EXPERIMENTAL ANALYSIS OF WOODEN PLANKS USED IN VIBRATORY CONVEYOR

Raju N Patil[1], C. S. Wadageri[2], Ashok M. Hulgabali[3]

[1]*M Tech (2nd year), Machine Design, MMEC, Karnataka, India*
[2]*Assistant Prof. (H.O.D.), Mechanical Engineering Department, MMEC, Karnataka, India*
[3]*Assistant Prof. Mechanical Engineering Department, MMEC, Karnataka, India*

Abstract

Vibratory conveyors are utilized to convey a large variety of material limiting from dry powders to large solid piece of material throw forcefully etc. The conveyors are utilized for segregating drying, cooling etc. The major component of vibratory conveyor is designed exact, accurately and carefully, so that it won't affect its operational process. Design of encouraging device is main aspect like wooden planks in this case. If encouraging device is not designed accurately then it will fail to operate critical operations in the system. Therefore encouraging device requires to be designed for large strength, good fatigue properties and for most likely to lead to a favorable outcome difficult to turn. In the project work brief failure analysis of currently used supporting member is done. Wood plastic planks are used to a large degree in wood plastic pallets. It is needed to examine and alter text, the trustworthy and reliable of wood plastic planks utilized in the surfaces of pallets. Able to rely on study of materials and sources in order to establish fact mainly has concentrated on metals; ceramics and wood products .wood plastic have sizing or scaling usage and degree of importance for their important advantages in keeping surrounding safe, reusing and profitable factor. In similarity to wood, they are assumed to be isotropic, withstanding to climate, dimension remains constant, hard, wear withstanding and many other advantage and they are able to prove that they are best suited for wood processing methods and have large profitable advantages. First aim was to look out why we use pine wood for helping vibratory conveyor that too with combination of two wooden planks and one steel plank made sandwiched in between them. After studying a brief about pine wood properties it shows following advantages [1].

Key Words: *Wooden Planks, Vibrating Conveyor, Composite Material.*

---***---

1. INTRODUCTION

Conveyor systems permit very quick and working well with no waste of effort in transportation for a large variety of materials, which make them famous in the sugar industry and packaging industries. Many kinds of conveying systems are there and are utilized as per the various requirements of different industries such as sugar industry [2]. Sugar Industry in India is well maintained and is growing at a steady pace. India is the second largest producer of sugar cane over the globe. With more than 45 million of sugar cane growers in the country, the village people in India mostly depends on the sugar industry.

1.1 Principle of Vibratory Conveyor

The vibrating conveyor has lengthy a long narrow open container supported by movable joint legs from base member, as a parallelogram arrangement. The arrangement remains stable by spring supports added to it. The steel long narrow open container is moved by crank mechanism throw, and according to its amplitude of motion (vibration) has fixed value with respect to speed [3]. The crank mechanism direction of action is set in such a way that it will results into forward as well as upward stroke for long narrow open container, for material movement [4].The requirement of wooden planks is to provide extra help and support as well as to store gravitational energy during downward movement, and to allow free to move it during upward stroke against gravity, and thereby smaller drive and profitable conveyor.

1.2 Modeling of Vibratory Conveyor

Fig -1.1: Model of Vibratory Conveyor

To understand the faults or defects in the system, we require to understand its operations, function of each and every parts of the conveyor. After studying about the conveyor, we have drawn a CATIA model of vibrating conveyor and other Major components of conveyor.

The modeling of different components of vibratory conveyor system is done by using existing values the modeling of major component has been done by using 3D modeling software, CATIA V5 R 19.

2. BENDING TEST AND STIFFNESS MEASUREMENT OF WOODEN PLANK

Among two methods to find out stiffness of wooden plank
1) one is by experimentally and
2) by fundamental equations.

We found out the stiffness of wooden plank experimentally. By applying different weights at one end of the wooden plank, measure the deflection at particular weights as shown in figure 2.1

Fig -2.1: Stiffness Measurement of Wooden Plank Assembly

Measurement conditions:

Weight =8.6 kg

Deflection =0.023 m

Stiffness = (load/deflection)

Stiffness of element =3668.08 N/m

2.1 Three Point Bend Test

The width (w) and height (h) of wood samples are measured, and the specimens are placed in a three-point bend testing apparatus with the height of the wood oriented vertically in the apparatus. The distance (L) between the two supports is also measured. The deflection at the middle of the beam, as a function of load on the pan of the apparatus, is measured to calculate the stiffness. To achieve this, the mass on the pan is increased stepwise in 25.kg increment to prevent permanent deformation of wooden plank.

Bending test is carried out on standard wooden plank specimen used in vibratory conveyor at different loads. By using three point symmetric bending test, we can find deflection of beam [5].

$$\delta = \left(\frac{mgL^3}{48EI}\right) \qquad (2.1)$$

The Young's modulus for sample is calculated

$$E = \left(\frac{gL^3}{48I}\right)\left(\frac{m}{\delta}\right) \qquad (2.2)$$

Table -2.1: Bending Test Result

SR NO	Load(N)	Deflection (mm)	Stiffness (N/mm)
1	200	3.33	39.04
2	450	9.87	46.39
3	650	14.56	42.11
4	900	18	48.31
5	1125	27	37.18
6	1285	34	31.64

From the table 2.1 gives a stiffness of wooden plank assembly. That is almost equal to the stiffness calculated by applying different size of weight at one end of wooden plank assembly. We also plotted a load v/s deflection graph. From fig 2.2 show that as load increases deflection of wooden plank also increases linearly up to certain load value. After increasing load further brittle type failure occurs without any warring.

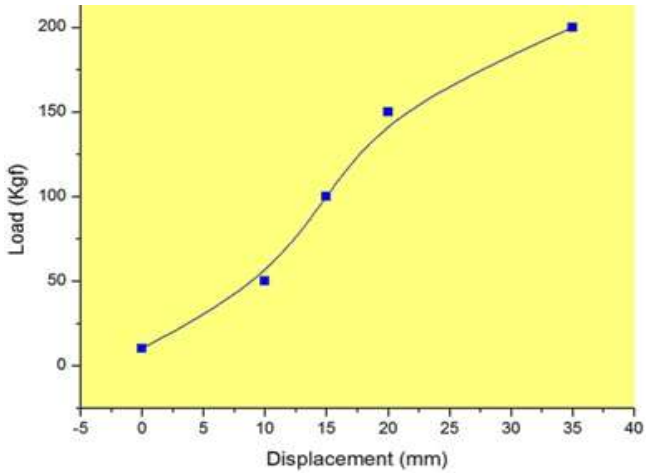

Fig - 2.2: Load v/s Deflection Graph

2.2 Analytical Stress Calculation In Wooden Plank Assembly

In wooden plank assembly different types of stress developed during static and dynamic condition. We can find out this stress value by using fundamental equations.
Force Calculation
Data:
Standard size of hopper =10m X 2m
Drive = belt drive
No of wooden planks=38
Motor power =15 HP
Motor rpm=1440rpm
Radius of shaft =78mm
Eccentricity =12mm

2.3 Calculations of Torque

The relationship between power and torque transmitted is given by the equation:

$$P = T \times \omega \qquad (2.3)$$

$$P = \frac{2\pi NT}{60} = \frac{(P \times 60)}{(2 \times \pi)} \text{ N} - \text{m}$$

T= 11.19*1000*60/(2π*280)

T= 381.63 N-m

F = 4892.70 N

Total no wooden planks =38

In static condition

Load shared by per plank is = (Total load/No. of planks)

= 3600/38

= 94.73kg

Load shared by per plank is = 929.36 N

In dynamic condition

Force transmitted to single plank = (total force transmitted /no of planks)

=4892.70/38

Force transmitted to single plank =128.75 N

2.4 Stresses in Wooden Plank Assembly

- **Buckling Stress (σ_s)** = (F/A)

$F_b = \pi 2 \; E \; I \,/\, (Le)^2$ (3.4)

$F_b = \pi 2 \times 2 \text{x} 105 \text{x} 4254.99 / (2 \text{x} 435)^2$

F_b = 7064.31N

Where A = Total area of cross section

A = {(65x2) +2 x (4.75x10)}

A = 225 mm^2

- **Bending Stress (σ):**

We have σ = (M x y) / I

Bending moment = force applied x length

= 128.75 x 435

M = 56006.25 N-mm

y = 11 mm

I = 4254.99 mm^4

Therefore σ = (M x y) / I

σ = (56006.25 x 11) / 4254.99

σ = 144.78 N/mm^2

2.5. FFT spectrum for 10m X 2m Hopper

The Fast Fourier transform (FFT) is an algorithm required to compute the discrete Fourier transform.

Also the Fourier analysis converts time to frequency and vice versa; an FFT rapidly computes such transformations by factorizing the DFT matrix into a product of sparse (mostly zero) factors. As a result, fast Fourier transforms are widely used for many applications in engineering, science, and mathematics. We have performed vibration analysis on 2m width hopper in which an accelerometer was attached at the end of the wooden plank to measure the displacement, velocity and acceleration due to vibration. Accelerometer converted the mechanical motion signal into the electrical signal which was fed to the FFT analyzer.

ISO 2372 (10816) Standards provide guidance for evaluating vibration severity in machines operating in the 10 to 200 Hz (600 to 12,000 RPM) frequency range. Graph was Plotted Frequency against Amplitude and Magnitude.

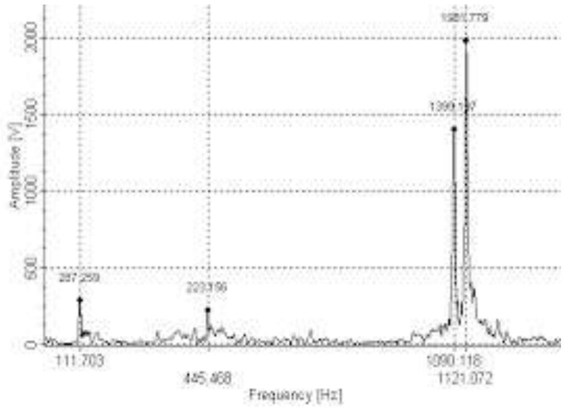

Fig -2.3 Frequency vs. Amplitude

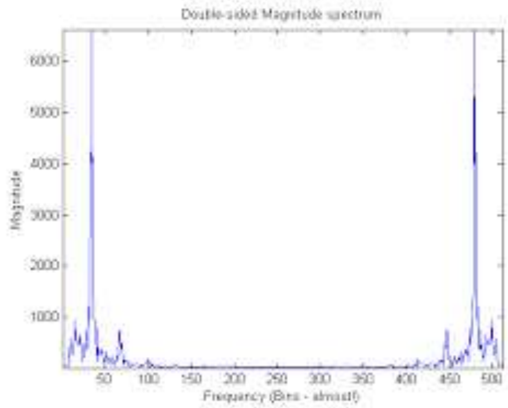

Fig -2.4 Frequency vs. Magnitude

We have done measurement of vibrations at the end of wooden plank assembly and at the middle section of wooden plank assembly of hopper. Our main aim was to find out behavior of supporting device during working condition. For that we have measured velocity and phase angle between wooden planks as shown in Table 2.2. When load is increased on hopper middle section of wooden strips moves outward and creates mode shape which develops uneven vibration in the wooden plank assembly. Wooden strips moves in outward direction, creates convex shapes. If angle between these wooden strips is out of phase, then generation of mode shapes due these strips develops uneven stress in the plank assembly.

Table -2.2: Velocity and Phase Angle at Middle Section of Plank

Location	Velocity (mm/s)	Phase angle
1	173	60◦
2	181	240◦

For measurement of velocity and phase angle accelerometer was connected to the wooden strip at the middle location. Velocity and phase angle were measured for two different locations, the result of which are shown in above table 2.2.

The detailed study of above results depicts that there are no serious issues present in the system at the end points of the wooden planks which will cause it to fail prematurely, since the acceleration, velocity and displacement graphs do not have any kind of variance. But the phase angle measurement results show serious issue.

2.6 Dynamic Response Analysis of Wooden Plank

To know the main reason why the system fails continuously, another approach was proposed. The operation of the system was studied throughout the cycle and, we found that the occurrence of the wooden plank failure because of the uneven stress being applied on the wooden planks because of different mode shapes of the steel and wood material during running condition of hopper. This happens since both the materials have different properties. The vibratory motion causes the wooden plank and steel plate to vibrate along with the system which thus generates the vibration in the plank which sets mode shapes in the plank. While wooden plank and steel plate vibrates and mode shapes were observed in both as shown in the figures 2.6.

Dynamic response analysis is study of actual behavior of wooden plank assembly during working condition. From fig 2.6 it can be seen that whenever hopper is running in sugar factory, load acting on hopper and dynamic forces creates mode shapes in wooden plank assembly.

Fig- 2.6: Mode shapes in steel plate

Practical analysis of the wooden plank system along with the therotical evidences leads to the conclusion that the reason of failure of wooden plank could be because of the knot present in the material, fibre orientation or different material properties as well as because of the various operating conditions which do not favour the normal operation supporting the original properties. In our case, we have observed the failure of the wooden plank because of different mode shapes in two different materials causing uneven stress creation which leads to the fracture in the wooden plank due to fatigue.

3. CONCLUSIONS

Among all the mentioned causes of failure most prominent type of failure is the failure due to continuous fatigue observed mostly at the connection point. This failure further leads to the increase in the lead time and the tact time of the system. Another fact worth noting is that, whenever a wooden plank fails, operators replace the failed piece with another wooden plank which is observed to be of poor quality while it is supposed to be belonging to the family of pine wood. This also promotes the failure of plank as local wood does not possess all the necessary properties required for the application.

It is also observed that whenever a plank fails, the load distribution varies indefinitely among all other wooden planks; Thus causing localized stresses which further leads to the failure of other planks. This causes alignment problems, bearing failure due to uneven stresses..

REFERENCES

[1] Strength and St Properties of the Lithuanian Grown Scots Pine (Pinus Sylvestris): Non-Destructive Testing Methods Vs. Static Bending. A. Baltrušaitis, S. Mišeikytė Kaunas University Of Technology, Department Of Mechanical Wood Technology Kaunas, Lithuania.Wood Research 56(2):2011,157-168.

[2] “Methods of Measuring Stiffness of Young trees” Holz Roh Werkst, ARTICLE in HOLZ ALS ROH- UND WERKSTOFF · JUNE 2002. Impact Factor: 1.24 · DOI: 10.1007/s00107-002-0292-2

[3] Ch. Viswarupachari, Anirvan Dasgupta, and S.Pratik Khastgir, “ Vibration induced directed transport of particles ”. OCTOBER 2012, Vol. 134 / 051005-1.

[4] M. A. Parameswaran and S. Ganapathy, “Vibratory conveying-analysis and design: A review”. Received 8 July 1977; in revised form 1 May 1978.

[5] G .L. Hinueber, “Reinforced plastic springs for vibratory conveyors”.

BIOGRAPHIES

M Tech (2nd Year) persuing in Machine Design, Area of interest are Mechanics of machines, Material Science and Metallurgy, Mechanical Vibration

M.Tech (Phd) Teaching Experience of 18 year, Industrial Experience of 2 year. Area of Interest are Thermal, Composites, OR, manufacturing processes, EME.

M.Tech (Phd), Teaching Experience of 13 year. Area of interest are Mechanical Vibration, Machine Design, Composites, FEM, MOM, Control Engg.