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Design and Modification of Prototype Vibratory Conveyor Hopper

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Abstract:

Design and development of Vibratory Conveyor Hopper is done in this paper and it is design according to customer requirement and purpose of use. The performance of New Designed Hopper with vibrating conveyor was observed with various parameters like Bearing, Flywheel, Shaft, Belts etc. on this Prototype which can used as a Benchmark for the further research and development. The assembly of different parts has been done and the conveyor is tested for various loads, Torque, Stresses and Deformations. Also, the suitable diameters for bearings and Flywheels has been Calculated for this Specific Design.

Keywords — **Prototypes, Conveyor, Stress Concentration, Torque, Load, Stress.**

I. INTRODUCTION

High strength, cured, fiberglass reinforced plastic material was first introduced for use of vibratory conveyor springs in 1954. Since then, fiberglass springs have been used successfully in a wide range of vibratory conveyors, feeders and screening equipment, providing infinite fatigue life and corrosion free service [6].

These springs are made of 3M's Scotch ply brand reinforced plastic, a unique material in which the epoxy resins are reinforced with continuous, linearly aligned, non-woven filaments. This allows the plies to be laid up so that the reinforcement is oriented to the greater strength and stiffness in the direction in which it is most needed [1].

Now a day's Vibratory Conveyor are used widely so the Application point of view the Modification of Conveyor may led to the optimization of Cost and Compactness of the conveyor may help in the view of space and Mobility of the Machine. So, our approach is to optimize the Cost as well as Material used for conveyor by calculating some of the loads and critical diameters used in this conveyor [5].

A. Process of Prototyping

Prototyping is an attractive idea for complicated and large systems for which there is no manual process or existing system to help determine the requirements. The prototypes are usually not

Complete systems and many of the details are not built in the prototype. The goal is to provide a system with overall functionality. Fig. 1 shows the layout of prototyping [3].

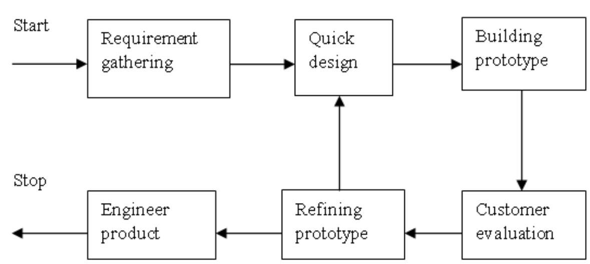

Fig. 1. Process of Prototyping

B. *Need For Prototyping*

1. Prototype model should be used when the desired system needs to have a lot of interaction with the end users.
2. Typically, online systems, web interfaces have a very high amount of interaction with end users, are best suited for prototype model. It might take a while for a system to be built that allows ease of use and needs minimal training for the end user [8].

II. DESIGN CALCULATION OF PROTOTYPE COMPONENTS

Design requirement:
Rotating speed of motor= 1440 rpm
Rotating speed at output= 290 to 310 rpm
Assuming 3 Hp induction motor= 2.23 KW
Service = 24 hour per day,
Material conveyer = Sugar

A. *Selection of Belt*

Correction factor (Fa) =1.4

1) Design power = Fa X Transmitted power
= 1.4 X 2.238
=3.1332 KW
2) From design data book cross section of belt selected is "**A**" section.
3) Pitch diameter of smaller and bigger pulley from reference is selected as

Smaller pulley diameter (d) = 85mm

$$\text{Speed ratio} = \frac{N1}{N2}$$
$$= \frac{1440}{290}$$

Speed ratio = 4.96
Larger pulley diameter (D) = (d) x Speed ratio
= 85 X 4.96
(D) = 422 mm ≈ 420 mm

4) Pitch length of belt (L_b) =

$$2C + (\frac{\pi}{2})(\frac{(D+d))+((D-d)^2)}{4C})$$

$$= 2 \text{ X } 600 + (\frac{\pi}{2} \ (420 + 85)) + (\frac{(420-85)^2}{(4 \text{ X } 600)})$$

= 2040 mm

$L_b \approx 2050$ mm

5) Correct centredistance:

$$(L_b) = 2C + (\frac{\pi}{2}((D + d))\left(\frac{(D-d)^2}{4C}\right)$$

$$2050 = 2C + (\frac{\pi}{2}(420 + 85)) + (\frac{(420-85)^2}{(4\,C)})$$

$$2050C = 2C^2 + 793.25C + 28056.25$$

$$2C^2 - 1256.75 + 28056.25 = 0$$

$$C = 605.19 \text{ mm} \approx 610 \text{ mm}$$

6) Correction factor for belt pitch length (Fc) from design data book = 1.04
7) Correction factor for arc of contact (F_d):

$$\alpha_S = 180 - \sin^{(-1)}(\frac{(D-d)}{2C})$$

$$\alpha_S = 180 - \sin^{(-1)}(\frac{(420-85)}{2*\mathbf{610}})$$

$$\alpha_S = 164.06 \approx 163°$$

Correction factor for arc of contact (F_d) = 0.96

8) Power rating of single v-belt:

$$P_{r=} 1.17 + 0.17$$

9) No of belts required:

$$\text{No of belt required} = \frac{(P \text{ X } F_d)}{P_{r*} F_c \, F_d}$$

$$= \frac{\mathbf{2.236\ X\ 0.96}}{\mathbf{1.34\ X\ 1.04\ X\ 0.96}}$$

$$= 1.60 \approx 2 \text{ belts}$$

B. *Design of Flywheel Assumptions*

Material = FG260
Motor power = 2.236kw, Stroke = 30mm,
Speed ratio = 4.96
Max fluctuation of Speed = 280 to 300 rpm
Width of Flywheel (b) = 2 x Depth of Flywheel (t)

1) Coefficient of Fluctuation Calculation (Cs): The difference between maximum fluctuations of speed to mean speed is called coefficient of fluctuation of speed (Cs).
W_{max}= Maximum speed during cycle
W_{min} = Minimum speed during cycle
W_{mean}= Mean speed
= $(W_{max} + W_{min})/2$
Assume Cs =0.0350
2) Mass Moment of Interia (I) Calculation: Kinetic energy of system (Ke) calculation:
Work done, W = 6000 X 0.030 X 0.15
= 27 N-m
Thus, energy absorbed is 27 N-m

Work done per cycle = 2π X 27X 4.96
= 841.44 N-m

Ke = W – (WC X 0.08)
= 841.44 – (27 X 0.08)
= 839.28 N-m
Therefore, mass moment of inertia is
I = Ke / (Cs X $Wmean^2$)
= 839.28/ (0.0350 X 295^2)
I = 0.27 $Kg.m^2$

For flywheel rim, [4]
Mass moment of inertia (Ir)
= C X I
= 0.9 X 0.27
= 0. 24$Kg.m^2$
We know that,
Ir = Mr X Rm^2
= $(2\pi\ R_m X\ b\ Xt) X R_{m^2} X \rho)$
$0.243 = (2\pi\ X\ 0.210\ X\ 2\ X\ t^2) X 0.2102\ X\ 7200$
t = 17 mm ≈ 20 mm
Therefore, b =2t
b = 2 x 20
b = 40 mm

C. *Design of Shaft*

Material for shaft = EN 8
Material property:
Syt = 465 N/mm^2
Sut = 700 N/mm^2
K_b= Combined shock and fatigue factor applied to bending moment = 2.0
K_t= Combined shock and fatigue factor applied torsional moment = 1.5
Coefficient of friction (μ) = 0.30

Design of shaft on strength basis [2]
According to ASME code
τ_{max}=0.30 Syt
= 0.30 X 465
= 139.5 N/mm^2
τ_{max}=0.18 Sut
= 0.18 X 700
τ_{max}= 126 N/mm^2
Select whichever is minimum. If keyways are present reduce above value 25 per cent.
τ_{max}= 0.75 X 126
τ_{max}= 94.5 N/mm^2

Torque developed by motor:
$$P = \frac{2\pi NT}{60}$$
$$2236 = \frac{(2\pi\ X\ 1440\ X\ T)}{60}$$
T= 14.82 Nm
Torque transferred to flywheel is:
T_f = T X velocity ratio
T_f= 14.82 x 4.96
T_f= 73.50 Nm

Load acting on flywheel arc are:
$T_f = (T_1 - T_2)\ X\ R_f$
$73.50 = (T_1 - T_2)\ X\ 0.210$
(T1- T2) = 350 N
$$\left(\frac{T1}{T2}\right) = e^{(\mu\ x\ \theta)}$$
$$\left(\frac{T1}{T2}\right) = e^{(0.30\ x\ 2.66)}$$
$$\left(\frac{T1}{T2}\right) = 2.22$$
Solving this equation, we get,
T1 = 636.31 N
T2 = 289.39 N
Design of shaft for fatigue loading: [10]
$$S_e = 0.5 \times S_{ut}$$
= (0.5×700)
=350$\frac{N}{mm^2}$ for S_{ut}
(1400 MPa)
$$S_e = K_a K_b K_c K_d S_e$$
S_e= Endurance Strength in N/mm^2
K_a= Surface finish factor
K_b= Size factor
K_c= Reliability factor
$K_a = 0.77$
a= 272 & b= -0.995 as shaft is forged.
$K_b = 0.85; \quad 7.5 < d \leq 50$
$K_c = 1$;
$$K_d = \frac{1}{K_f}$$
$$K_f = 1 + q(K_t - 1)$$
q= Notch sensitivity factor = 0.55
K_t= Stress concentration factor = 2
$$K_f = 1.55$$
$$K_d = \frac{1}{K_f} = 0.716$$

$$S_e = K_a K_b K_c K_d S_e$$
$$= 0.77 \times 0.85 \times 0.897 \times 0.716 \times 350$$
$$= 77 \frac{N}{mm^2}$$
$$\left(\frac{32\, Mb_{max}}{\pi\, ds^3}\right) = \left(\frac{S_e}{f_s}\right)$$
$$(32 \text{ X } 29700/\pi d_s^{\ 3}) = (77/2)$$

$d_s = 33.33\text{mm}$
$d_s \approx 50\text{mm}$

D. Selection of Bearing

Pedestal bearing = 2211 k, H- 311 double row self-aligning ball bearing [7].
At the centre of shaft = 22218 k, H318 double row spherical roller bearing

TABLE I
Table for Prototype Calculation Results

Sr. No.	Parameter	Value
1	Belt design power	3.13kw
2	Belt cross section	A-Type
3	Smaller pulley diameter	85mm
4	Larger pulley diameter	420mm
5	Belt pitch length	2050mm
6	centre distance	610mm
7	No of belts	2nos
8	Mass moment of inertia	0.27kg.m^2
9	Self-align ball bearing	2211K,H311
10	Spherical roller bearing	22218K,H318
11	Shaft diameter	50mm

III. MANUFACTURING OF PROTOTYPE

Manufacturing is the production of useful components using labour, machine tools. We built prototype in which raw material is transformed into finished good. To build this prototype we manufactured some components in company like eccentric shaft, flywheel etc. Also some components brought out from outside such as bearings, belt etc. [9].

Fig. 1Eccentric Shaft

Fig. 2 Basement Frame

Fig. 3 Cover plates for Attachment

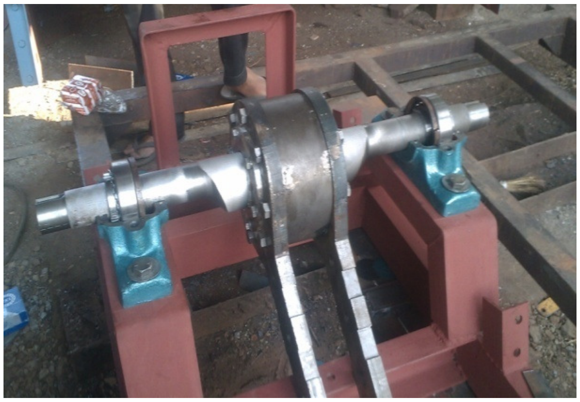

Fig.4Assembly of Parts

IV. CONCLUSIONS

A prototype was built on the basis of measurements taken from actual hopper system so as to carry out different tests on the prototype which are required to be conducted on the actual system such as alignment test. Alignment test was proved positive which eliminates various other problems like lateral motion of hopper, failure of main bearings.

Alignment Test performed on Prototype shows better stability of the vibrating conveyor, when material used as supporting element of different material.

Due to some inherent properties of Composite material, it has a capability to store certain amount of energy which is released and stored repetitively during the cycle of operation. This reduced the power consumption of the system allowing us to a motor with lower capacity.

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