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Design and Capacity Analysis In Selection of Vibrating Feeder

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Abstract

Vibrating feeder place an important role in bulk materials handling in cement plant, minerals plant and in many other industries to extract lumpy / pulverised materials from bin, hopper, mill discharge, etc to provide controlled material flow. By means of doing this project “Design and Capacity Analysis in Selection of Vibrating Feeder”, we can design and select the best suitable vibrating feeder for our application. Vibrating feeder vendors are providing the equipment with their standard amplitude which results in the selection of vibrating feeder with higher capacity than the required capacity. By means of reducing the amplitude based on the required capacity will end up with lesser power consumption and longer life time of the equipment since the load acting on the trough will be less for lesser amplitudes.

Keywords: Vibrating feeder, Capacity analysis, amplitude, Power consumption,

Introduction

The vibrating feeder is an efficient and reliable device which is used to convey and control the flow of materials. Fig. 1 shows the typical arrangement of a vibrating feeder. There are three types of vibrating feeder based on the construction. They are

- Trough vibrating feeder.
- Tubular vibrating feeder
- Vibrating grizzly feeder.

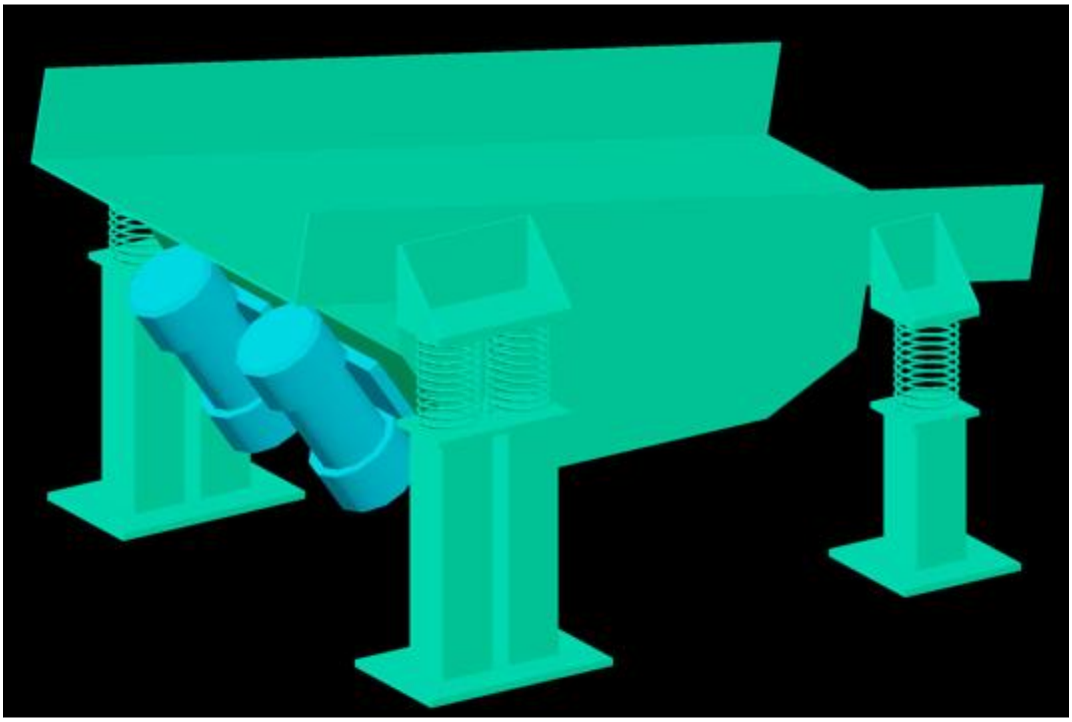

Figure 1: Vibrating Feeder

This paper deals with linear motion trough type vibrating feeder with electromechanical drive arrangement. Feeding by definition, means, “to supply ormaintain a flow of material.” Feeders are placed throughout a plant to maintain the flow of product coming into the next stage of the process. Vibrating, again by definition, means “to move back and forth rapidly.” The equipmentand process solutions described in this guide all use this rapid “back and forth” motion tomove or convey product. On a vibratory feeder, material is “thrown” up and forward sothat it drops to the surface at a point further down the tray. This is the feeder’s amplitude as shown in Fig 2.

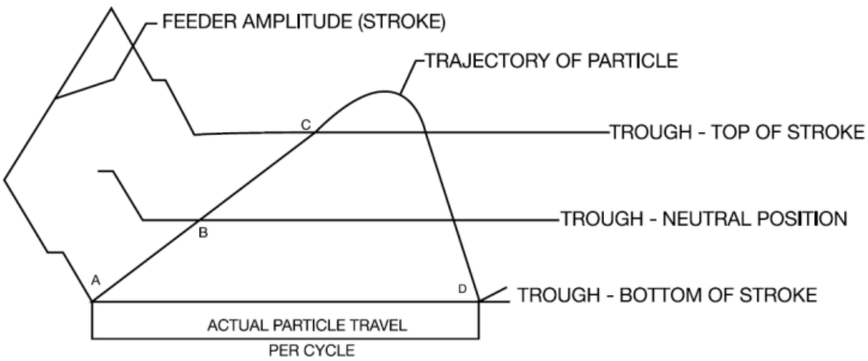

Figure 2: Material Flow on Trough

Vibrating feeders are designed to feed the materials at a controlled rate. They are normally located beneath a storage silo, reclaim tunnel or storage bin. The units are designed to withstand head load the material in hopper and can be equipped with rate controls to vary the output from minimum to 100% with reasonable linearity.

Application of Vibrating Feeders

Vibrating feeders have wide range of application in various industries, such as,

- Cement plants
- Mineral plants
- Power plants
- Food industry
- Pharmaceutical industry, Etc.,

Working Principle

The vibrating consists of three main elements. They are

- Carrying trough in which the material is transported.
- Drive system - An eccentric drive assembly which is the source of the controlled vibrating motion applied to the equipment.
- Support structure which mounts the conveyor in place and ties all of the other elements.

The trough is the only portion of the vibrating feeder that comes in contact with the material being transported. It can be fabricated in a variety of materials in almost any shape and size can be adapted to perform various processes while the material is in motion. Usually the support structure of the vibrating feeder design is simple by incorporating structural steel members. Is has to be designed based on the application the vibrating feeder.

Based on the excitation, we have to select the type of drive which is given below.

- Electromechanical drive
- Electromagnetic drive

The drive is the prime element of the vibrating feeder because it is the source of the controlled vibration. The vibration is isolated from the supporting structure through suitable isolation springs. The vibrating mass of a feeder is mounted to its base frame with springs. The springs provide non rigid support, making vibratory motion possible. The springs also serve as an important part of drive system. Springs are also used as dampening devices. They can be used to curtail large forces or absorb unwanted vibrations.

Feed Rate Controls

Variable feed rate of sub resonant is accomplished by varying either the operating speed of the AC motor or the magnitude of the force generated by rotating eccentric weights. A Variable Voltage Variable Frequency Drive (VVVFD) is used to control the feed rate as per the requirement. Normally the control range shall be 5:1, 10:1, and 20:1.

Effect of Amplitude Over Capacity

Amplitude is one the major design parameter of a vibrating feeder. If we increase the amplitude will results in the extraction of more material from the preceding equipment. Obviously, capacity will change when there is a change in amplitude. The normal operating range of amplitude for vibrating feeder is 1 to 12 mm with the frequency range of 13 to 60 hz.

Capacity Analysis

Vibrating feeder vendors are providing the equipment with their standard amplitude which results in the selection of vibrating feeder with higher capacity than the required capacity. By means of reducing the amplitude based on the required capacity will end up in the lesser power consumption and longer life time of the equipment. The below factors to be contended to determine the capacity of the vibrating feeder.

- Frequency
- Amplitude
- Stroke pattern
- Angle of inclination of the trough
- Material bulk density
- Material thickness
- Dampening effect of the material
- Internal friction of the material
- Sliding friction of material on trough

The capacity of a unit can be estimated using the following equation.

$Q = Wd\rho s / 4800$

Where

Q – Capacity of unit (tons/hr)

W – Trough width (in)

d – Depth of material (in)

ρ – Material bulk density (lb/ft^3)

s – Linear flow rate of material (ft/min)

Table 1 lists the conveying speeds and bed depths for some common materials. The values given in the table should be used as guideline.

Table 1: Typical characteristic of bulk solids on vibrating feeders

Material	**Approximate Size (mm)**	**Average bed depth (mm)**	**Average transport velocity (m/s)**
Alumina	0.15	75	0.15
Bagasse	0.25-5	150	0.4
Carbon black	1.5 (pelletized)	75	0.18
Cement clinker	6-10	125	0.36
Cereal	6-10	150	0.36
Coal	18-26	125	0.36
Crumb rubber	6	100	0.3
Detergent powder	0.15	75	0.25
Glass cullet	3-12	100	0.3
Gravel	6-10	125	0.33
Limestone	10-30	100	0.36
Milk powder	0.075	35	0.13
Plastic pellets	3-6	100	0.36
Sand-damp	0.8	100	0.4-0.45
Sand dry	0.8	75	0.25-0.3
Salt(table)	0.4-0.8	50	0.3
Steel shot	1.5-3	50	0.36
Steel turnings	6-12	100	0.28
Sugar (granulated)	0.5-0.8	60	0.25
Tobacco	Cut	250	0.36
Wood chips	10	250	0.4

Velocity

The velocity of the vibrating feeder shall be calculated by using the below equation.

$$V = 0.5\left[\frac{2\pi RPM}{60}\right] D * 10^{-3}$$

Where

V – Velocity of the vibrating feeder (m/s)

D – Amplitude (mm), For Example

D = 10mm (Amplitude 5mm)

RPM = 950

Material – Slag

$$V = 0.5\left[\frac{2\pi 950}{60}\right] 10 * 10^{-3}$$

V = 0.5 m/s

By means of doing the capacity analysis with different amplitudes with selected trough width results in lesser power consumption and longer life time of the vibrating feeder.

Structural Analysis of Trough

An uniform distribution load with respect to different amplitudes is applied on the trough of the vibrating feeder. Fig. 3 graph shows the difference in deflection on Y-axis based on the amplitude. But in practical, there will be only half of the deflection mentioned on the table since, almost half of the material will be in air while in vibration motion.

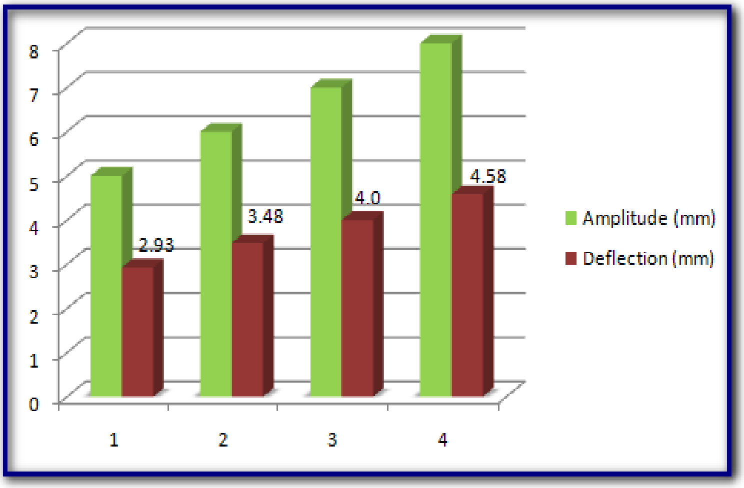

Figure 3: Difference In Deflection

The above deflection study was done for the case of a vibrating feeder for handling 500 t/h of slag material with the material bulk density of 0.97 t/m3 and the trough MOC considered was mild steel material with 8mm thickness.

Power Calculation

We have to do the power calculation of a vibrating feeder by two methods.

- Based on load. (Material weight + Tare weight)
- Based on the centrifugal force of the selected unbalanced motor.

Consider the below design parameters for power calculation

Capacity, Q	-	500 t/h
Trough width, W	-	1.200 m
Length of trough, L	-	2.250 m
Burden depth, D	-	0.220 m
Amplitude, A	-	5 mm
Bulk density, ρ	-	0.97 t/m^3
No. of vibrators	-	2
Structural weight of vibrating parts	-	300 kg

Method I

Total weight = Material weight + structural weight of vibrating parts (kg)

Material weight for power selection = WLDρ*1000
= 1.2 x 2.25 x 0.22 x 0.97 x 1000
= 576.18 kg
Therefore Total weight = 576.18 + 300 = 876.18 kg
Total static weight, Mt = Total weight * Amplitude (kg.mm)s
Mt = 876.18 x 5
Mt = 4380.9 kg.mm
Static moment of vibrator, Mv = Mt / No. of vibrators (kg.mm)
Mv = 4380.9 / 2
Mv = 2190 kg.mm
Power required for each motor, Watts

$$\text{Watts} = \left[\frac{2\pi N(Mv * \frac{9.81}{1000})}{60}\right]$$

Watts = [2 x π x 950 x (2190x9.81/1000)]/60
=2140 Watts
Power required for each vibrator = 2.14 kW

Method II
Centrifugal force of selected unbalanced motor, C = 34620 N

$$\text{Power required, W} = \frac{ACN}{(7800 * 9.81)}$$

Power required, W = 5 x 34620 x 950 / (7800 x 9.81)
= 2149 Watts
Power required = 2.15 kW

Computerised Program For Selection of Vibrating Feeder

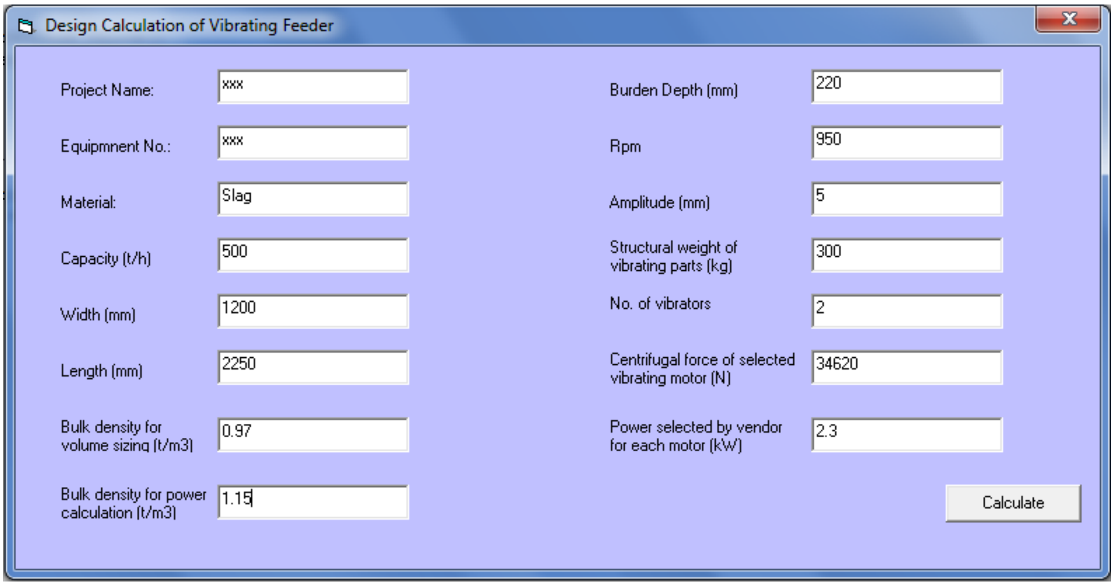

Figure 4: Selection Program For Vibrating Feeder – Input Sheet

This design calculation program of the vibrating feeder will be useful for us to check the design parameters of the vibrating feeder which are selected by the vendors. We have to enter the available inputs which we received from vendor as the input to the program as shown in Fig.4. Based on the given inputs, we can get the required output of design parameters enable to verify that the vibrating feeder selected by the vendor is suitable for our application or not. Fig. 5 shows the output sheet of the selection program. In this sheet we have to enter the values for the 'No. of vibrators' and 'Centrifugal force of selected vibrating motor'.

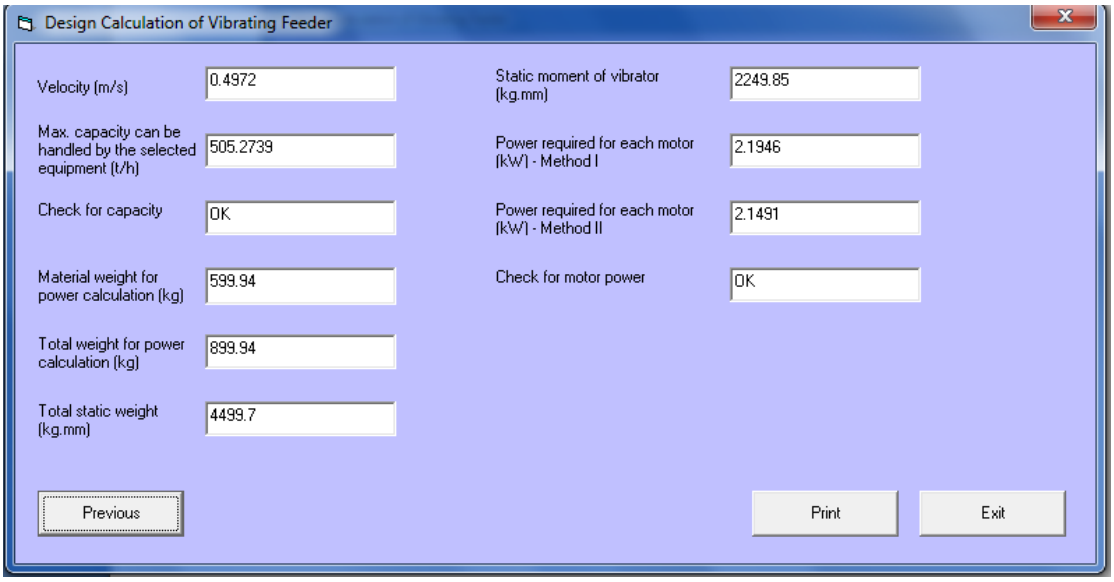

Figure 5: Selection program for vibrating feeder – Output sheet

Conclusion

For the above application, vendors use to select the amplitude as 6 to 8mm which will results in the higher absorbed power which leads to higher operational cost. By doing the above calculations we can conclude that the amplitude should be 5 mm for the selected application. We can select the best suitable vibrating feeder by means of the given calculations with different amplitudes.

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