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Research Article

Structural Investigation of the Tapered Conveyor Shaft of the Small Scale Pineapple Juice Extraction Machine

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Abstract: In order to avoid easy failure of the screw conveyor, this article obtained part analysis based on load distribution under working conditions and gained equivalent stress and deformation under several load conditions by using **ANSYS** Workbench 14.0 platform to check the strength of worm conveyor shaft. The material selection was done using Granta CES Edupack, 2011. From the analysis, the maximum equivalent von mises stress was found to be $5.9372*10^7$Pa and total deformation was found to be $8.53*10^{-4}$m. The method and results from this study can provide reference for the design and improvement of screw tapered conveyor.
Keywords: Investigation, Tapered Conveyor & Juice Extraction.

INTRODUCTION

Engineering materials behave differently under the influence of applied load such as static load, quasi-static load, and dynamic load. The conveyor was designed not only to convey sliced pineapple but to also squeeze the juice out from the pineapple. As it is conveyed and squeezed, the weight of the pineapple, the force from the rotating shaft speed of the electric motor caused some stress concentration which may result to failure or deformation on the blades and the shaft. Wear occur as a result of pineapple to shaft contact. Durability of an engineering part is enhanced by good selection of material, proper design, and production. Failure if occur will causes production loss, running or maintenance cost increase and delays. Their behaviour is dependent on a number of factors such as strength, toughness, corrosion resistance. Tapered end screw conveyor is one of the most important parts of the pineapple juice extraction machine. It is necessary to make a research on it to improve the design, improve on the efficiency; hence, finite element analysis Software was employed to run simulation on the tapered conveyor. This was to ensure high and optimal performance. The rate of volume transfer of a conveyor is proportional to the rotation rate of the shaft. In industrial control applications the device is often used as a variable rate feeder by varying the rotation rate of the shaft to deliver a measured rate or quantity of material into a process.

Aju *et al* [1], developed a Small Scale Pineapple Juice Extraction Machine using local available resources. It was powered by a 2 hp single phase electric motor. Test indicates that juice yield, extraction loss, and extraction efficiency were 75%, 4.8% and 71% respectively. This shows remarkable improvement of that reported by Olaniyan et al. The pineapple juice extraction Machine was able to produce 18lts/s. Hongbin Liu *et al* [2] showed that the influence of centrifugal hydraulic pressure was less than that of centrifugal force on the strength and deformation of conveyor. Besides, the maximum equivalent stress occurred at the inside of the feed opening, while the maximum deformation occurred at the conveyor blade edge of taper extremity. He thereafter states that the computing model had a great influence on the analysis results, and the simplified loads had a great influence on the deformation analysis results. Quan Yang, *et al* [3] established simplified mathematical model of screw conveyor, and also carried out the kinematics analysis and simulation by using MATLAB software. As a result, the movement change curves of all parameters of the screw conveyor were obtained when it was working. This result also provides theoretical basis for the improvement of the structure of the feeding screw conveyor of grain combine. Yan *et al* [4] indicated that static analysis is an extremely important field, not only decide to what the structure size is, but also for the subsequent fatigue analysis, providing the basis for the overall stability analysis. In this paper, tapered screw conveyor simulation under different speed, the internal movement of materials to simulate the process for improving the productivity of the tapered screw conveyor has certain significance. This would provide an important basis for further design optimization of the pineapple juice extractor. Lei [5] reported that the degree of freedom theory analysis software of EDEM with discrete element and setting periodic boundary model are applied in this paper to simulate the vertical screw conveyors grain (rice) delivery process under different intermediate support structure. The results show that traditional intermediate support structure is three times statically. indeterminate structure, while the degrees of freedom of new intermediate support is 1; The vertical screw transmission capacity of new type of vertical screw axis machine which uses intermediate spokes structure is slightly decreased, and the driving power required to drive screw axis increases slightly at the same time. The materials axial transport speed is not affected, but the requirement is greatly reduced for the manufacture and installation accuracy. Shimizu [6] stated a numerical analysis using the 3D distinct element method (DEM) is conducted in order to examine the performance of screw conveyors. In particular, the simulation of horizontal and vertical types is studied. The results are compared with previous work and empirical equations. As a result, it is determined that this method is sufficiently well developed and useful to analyse the performance of screw conveyors.

MATERIAL AND METHODOLOGY

Stainless steel material was employed for this investigation due to corrosion resistance and area of application. Stainless steels are alloys of iron with chromium, nickel, and - often - four of five other elements.

Table 1: General Properties of the Stainless Steel

S/N	Material Description	Values	Units
1	Density	$8.1*10^3$	kg/m^3
2	Young's modulus	$2.1*10^{11}$	Pa
3	Shear modulus	$8.4*10^{10}$	Pa
4	Bulk modulus	$1.51*10^{11}$	Pa
5	Poisson's ratio	0.275	
6	Yield strength	1e9	Pa
7	Specific heat capacity	530	J/kg.°C
8	Thermal conductivity	24	W/m.°C
9	Thermal expansion coefficient	2e-5	strain/°C
10	Elongation	0.7	strain

Source: Granta CES, Edu pack (2011)

Table 2: Boundary Conditions for the Simulation

S/N	Parameter Description	Values	Units
1	Density	$8.1*10^3$	kg/m3
2	Young's modulus	$2.1*10^{11}$	Pa
3	Shear modulus	$8.4*10^{10}$	Pa
4	Bulk modulus	$1.51*10^{11}$	Pa
5	Poisson's ratio	0.275	
6	Yield strength	10^9	Pa
7	Pineapple weight	2844.4	N

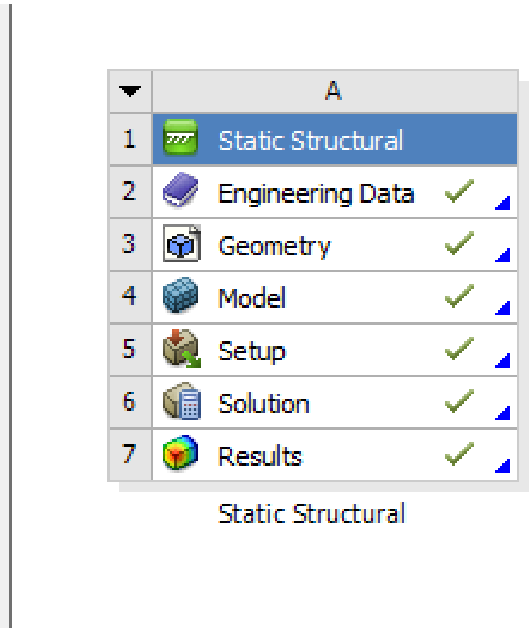

Fig-1: Flow chat of the Static structural analysis of the worm shaft conveyor

RESULTS

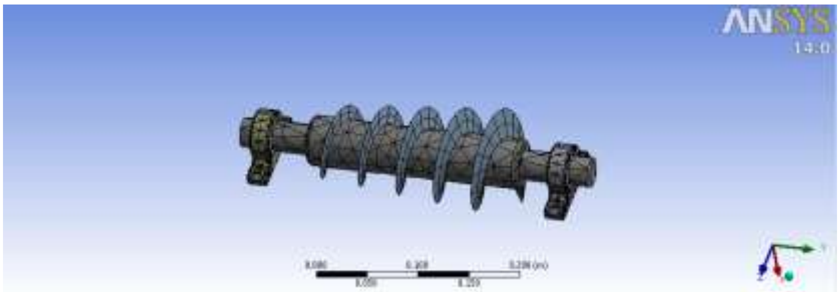

Fig-2: Finite Element Mesh of the Worm Shaft

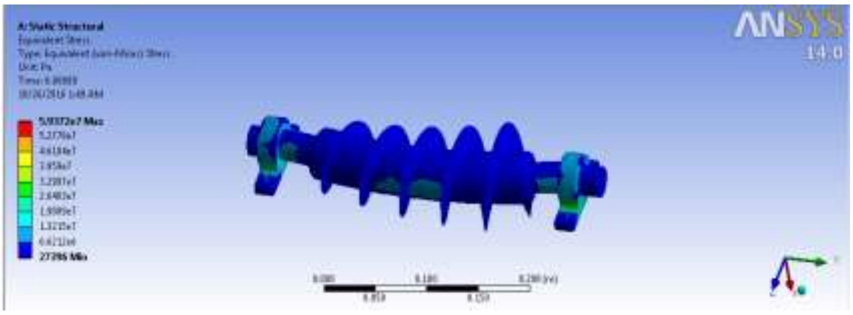

Fig-3: Equivalent (von-mises) stress

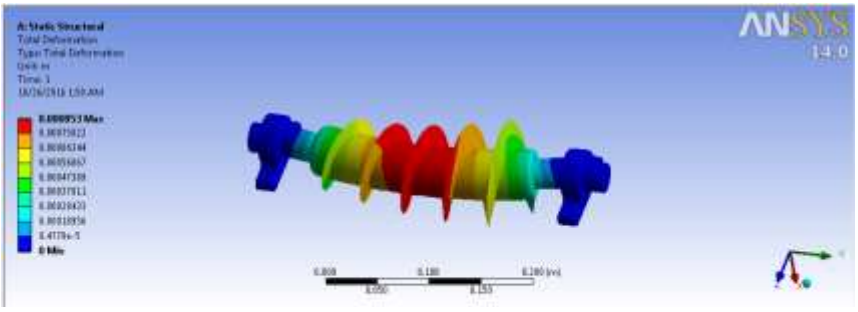

Fig-4: Total deformation

DISCUSSION

From figure 1a, the mesh was achieved when the geometry of the model was imported into the Ansys workbench 14.0 environment, where the material for the mould was formulated in the engineering data and assigned to the geometry. The mesh was performed in the model of the static structural with a triangular surface mesher, the triangular mesher was chosen because, it doesn't take time to analyse and fine size mesh was selected for the meshing. An edge length of 6.6897e-002 m with statistics; nodes 8937 and elements 4008 were achieved.

While from figure 1b and 1c, the maximum equivalent von–mises stress and total deformation of the structural analysis of the conveyor worm shaft of the small scale pineapple juice extraction machine were $5.9372*10^{7}$Pa and $8.53*10^{-4}$m respectively.

Accordingly,

1. It was observed that the maximum equivalent von-mises stress of the static structural analysis was far less than the yield strength of the steel material under investigation which is 10^{7}Pa, while the total deformation obtained from the analysis is far less than the elongation of the material which is 0.7strain as presented in table 2.0, from the results, it shows that the worm shaft would be reliable and durable in operation. Therefore, the higher the strength of a material, the lesser its response to deformation.

CONCLUSION

A worm conveyor shaft of the small scale pineapple juice extraction machine has been investigated structurally using knowledge based software. ANSYS workbench 14.0 was used to perform structural analysis to determine von-mises stress and total deformation, while granta CES edu pack 2011 was used for the selection of material. The results of the analysis showed that the worm shaft of the conveyor would perform in durability and reliability comparing their von-mises stress to yield strength of the material and deformation to elongation of the material.

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