200

Mild steel has a high proportion of iron to carbon, the reduced carbon content of mild steel makes it easier to shape, drill, weld and cut than other, more brittle varieties of steel.

Fig 3: Mild steel angles

2.1.2. Motor mounting and stopper

Fig 4: Motor support

Motor support is fixed to the structure by means of welding to support motor which will be connected with hopper as shown in figure (4).

2.1.3. Hopper

The material used for fabricating the hopper is SAE304 stainless steel sheet as shown in fig (5). Stainless steel with excellent corrosion resistance and It gives better low-temperature performance. At -180 ℃ condition, strength, elongation, area reduction rate is very good.1mm thickness sheet is used to prepare the hopper.

Table 3: Properties of stainless steel

properties	SAE304 stainless steel
Yield's strength [MPa]	215
Carbon [Max %]	0.08
Ultimate strength [MPa]	505
Youngs modulus [GPa]	193-200

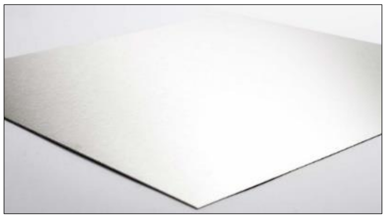

Fig 5: Stainless steel sheet

As it has 18% of chromium is highly resistant to rust. Stainless steels are widely used in food and beverage manufacturing and processing industries for manufacture, bulk storage and transportation.

2.1.4. Spindle and limiting disc

Stainless-steel spindle with limiting disc in the hopper is shown in figure (6), a spindle is a slender rounded rod with tapered ends serving as an axis that revolves or on which something revolves.

Fig 6: spindle

Fig 7: Spindle with limiting disc

A stainless-steel rod of 22.5mm has been cut, facing and tapering is performed on ending portion. Six 12mm drills are made on pipe at an interval of 25mm.

A circular limiting disc of mild steel 90mm length is welded to drilled rod and boring is done on the face with lathe machine to facilitate the pin of the motor into the hole so that it can rotate the shaft as shown in figure (7)

Fig 8: DC motor

2.1.5. Electricals and wiring

300RPM speed and 12watts motor which is cost-efficient and powerful is shown in figure (8)
A gear motor adds mechanical gears to alter the speed/torque of the motor. A switch is connected to the motor with the help of wiring to give instructions.

3. Design Calculation

3.1. Hopper Volume Calculation

Length of the hopper (L) = 203.2mm
Top width of the hopper (a) = 152.4mm
Bottom width of the hopper (b) = 25.4mm
Height of the hopper (h) = 101.6mm
Area of the hopper (A) = ((a + b)/2) x h (1) = ((152.4+25.4)/2) x101.6 = 9032.24mm2
Volume of the hopper (V) = A x L = 9032.24 x 203.2 = 1835351mm3 = 1835351/106 = 1.83 lit

3.2. Motor Power Calculation

Speed of the shaft (N) = 10 rpm
Diameter of rotating spindle (D) = 25mm = 0.025m
Diameter of the Pipe (Dp) = 26mm
Thickness of the film (t) = (Dp-D)/2(2) = (26-25)/2 mm = 0.5mm = 0.0005m
Length of the film / spindle (L) = 203.2mm = 0.2032 m
Viscosity (μ) for Chocolate Syrup = 25000 Centipoises (max) = 25000/1000 = 25kg/ms
According to Petroff's equation, Power required to turn the spindle (P) = $\frac{\mu \pi^3 D^3 N^2 L}{60 \times 60 \times t}$(3) = (25 x 3.143x 0.0253x 102x 0.203)/(3600x0.0005) = 0.1365 Watts

4. Solid works Model

A 3d representation of slurry feeder is shown in figure (9) using Solidworks software.

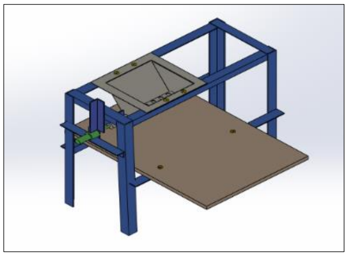

Fig 9: Isometric view

4.1 Drafting
Drafting is essential for communicating ideas in industry and engineering. People use familiar symbols, perspectives, units of measurement, notation systems, visual styles, and page layout.

4.1.1. Drafting of Structure

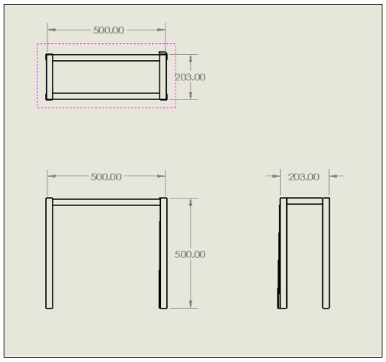

Fig 10: Drafting of structure

4.1.2. Drafting of Hopper

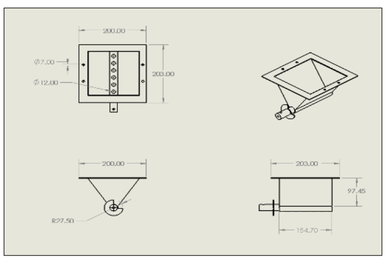

Fig 11: Drafting of hopper

4.1.3. Drafting of Feeder

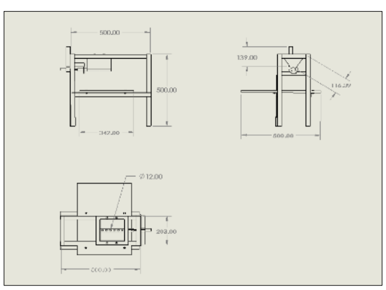

Fig 12: drafting of slurry feeder

5. Conclusion
The fabricated model of the slurry feeder is constructed with a single motor for multiple discharges to meet the demand and supply, multiple processing or disposal systems for slurries. The following things we can conclude from our slurry feeder model

- As fabricated hopper capacity is 1.8lits which is more than sufficient to handle slurry of 1 litre without any spillage.
- As hopper and spindle are fabricated from SS 304 material it can handle the slurries of food-grade and acidic without corrosion.
- As selected Motor Power is 12Watts which is higher than required Motor Power of 0.1365Watts the selected motor can handle slurries with higher viscosity also.
- With our design, we are able to achieve multiple discharges with a single motor.

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