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Functional Design and Fabrication of Travelling Type Swivel Chute Wagon Filler – A Prototype

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ABSTRACT

Conventionally coal is loaded in to railway wagons with the help of labour, fixed chute feeders and grabs type cranes. Loading of coal in to rail wagons with the help of labour requires lot of time and labour, looking to the today's labour charges and quantity to be loaded this process is no longer viable. Loading of railway wagons with fixed chute loaders consumes lot of power, since it requires elevating the coal to top of the coal bunkers / silos using conveyors. It also requires lots of coordination and time because while & after filling of each wagon, entire rake (no. of wagons coupled with engine) has to move forward gradually. Even after such an effort the complete wagon filling is not possible without involvement of labour for spreading. Grab crane type loader consumes lots of time as they have to go back to yard every time and also grab can hold only few tons of coal per stroke. This also creates huge dust pollution and requires labour to spread the coal. As a part of our project dissertation we are planning to design, fabricate and test travelling type swivel chute wagon filler which can move all along rake and fills the coal in to wagons with least labour involvement and lesser time / power consumption.

Keywords: Material handling, Methodology, Mobile wagon loader, tripper, conveyor, chute, storage silo, G.I Sheet (galvanized iron sheet)

I. INTRODUCTION

Material handling can be defined as an integrated system involving such activities as moving, handling, storing and controlling of materials by means of gravity, manual effort or power activated machinery. Moving materials utilize time and space. Any movement of materials requires that the size, shape, weight and condition of the material, as well as the path and frequency of the move be analysed. Storing materials provide a buffer between operations [1]. It facilitates the efficient use of people and machines and provides an efficient organization of materials. The considerations for material system design include the size, weight, condition and stack ability of materials; the required throughput; and building constraints such as floor loading, floor condition, column spacing etc [2]. The protection of materials include both packaging and protecting against damage and theft of material as well as the use of safeguards on the information system to include protection against the material being mishandled, misplaced, misappropriated and processed in a wrong sequence. Controlling material includes both physical control as well as status of material control. Physical control is the orientation of sequence and space between material movements. Status control is the real time awareness of the location, amount, destination, origin, ownership and schedule of material. Maintaining the correct degree of control is a challenge because the right amount of control depends upon the culture of the organization and the people who manage and perform material handling functions [3]. Material handling is an important area of concern in flexible manufacturing systems because more than 80 % of time that material spends on a shop floor is spent either in waiting or in transportation, although both these activities are non-value added activities. Efficient material handling is needed for less congestion, timely delivery and reduced idle time of machines due to non-availability or accumulation of materials at workstations. Safe handling of materials is important in a plant as it reduces wastage, breakage, loss and scrapes etc [4].

II. METHODOLOGY

Wagon loading systems are generally provided in the mines and ports for loading the material into the wagons. The following are the major types of wagon loading systems are

(a) Rake will be stationary and loader will be moving.
(b) Rake will be moving and loader will be stationary.

Rake will be stationary and loader will be moving. The loading systems under this type could be further classified into two types viz. (i) the mobile loader will be travelling for the complete length of the rake (ii) series of loaders will be provided with limited travel and would load a particular number of loaders at a time Rake will be moving and the loader will be stationary. This type is generally known as rapid loading system or flood loading system. The loading systems under this type could be further classified into two type's viz. (i) volumetric type and (ii) gravimetric type[5]

The type of wagon loading system depends on the properties of the material to be loaded and limitations in the layout. Hence each type of wagon loading systems mentioned above are applicable and are being adopted on different occasions. Generally one rake consists of about 58 wagons and capacity of each wagon is 55 tonnes. The total quantity of material in each rake would be about 3200 tonnes. The wagon loading system consists of a buffer storage silo and the wagon loader.

A. Storage Silo:

The capacity of the storage silo will be generally equal to one rake load of material to enable loading of the rake without any interruption. However, this would depend on the properties of material like flow ability, moisture content etc. In cases where higher quantity of material cannot be stored due to arching / chocking problems, the silo capacity could be lower. This silo would act as a buffer silo and the feeding conveyor to this silo shall be operated continuously to ensure that there will be no starvation of material while loading into the wagons.

B. Mobile Wagon Loader:

The mobile wagon loader consists of a long conveyor, a travelling tripper, a cross belt conveyor mounted on the tripper and a loading chute. This system will be provided parallel to the rail track where the rake containing 58 wagons will be parked. The travelling tripper will be travelling along the conveyor for loading the material into the wagons. The storage silo will be located at the tail end of this conveyor and feeds the material continuously onto the conveyor.

At the start of the loading operation, travelling tripper will be located at the starting edge of the first wagon of the rake. The material from the silo will be fed onto the conveyor which will be conveyed to the cross conveyor mounted on the tripper. The material will be loaded into the wagon through the loading chute. The travelling tripper moves forward while discharging the material into the wagon at a constant speed. When the loading chute approaches the end of the wagon, the loading chute changes over from one wagon to the next wagon and thus there will not be any spillage between the wagons. The loading operation will continue to the next wagon without any interruption. This process will be continued till the loading of the last wagon of the rake [6].

This type of system is suitable for all types of material and especially for the sticky material. The limitation of this type of system is that the mobile loader will be too heavy and bulky. The time taken for loading one rake is about 3 to 4 hours [7].

There is another type of mobile wagon loading system which consists of a set of six or seven short pivoted conveyors. The pivot of these conveyors will be such that the discharge chute of the conveyors will be travelling in a straight line. These conveyors will be pivoted at the tail end and mounted over the rail track at the head end [8]. The bottom elevation of the conveyor will clear the wagons. The travel of the head end will be limited to one wagon length. A surge hopper will be provided at the tail end of each conveyor which ensures continuous supply of material. At the start of the loading operation, the rake will be parked below the conveyor system such that the forward edge of the first six wagons will be below the loading chute of each loading conveyor. The loading operation will begin at the starting edge of the wagon and as the material flows, the conveyor would travel along the wagon and loading will be completed as it reaches the other edge of the wagon [9]. Each wagon loader will load one wagon at a time. At the end of the loading operation, the rake shall be shifted by six wagons so that the next six wagons will be ready for loading the material.

Figure 1. Typical Mobile fixed chute Wagon Loader

III. FABRICATION PROCEDURE

A. Marking: The required dimensions of component is marked on the galvanized iron sheet as according to drawing give below.

B. Cutting: The required dimensions of swivel chute marked on the G.I sheet. Now the G.I sheet is cut with the help of hand drilling machine.

C. Finishing: Finishing operation is performed on G.I sheet in order to remove the burs formed during cutting and to get a smooth edges.

D. Bending: The bending operation is performed on the G.I sheet to get required shape as per the dimensions. The sheet is bend at right angles by placing it in the bench vice to acquire the required shape.
Drilling: A 3 mm drills are made on component as per the requirement in drawing and are fixed with nut and bolt.

IV. FABRICATION WORK OF COMPONENTS MAKING

Figure 2. Swivel Chute

Figure 3. Short Conveyor

Figure 4. Long Conveyor

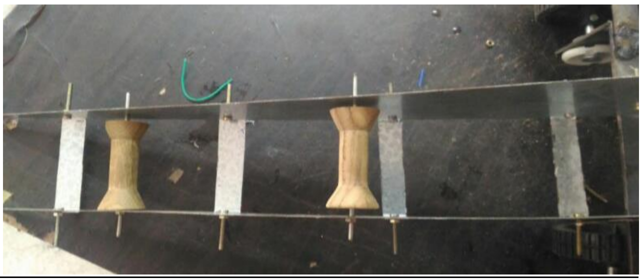


Figure 5. Travelling Tripper

Figure 6. Finished Prototype Swivel Chute Wagon Loader

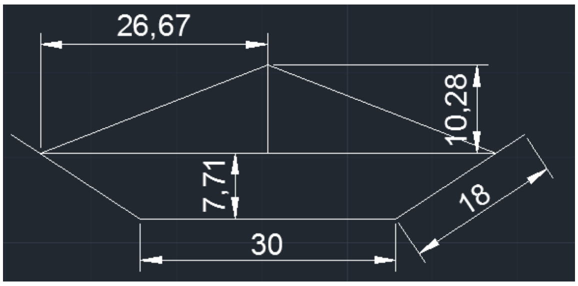
V. CALCULATIONS

Capacity of conveyor =25 kg/hr
Design capacity = 25×120% =30 kg/hr
Type of material = rice, coal, ore
Density of material (ρ) = 800 kg/m^3
Speed of belt = 1.25 m/min
Pulley radius = 20mm

Motor speed $=\frac{\text{speed f the belt}}{2\times\pi\times(\frac{r}{1000})}$

$= \frac{1.25}{2\times\pi\times(\frac{20}{1000})} = 9.95$ r.p.m

Speed of motor considered = 10 rpm



Area required considering 1.25 m/min belt speed:

$$= \frac{\text{design capacity}}{\text{belt speed}\times 60\times\text{density of material(bulk)}}$$

Design capacity = 30 kg/hr
Belt speed =1.25 m/min
Density of bulk material = 800 kg/m^3

$= \frac{30}{1.25\times60\times800} = 0.0005$ m^2=500 mm^2

Area required considering 90% fill factor:
=**500/0.9 =555.56**

Length of the idler bottom considered = 30mm
Length of the idler inclined portion considered =18mm
Width of the belt considered =60mm
Clearance considered = 1mm

Area of two triangles (A_1) = $2\times(\frac{1}{2}\times b\times h)$
Where b = base, h= height
= $2\times(\frac{1}{2}\times26.67\times10.28)$

A=274.16 mm^2

Area of trapezium (A_2) = $h(\frac{a+b}{2})$
=7.71×($\frac{30+53.3}{2}$)
=321.12 mm^2

Total area = A_1+A_2
=274.16+321.12
=592.28 mm^2

The area considered is greater than the area required. So the idler selected is acceptable.
Mass of the carrying idlers = $\frac{9\times40}{1000}$ =0.36 kg
(No of carrying idlers =9, diameter of idler = 40mm)
Mass of return idlers = $\frac{9\times30}{1000}$ =0.27 kg
(No return idlers= 9; diameter of return idlers = 30mm)
Mass of pulleys = $\frac{(100)+(50\times2)}{1000}$ = 0.2 kg.
Total mass of rotating parts = (0.36+0.27+0.2) = 0.83kg.
Mass of the belt =0.1 kg
Mass of the material on the belt = (555×4000)/10^6.
= 2.22 kg.
Coefficient of friction = 3
Gravity = 9.81 m/s^2
Force =coefficient of friction× total mass× 9.81
= (3× (0.83+0.1+2.22) ×9.81) = 92.7 Nm
Power = force × velocity
=92.7×$\frac{1.25}{60}$ =1.93 watts.
(By considering 80% motor and gearbox efficiency)
Power required =$\frac{1.93}{0.8}$ = 2.41 watts.

VI. CONCLUSION

The swivel chute wagon loading system has many advantages like better accuracy, more uniform loading and the loading operation will be much faster. Because the mobile wagon will be moving and it consist of swivel chute which help in uniform filling of bulk material in to wagon. Previously as we are using fixed chute feeders and grab crane type loader those takes more time as compared to swivel chute wagon filler so the time taken to fill the wagon is reduced. We have achieved carrying capacity of 30 kg/hr with a belt speed of 1.25m/min. As we increase the dimensions of wagon loader the material carrying capacity increases gradually.

VII. ACKNOWLEDGEMENTS

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