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FINITE ELEMENT ANALYSIS OF WOODEN PLANK USED IN VIBRATORY CONVEYOR FOR SUGAR INDUSTRY

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Abstract - ***In the process of sugar manufacturing, we use vibrating conveyor for sorting a sugar lump from sugar flow. Wood strips are used to support the system and transmitting a motion to conveyor. During this process strips (planks) are subjected to cyclic loading, resulting in a failure of strips after certain no of load cycles. It also increases power consumption and breakdown time. Failure of material under cyclic or fluctuating loading condition is known as fatigue failure. Fatigue, or metal fatigue, is the failure of a component as a result of cyclic stress. The failure occurs in three phases: crack initiation, crack propagation, and catastrophic overload failure. The duration of each of these three phases depends on many factors such as stress concentration, raw material characteristics, magnitude and orientation of applied stresses, manufacturing process etc. Fatigue failures often result from applied stress levels significantly below those necessary to cause static failure [1]. The study of stress analysis is done by using ANSYS 14.5 software. In these chapter by using FEA (finite element analysis) method stress and frequency is calculated. Structural analysis of wooden plank is carried in workbench to find stress in wooden plank and model analysis for finding mode shapes at different frequencies to avoid resonance problem.***

Key Words: *Structural analysis, FEA, wooden plank, Modal Analysis, Stress.*

1. INTRODUCTION

Clear straight-grained wood is used for determining fundamental mechanical properties; however, because of natural growth characteristics of trees, wood products vary in specific gravity, may contain cross grain, or may have knots and localized slope of grain. Natural defects such as pitch pockets may occur as a result of biological or climatic elements influencing the living tree. These wood characteristics must be taken into account in assessing actual properties or estimating actual performance of wood products [2]

Fig. 1.1: Existing Vibratory Conveyor with Wooden Planks

Failures of wooden planks occur with a frequency of 15 to 20 days, with most failure occurring at a point as shown in figure 1-1. Failure of wooden planks creates other problem in vibratory conveyor such as alignment problem, failure of connecting rod and bolts.

1.1 Failure of wooden plank due to Tension

Almost pure longitudinal tension occurs in the pulled members of the wooden plank. Wooden planks are solicited by tension and bending due to force transmitted by drive. The failure to longitudinal tension should lead to a progressive rupture of the fibers, not necessarily positioned in the same transversal section, at an accelerated pace because the section gets smaller and smaller [3]. But it is very difficult indeed to take hold of the extremities of the member in a totally efficient way and what generally happens is that the material gives way at the abutment of the joint and the tension vanishes.

A quite specific failure mode is to be considered, which, is the longitudinal break of the extremity of a member where a pin or nail is inserted. The wood divides along the fibers, in other words it splits, and the holding device slides along the borders of the split thus allowing the tension to release as shown in figure 1.2.

Fig-1.2: Failure Cause by Tension in Wooden Plank Assembly

1.2 Failure due to Bending

Predominantly, breaks of the members are caused by bending moments. After the first phase of deformation, the break generally occurs to tension at the intrados caused by the presence of knots and possibly other defects or damages (made by fungi, wrong working etc.). When the tensions induced by loading are bigger than the rupture strength to compression but, at the same time, lower than to tension, it is constituted by a first phase of bulging and longitudinal cracking of the compressed regions at the extrados followed by the increase of the tensile strain and consequently the crack at the intrados due to tension as shown in figure 1.3.

Fig-1.3: Wooden Plank-Before and After Failure

1.3 Failure of the Connection

Amongst the main causes of discontinuity of the joints we caught to remember the effects of swelling and shrinkage produced by the fluctuations of temperature and humidity, the ageing of the adhesives, the defects and the biotic damage of the wood, the corrosion of the metallic fastenings, the inadequacies of the design and occasional factors. At the more general level, the effects are reduction of the abutment surfaces and consequent concentration of the stresses on small areas, eccentricity of the stresses, widening of the encasement with occurrence of clearances as shown in figure 1.4.

Irregularities of the grain of one ruler ending in one joint turns to be very dangerous for the life of the connection because the affected member, when in place and solicited, is soon twisted by torsion with the consequence of tensions acting not along the main axis but in a different direction, to which the joint is not suitable and wood less strong.

Fig- 1.4: Crack Prorogated near Discontinuity of Wood Plank

2. INTRODUCTION TO STRUCTURAL ANALYSIS

Structural analysis is the determination of the effects of the loads on the physical structures and their components. Structures subjected to this type of analysis must withstand loads, pressures, torques and moments like parameters which act on them.

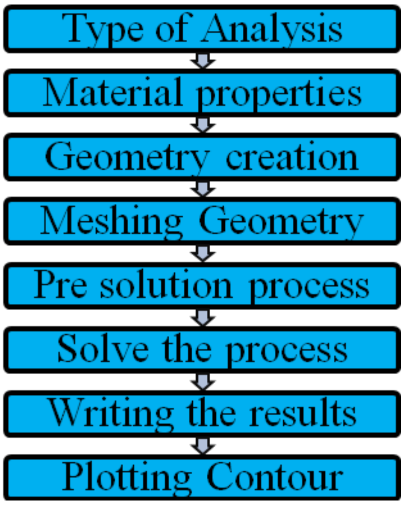

Fig-2.1: Process of FEM

Structural analysis incorporates the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. Structural analysis is performed to obtain the response of a structure under applied static loads, displacements, reaction forces, stresses, and strains [4]. Fig 2.1 shows process of FEA carried out in workbench 14.5.

2.1 Structural Analysis of wooden plank

Pre-Processing:- As far as pre-processing is concerned, it is the step in which required engineering data is provided to the solver i.e. ANSYS Workbench. In this analysis, the data given as input is, materials for wooden plank assembly are wood and mild steel.

Properties of Steel:- Material Density for steel =7860 kg/m^3, Modulus of Elasticity=2.1x10^{5}Mpa, Poisson's Ratio=0.372, Ultimate Tensile Strength=320 MPa.

Properties of Pine Wood:- Material Density for pine wood at 12% moisture =515 kg/m^3, Modulus of Elasticity=1.1x10^{4}Mpa, Poisson's Ratio (μLR) =0.347, Ultimate Tensile Strength=3200 KPa. Ultimate compressive Strength =41900Kpa.

Boundary Condition:- All fasteners areas on wooden plank bolts (studs) are fixed (DOF restricted) and applied driving force per plank = 136.05 N. After applying these boundary conditions, the solver is allowed to solve the Current problem.

Meshing:- For meshing, Tetrahedron element is chosen as wooden plank has complex geometry in the form of curvature. Also, for better accuracy sizing is selected as proximity and curvature. Meshing is selected as fine mesh as shown in figure 2.2.

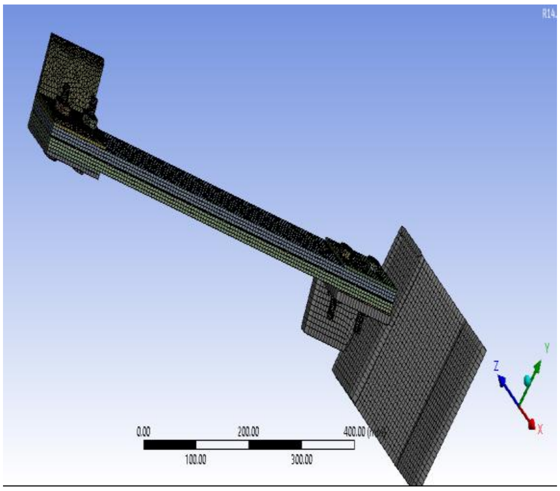

Fig-2.2: Meshing In Wooden Plank Assembly

Structural analysis shown in fig 2.3 shows maximum stress developed in the wooden plank assembly. The maximum stress value found is within the safe limit. We can see the location of maximum stress developed in wooden plank at the end connection of plank. So there could more chances of failure occurred in that location [5].

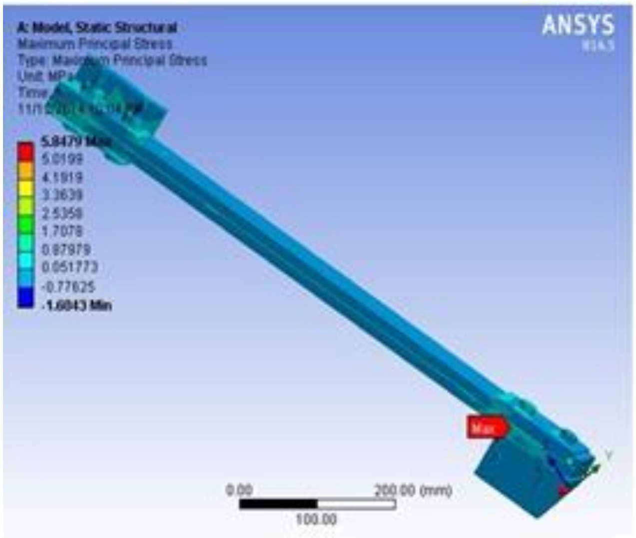

Fig-2.3: Maximum Principal Stress in Wooden Plank

2.2 Modal Analysis

Determines natural frequencies of a system (free vibration), including the effects of loading on a pre-stressed structure. We performed modal analysis on wooden plank in workbench 14.5. Table 2.1 shows different frequency which is nothing but modal frequencies of wooden plank.

Table 2.1: Modal analysis results

Mode	Frequency [Hz]
1.	97.084
2.	145.68
3.	502.91
4.	651.01
5.	984.12
6.	1525.8

3. CONCLUSIONS

FEA analysis of the wooden plank shows that forces and stresses acting on the plank at various points lie within permissible limits. So it is now clear that the failure is not occurring because of the system developed forces. Another approach of modal analysis of the wooden plank showed similar kind of positive results supporting our conclusion. The difference between the modal frequencies of the plank and the actual system operating frequency is very large. Thus, there are very less chances of resonance to occur. So the possibility of failure because of resonance vanishes.

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