



International Journal of Engineering, Business and Enterprise Applications (IJEBA)

(Open Access, Double Blind Peer-reviewed, Refereed and Indexed Journal)

www.iasir.net

Redesign tree mat bagasse lift a sugar mill with CAD tools

Mejías Brito Johann¹, Silva Medina Pedro¹, Lugo Báez Rosario¹, Martínez Grave de Peralta José¹, Tejeda Castrejón Jesús²

¹Electrical and Electronic Engineering Department/ Instituto Tecnológico de Colima, México

²Industrial Engineering Department/ Instituto Tecnológico de Colima, México

Abstract: In this paper the results of a study of modeling and simulation, carried out on a tree truck carrying bagasse mat exposed. For this study was conducted modeling in 3D with SolidWorks 2010 software, static analysis was performed with techniques of computer-aided engineering through the pack finite element analysis SolidWorks Simulation. Derived from analysis of the graphical views stress distribution and numerical values of the parameters calculated are obtained; which allowed for the redesign of the machine element in question and thus improve their performance and productivity in the sugar mill.

Keywords: Desing assisted by computer; MEF; static analysis; redesign

I. Introduction

Sugar cane is the most important in the world sugar generator crop, the largest producer is Brazil with 30%, followed India (21%), China (7%), Thailand (4%), Pakistan (4%), Mexico (3.5%), Colombia (3%), Australia (3%), United States of America (2%) and Indonesia (2%) (Senties & Gómez, 2014; Singh & Solomon, 2015; Narimoto et al, 2015). In the Americas it is widespread due to climatic conditions which favour production. The sugar industry in Mexico integrates agricultural activities growing, harvesting and transporting cane to the production of standard and refined sugar, with other products and by-products (Aguilar et al., 2011). Similarly Dominguez et al., (2014) mentions that the sugar industry is one of the most traditional activities and importance in the economic development of the country. However, over time it has slowly been the effect of the economic crisis, disputes between cane growers and mill owners, and technological backwardness.

In order to raise the performance of production units working on eliminating the deficiencies identified in the previous harvest, when production was below planned; this is caused in part because of technological aging machines that can still be exploited and use of low-efficiency powertrains. Similarly Rodriguez et al., (2006) observed that trees and axes mills and conveyors are critical highly valiant they are subjected to considerable loads, causing it to rupture in a relatively short work cycles number, which is a high cost for any sugar mill. Moreover Gomez, et al., (2005) confirmed that the flaws in these machine elements arise as a result of fatigue, and in many cases, by the synergy between this and corrosion caused by cane juice.

The increased capacity ground in the mills has led to the need to analyze the production process to improve efficiency and address labor capacity, requiring sometimes make design modifications in various mechanical elements. In the sector of the sugar industry they have conducted several studies with the use of tools Computer Aided Design (CAD), Estrada et al., (2013) performed a study of the stress state deformational parallelogram cutting mechanism for CCA-5000 sugarcane harvester. In the work Estrada & Gomez (2012), made the resistance and rigidity of the main frame of sugarcane harvester KTP-2M using the Finite Element Method (FEM) analysis. In this research the importance of using CAD tools and methods using Finite Element Analysis (FEA) is appreciated.

A failure detected more frequently in one of the mills in the Pacific region of Mexico, is on the mat truck carrying bagasse last tandem mill to the first conveyor. Tree mat fracture frequently lift the increased movement of the quantity of material, causing with this stops almost daily and thus productivity losses milling. To address this deficiency in this work redesign tree truck mat bagasse with the help of CAD tools, in this case the SolidWorks / Simulation package thus obtaining accurate results and cost reduction is carried out by allowing analysing virtually the behaviour of new solutions and reducing the number of cycles of their development.

II. Methodology

The tree under study can be seen in Figure 1, this receives the motion and power of a drive unit and must reduce the speed at which requires the movement of the mat. The movement comes from an engine delivering a reductant which in turn transmits the tree chain, this staggering keeps the output speed. On the shaft 4 wheels called bagasse

which have 13 teeth and step 8 inches above them go bagasse chains (ECA B6) are mounted. The material that is built the machine element in question is AISI 1045. This material has good machinability in normalized as well as the hot rolled condition. Based on the recommendations given by the machine manufacturers, operations like tapping, milling, broaching, drilling, turning and sawing etc. can be carried out on AISI 1045 steel using suitable feeds, tool type and speeds. The mechanical properties of this can be seen in Table 1.

Table I. Mechanical Properties of AISI 1045 steel.

Mechanical Properties	Metric	Imperial
Hardness, Brinell	163	163
Hardness, Knoop	184	184
Hardness, Rockwell B	84	84
Hardness, Vickers	170	170
Tensile Strength, Ultimate	565 MPa	81900 psi
Tensile Strength, Yield	310 MPa	45000 psi
Elongation at Break (in 50 mm)	16.0 %	16.0 %
Reduction of Area	40.0 %	40.0 %
Modulus of Elasticity	200 GPa	29000 ksi
Bulk Modulus	140 GPa	20300 ksi
Poissons Ratio	0.290	0.290
Shear Modulus	80 GPa	11600 ksi

The Finite Element Analysis allows a mathematical model for calculating the real system, which is easier and cheaper to modify compared to a prototype, which remain necessary, but in smaller numbers (Lazo & Rojas, 2006; Arbeláez & Marin, 2007; Rojas & Mill, 2015). For this study the modeling was done in 3D, it was developed with the CAD SolidWorks 2014 (DVX0122-SP1.0/2, x64) software The defined model includes a detailed representation in three dimensions (3D) of the shaft under study (Figure 1) full scale (1: 1), with the inclusion of all the constructional details. The static analysis was performed with techniques of computer-aided engineering through the pack finite element analysis SolidWorks Simulation.

In Figure 2 a diagram illustrating the equations involved in the proper structural theory that satisfy the derived model is observed, these are:

- Equilibrium equations that relate the external forces with stresses occurring.
- Compatibility equations that relate the deformations with displacements that occur.
- Constitutive equations that relate the deformations tensions.

Figure 1. Tree isometric perspective of the lifting mat bagasse.



For the application of the method with the use of CAD software the following operations are performed: Pre-Processing: problem identification was made, geometric and material characteristics and decide whether it can be modelled with FEA package that counts, creation of geometric pattern through a CAD package, or module corresponding geometry, the allocation of material properties, selecting the type of finite element to use, physical characteristics it, approach the boundary conditions and applied loads, and the conditions of application of these and finally realization of the meshing of the model the characteristics and size selected by the user.

Analysis: The complete model of the item in question is subjected to appropriate analysis, this module is responsible for building and solving the equations of the mathematical model built in the pre-processor module.

Post-Processing: graphical views of the distribution of stresses, strains, displacements, safety factors, etc., animations, and the results of deformations, displacement (mm) and Von Mises stresses (MPa) are obtained.

For determination of the stress distribution equivalent (σ_{eq}) the Von Mises criterion is applied to determine the most dangerous area of the device, which is given by the expression:

$$\sigma_{von Mises} = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2}{2}} \quad (1)$$

σ_1, σ_2 y σ_3 : Principal stresses.

Determining the safety factor from obtaining the equivalent stresses for the most dangerous area and limits or yield stress according to the type of material used for construction of the device is performed according to the following expression:

$$n = \frac{\sigma_{lim}}{\sigma_{eq}} \quad (2)$$

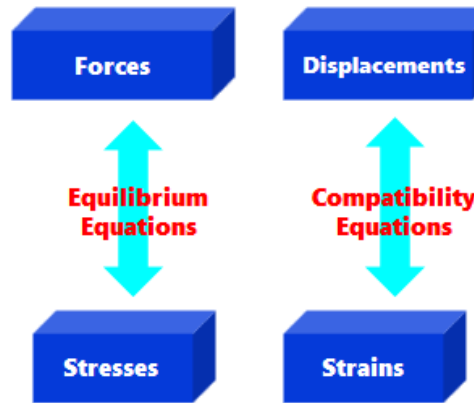
σ_{lim} : Allowable stress.

σ_{eq} : Equivalent stresses.

For which it must meet the following condition of strength:

$$\sigma_{eq} \leq \sigma_{lim} \quad (3)$$

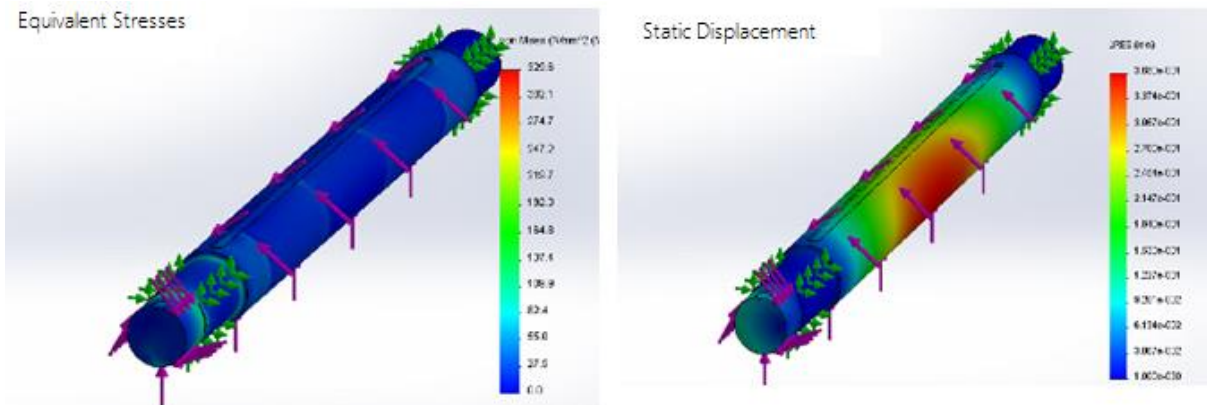
Figure 2. Tree lift mat bagasse, isometric perspective and constructive plane.



III. Results

The 2D and 3D modeling of the mechanical element under study allowed the geometric documentation tree mat truck. Derived from analysis with SolidWorks / Simulation graphical views of the distribution of stresses and strains are obtained, and the numerical values of the calculated parameters, just as you can display the stress plot on other systems of units. Analysis of the obtained extreme stresses can be observed that the maximum stresses are of 339.6 MPa compared with the yield strength of AISI 1045 steel is 565 MPa. Therefore since the maximum stresses were lower it can conclude that the tree will withstand the loads to which it is subjected. In the case of static displacement, a maximum of 3.6 mm is obtained in the red area, as shown in Figure 3, indicating the critical region.

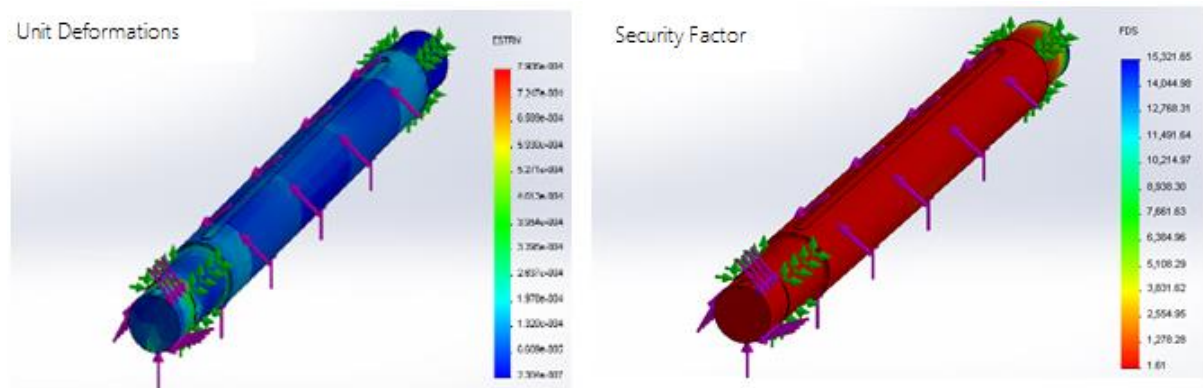
Figure 3. Equivalents of stresses analysis and static displacement.



Design verification is performed when the material, shape and dimensions already preset and need to know if they are adequate to resist loads acting state. This last step is conclusive to determine the veracity of the results before performed, as shown in Figure 4. The analysis of the changes made to the structure is made, 10 mm increased the cylinder diameter and 10 mm to the stumps, in addition to the fillet radii and bevels to give a safety factor of 1.36

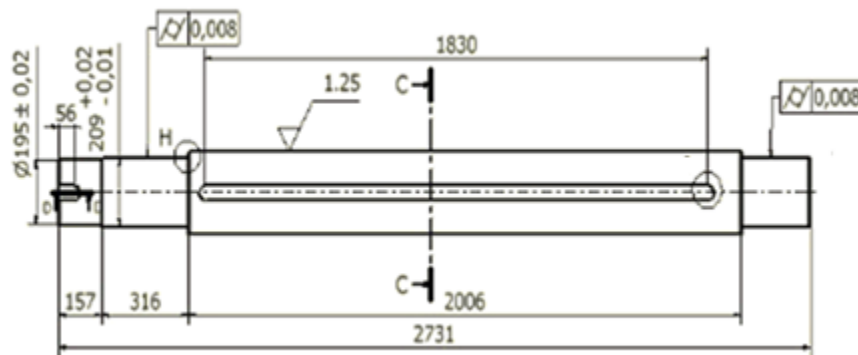
for the new design, which ensures reliable performance of it during the occurrence of extreme loads in operating conditions of the machine.

Figure 4. Analysis of unit deformations, and Security Factor.



Finally derived from the results of the studies tree redesign was performed with the optimum dimensions to withstand the loads to which this machine is brought under this element during the production process in the sugar mill; constructive plane can be seen in Figure 5.

Figure 5. 2D tree mat bagasse lift model.



IV. Conclusion

The geometric documentation tree truck bagasse mat by the parametric SolidWorks software was performed, in addition to the static analysis of the same, thanks to the competition package finite element analysis SolidWorks Simulation.

From the study conducted it showed that the use of professional software is very advantageous because it allows Reducer modifications invested in time.

The redesign of the tree of the lift mat bagasse yielded results that increasing 10 mm cylinder diameter and 10 mm to the stumps, in addition to the fillet radii and bevels, is achieved to decrease the voltage maximum reference to 146.31 MPa.

With modifications made in the distribution design safety factor of 1.61 is the same is in the allowable limits so we can say that the tree withstands the loads to which it is subjected.

V. References

- [1] Abreu, Y., Estrada, R. A., & Calzadilla H. (2015). Análisis dinámico del sistema de dirección de la cosechadora de caña cubana CCA-5000. *Revista Ciencias Técnicas Agropecuarias*, 24(1), 5-13.
- [2] Aguilar, N., Galindo, G., Fortanelli, J., & Contreras, C. (2011). Factores de competitividad de la agroindustria de la caña de azúcar en México. *Región y sociedad*, 23(52), 261-297.
- [3] Arbeláez, J. J., & Marín, J. P. (2007). Modelado multicuerpo de un cuarto de vehículo liviano, utilizando el software visualnastran para ser evaluado, bajo los criterios de la norma eusama en cuanto a la adhesión. *Scientia Et Technica*, 1(35).
- [4] Ceballos, W. F., Gómez, A. L., & Coronado, J. J. (2010). Comportamiento a fatiga del acero sae 4140 usando alta rugosidad superficial y ambiente corrosivo. *DYNA*, 77(162), 125-135.
- [5] Domínguez, C. Á., Sosa, R. & Bravo, H: (2014). Prevención, minimización y control de la contaminación ambiental en un ingenio azucarero de México. *Ingeniería, investigación y tecnología*, 15(4), pp. 549-560

- [6] Estrada , R., & Gómez, E. (2012). Análisis del bastidor principal de la cosechadora de caña a través del Método de los Elementos Finitos.//Analysis of the main frame in cane combine-harvester using the Finite Elements Method. *Ingeniería Mecánica*, 6(3), 45-52.
- [7] Estrada, R., Aballes, C. R., & Pérez, R. (2013). Análisis dinámico del mecanismo paralelogramo del cortacogollo desfibrador para la cosechadora cañera cubana CCA-5000. *Revista Ciencias Técnicas Agropecuarias*, 22(1), 05-11.
- [8] Gómez A.L. Coronado J.J. Váldes J.A. Desgaste de máquinas de preparación y molienda de caña de azúcar. Serie Procesos Industriales. Cenicaña. ISBN 978-958-8449-00-5, pp. 283. sep. 2008.
- [9] Gómez, F.C., Trejo, L.I., Morales, V., Salazar, J., Velasco, J., Senties, H.E., & Ladewig, P. (2014). Necesidades de innovación en la producción de caña de azúcar. *Agro Productividad*, 7 (2), 16-21.
- [10] Gómez, J. A., Gómez, A. L., & Coronado, J. J. (2005). Análisis del comportamiento a fatiga de un acero AISI 1045 en un ambiente de jugo de caña de azúcar. *Scientia et Technica*, 1(27). pp. 81-86.
- [11] Lazo, O. R., & Rojas, L. R. (2006). Diseño asistido por computador. *Industrial Data*, 9(1), 007-015.
- [12] Mora W., J. S. Rivas., J.J. Coronado. (2005). Diseño de Dos Chumaceras con Sistema de Sellado para el Eje de Maza Superior de Molino de Caña de Azúcar. *Revista Técnica de la Facultad de Ingeniería. Universidad del Zulia. Venezuela. Vol. 28, No. 3*, pp. 219-232.
- [13] Narimoto, L. R., Camarotto, J. A., & da Costa Alves, F. J. (2015). The operation of mechanical sugarcane harvesters and the competence of operators: an ergonomic approach. *African Journal of Agricultural Research*, 10(15), 1832-1839.
- [14] Perdomo, W. M., Murillo, J. S. R., & Marín, J. J. C. (2010). Design of two bearings with sealing system for the top roll shaft of sugar cane mill. *Revista Técnica de la Facultad de Ingeniería. Universidad del Zulia*, 28(3).
- [15] Rivas J. S., J. J. Coronado, A. L. Gómez. (2006). Tribological aspects for the shafts and bearings of sugar cane mills. *Wear. Elsevier. Vol. 261, No. 7-8*, pp. 779-784.
- [16] Rivas J.S., S.A. Rodríguez., J.J., Coronado. (2004). Análisis de la confiabilidad de los ejes de molino de caña de azúcar. *Revista Tecnura*, 8(15), 45-54.
- [17] Rodríguez S.A., J.J. Coronado, N. Arzola. (2004). Mecánica de la fractura aplicada a ejes de molinos de caña de azúcar. *Ingeniería*, 10(2), 23-29.
- [18] Rodríguez, S., Coronado, J. J., & Arzola, N. Predicción de vida remanente en ejes de masa superior de molino de caña. *Ingeniería e Investigación*; Vol. 26, núm. 1 (2006); 84-91 *Ingeniería e Investigación*; Vol. 26, No. 1, pp. 84-91.
- [19] Rojas, J. I., & Molino, J. (2015). Diseño paramétrico tridimensional y análisis estático del primer malacate español utilizado para drenar agua de las minas. *Dyna*, 82(190), 237-245.
- [20] Senties, H.E., & Gómez, F.C. (2014) Nuevas directrices en el mejoramiento genético de la caña de azúcar (*Saccharum spp*) *Agro Productividad*, 7 (2), 9-15.
- [21] Singh, A. K., & Solomon, S. (2015). Development of a Sugarcane Detrasher. *Sugar Tech*, 17(2), 189-194.