Effect of Percent Trough Load on Horizontal Screw Conveyor

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***Abstract*—This Screw conveyors are widely used for transporting and / or elevating particulates at controlled and steady rates. They are used in many bulk material applications in industries commonly agriculture, chemicals, plastics, cement, food processing. They are also used for metering (measuring the flow rates) from storage bins and adding small controlled amount of trace materials or powder. Many studies on screw conveyors were conducted to examine the performance and to develop new types. The purpose of this paper is to study the effect of percent trough load upon the horizontal screw conveyor power requirement and also gives the idea about selection of conveyor speed and diameter of screw. After considering previous papers it is noticed that percent trough load is a one parameter which is not considered effectively and it is discussed in this paper by taking examples.**

***Index Terms*— Screw conveyor, trough load, horsepower**

I. INTRODUCTION

The screw conveyor is simplest and most efficient transport system for the bulk materials and is widely used in all fields of industry. A screw conveyor consists of a shaft mounted screw rotating in trough and a drive unit for running the shaft. The basic principle of material which is moved forward along the axis of trough is similar to the sliding motion of nut along a rotating screw when nut is allowed to rotate. The material is moved forward by the thrust of screw thread or flight [1].

As shown in figure1, a helical blade is attached to a drive shaft which is coupled to a drive unit. The shaft is supported by end and intermediate bearings. The U-shaped trough has a cover plate with opening for loading the conveyor. A discharge opening is provided at bottom of the trough. The loading and discharge point can be located anywhere along the trough.

The advantages of horizontal screw devices are reduced risks of environmental pollution, the transportation of material is protected from exterior contamination, flexibility of use, functional reliability, easy to install, easy to clean, can control very well the flow of free flowing materials.

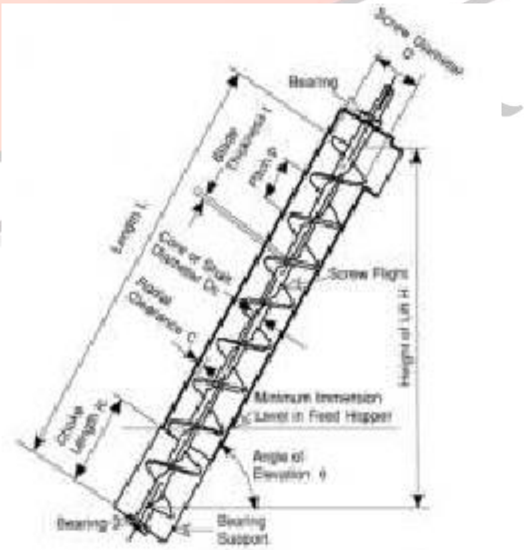

Figure 1: Enclosed screw or auger conveyor

Chang and Steele, (1997) investigated the performance characteristics of inlet section of a screw conveyor for two corn lots. Burr et al., (1998) designed and evaluated an auger with linear tapered inside diameter having a minimum flighting height for uniform rectangular cross-section containers [5]. Nicolai et al., (2004) determined the capacity, volumetric efficiency and power requirements for 20 cm and 25 cm diameter conveyor in transporting corn operating in a speed range of 250 to 1100 rpm and inclination angles of 13, 20 and 30 degrees. Moysey and Thompson (2005) developed a new 3-D model for studying the local phenomenon of solids flow within the screw channel. Maleki et al., (2006) evaluated the seed distribution uniformity of multi flight auger as a grain drill metering device. Dai and Grace (2008) developed a theoretical model for the torque requirement of a screw feeder by considering the bulk solid mechanics of a material element within a pocket. Asghariet et al., (2008) studied the effect of auger speed and air flow a discharge rate of bagasse. Justin W. Fernandee et al., (2009) gives the better design of screw feeders for specific materials by using discrete element method (DEM) to simulate the particle transport in horizontal screw feeder system

[2]. Philip J. Owen et al., (2009) study the screw performance under affecting factors mass flow rates, transport velocities for different angle of inclination by using discrete element method (DEM) and laboratory experiments [3].

Reviewing of the literature shows that there is no result concerning the screw conveyor performance evaluation in handling of corn germ and castor bean by considering percent trough load, power requirements of screw conveyors vary as a function of many parameters including screw rotational speed, auger diameter, angle of inclination, design of intake section, clearance between auger and housing, pitch auger flighting and type of material to be conveyed (Nicolai et al. 2006).

Hence the objective of this research is to check power requirements of screw conveyor by considering the percent trough loading in transportation of corn germ, castor bean and sugar. Percent trough loading is the percent of trough volume filled by material which is to be conveyed to the total trough volume available. Here we considered 15%, 30%, 45% and 95% of trough loading as shown in figure 2. The other considerations are taken into account as per requirement.

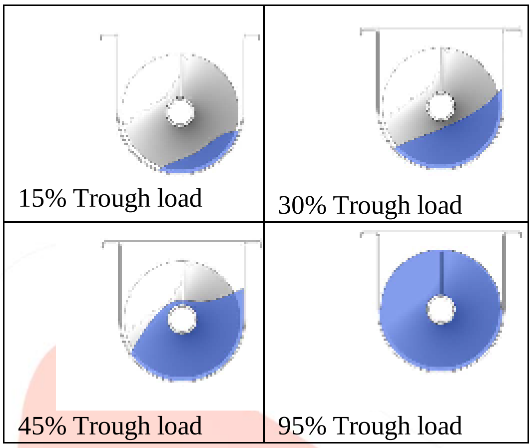

Figure 2: Percent Trough load

II. MATERIAL AND METHODS

The material used for studying screw conveyor performance in account of various affecting factor is corn germ, castor bean and sugar (refined, granulated, dry) whose density is 21, 38, 53 lbs per cubic foot respectively. Here we take the required capacity as 2000 cubic foot per hour for the conveying length of 48 foot. Here the flighting of screw is made from standard full pitch ribbon flights. Material used for hanger bearing is bronze. The drive type used here is double reduction shaft mount reducer with V-belts and sheaves. With this setup following procedure is followed.

The material is loaded from the hopper or inlet into the trough as per requirement. Here we considered, percentage loadings of trough are 15%, 30%, 45% and 95%. In reference of trough loading corresponding required speed diameter and total horsepower required are calculated and are shown in graphical form.

Required capacity is affected by various factors of screw which are special screw pitch capacity factor (CF_1), flight modification factor (CF_2) and mixing paddle capacity factor (CF_3). Therefore equivalent capacity is required.

$$\text{Equivalent capacity} = \text{Required capacity} \times CF_1 \times CF_2 \times CF_3$$

The diameter of conveyor would be selected from corresponding percentage loading to achieve the equivalent capacity within the recommended rpm range.

The horsepower required to operate a horizontal screw conveyor is based on proper installation, uniform and regular feed rate to the conveyor and other design criteria. The horsepower requirement is the total of the horsepower to overcome the friction (HP_f) of the conveyor components and horsepower to transport the material (HP_m) multiplied by the overload factor (F_o) and divided by the total drive efficiency (e).

$$HP_f = \frac{LNF_dF_b}{10^6}$$

$$HP_m = \frac{CLDF_mF_fF_p}{10^6}$$

$$(HP)_{total} = \frac{(HP_f + HP_m)F_o}{e}$$

Where, L (feet) is total length of conveyor, N is operating speed in rpm, C is capacity in cubic feet per hour, D is density of material as conveyed in (lb/cf), F_d is conveyor diameter HP factor which for diameters 9, 12, 18 and 30 is 31,55,135 and 360 respectively. F_b is hanger bearing HP factor with value 1.7. Material factor (F_m) is 0.8, 0.4 and 1.2 respectively, Flighting modification factor (F_f) is 1.14. Paddle HP factor (F_p) is 1.

III. RESULT AND DISCUSSION

As we discussed that the horsepower depends upon density, capacity and other factors. Since for bean, corn and sugar densities are different, the power calculation, diameters and capacity according to the capacity are discussed in graph form. If we keep same diameter to deliver required capacity for all types of percent loading then rpm required for screws goes on increasing. To deliver more capacity the screw has to be rotated fast as shown in figure 3.

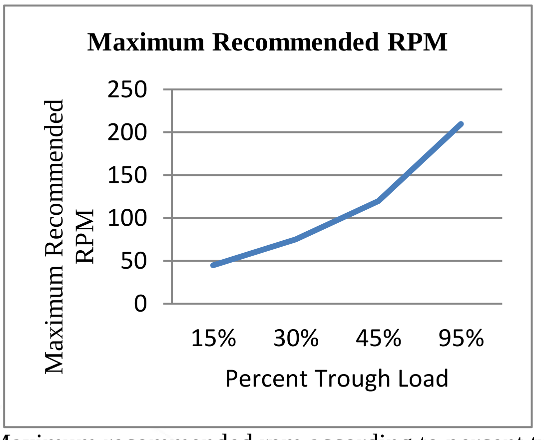

Figure 3: Maximum recommended rpm according to percent trough load

If we increase both diameter and screw rotations then horsepower required gets wasted or overall cost increases. Hence it is required to select proper diameter. For minimum trough loading the large diameter screws are used and it is handled at low speed. As shown in figure 4, the diameter size goes on reducing with increase in trough loading. If we keep same percent load for trough and the value of diameter is increased then we find that it delivers more capacity per rpm of screw as shown in figure 5.

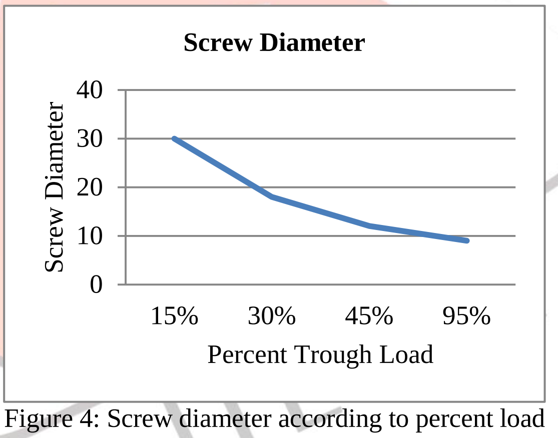

Figure 4: Screw diameter according to percent load

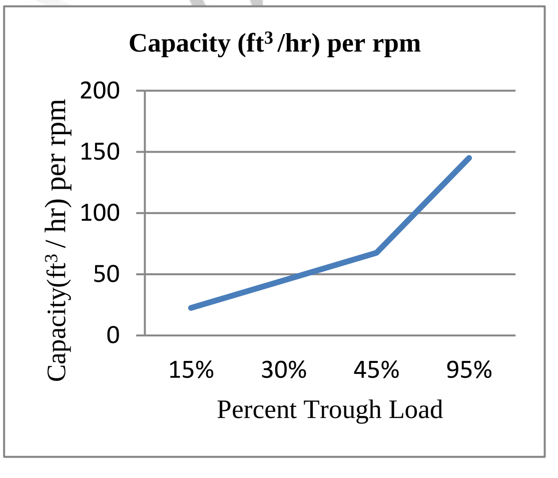

Figure 5: Capacity per rpm according to percent trough load

For standard screw conveyor by considering different diameters with corresponding rotations of screw, the minimum horsepower values are obtained for each type of percent loading for bean, corn and sugar which is shown in figure 6.

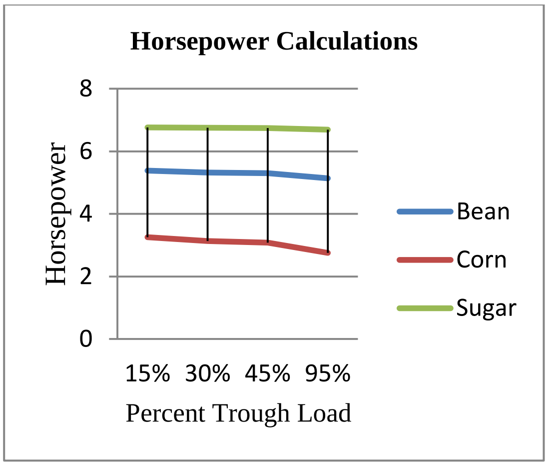

Figure 6: Horsepower calculations according to percent trough load

IV. Conclusion

(1) As percent trough load increases the value of diameter of screw required to deliver given capacity goes on reducing.
(2) For particular percent trough loading, as diameter screw increases the capacity for given rpm of screw increases.
(3) As percent trough load increases the maximum recommended rpm of screw goes on increasing.
(4) Trough load is decided on characteristics of material which is to be delivered.

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