DESIGN AND STRENGTH ANALYSIS OF BEAN WASHING MACHINE FRAMES USING THE FEA METHOD

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Abstract. Washing nuts is a crucial aspect in processing nuts to achieve the desired quality and cleanliness standards. Focusing on the nut washing machine as a key element is essential to achieve optimal production results. In developing this machine, the frame design is a key element, which must be able to withstand operational loads so that the machine can operate with stability and efficiency. The Finite Element Analysis (FEA) analysis method is used to understand and optimize machine frame design by breaking down the structure into small elements, evaluating stress distribution, deformation and structural response. From the results of the static analysis simulation, it was found that the nut washing machine frame using ASTM A36 material was able to withstand operational loads well. The maximum stress is 46.93 MPa, displacement is 0.143 mm, and safety factor is 5.33 ul, indicating adequate frame strength and durability. Thus, it can be concluded that the bean washer frame design meets the structural reliability criteria, providing confidence that the machine can operate safely and efficiently.

Keywords: Finite Element Analysis, Frame Design, ASTM A36, Stress, Displacement, Safety factor.

1. Introduction

Peanut washing plays a central role in the peanut processing process to produce final products that meet quality and hygiene standards. At this stage, the peanut washing machine becomes a key element in ensuring optimal production results. The performance of a peanut washing machine not only affects operational efficiency but can also impact the cleanliness and quality of the product produced [1].

In developing a peanut washing machine, the design of the machine frame is a very crucial aspect. The machine frame must be able to withstand operational loads well so that the machine can operate stably and efficiently [2]. To ensure optimal design, in-depth strength analysis is required to understand the structural response of the machine under operational loads.

One analysis method that can be used to understand and optimize machine frame design is Finite Element Analysis (FEA). This method breaks down complex structures into small elements to evaluate stress distribution, deformation, and other structural responses. By applying FEA to bean washer design, we can gain deep insight into the machine's structural performance and identify critical areas that require special attention.

Therefore, this research aims to bridge the knowledge gap in peanut washing machine design by adopting the Finite Element Analysis method. By combining knowledge about material characteristics, operational loads, and realistic boundary conditions, it is hoped that this research can make an important contribution to improving the reliability and efficiency of peanut washing machines. It is hoped that the results of this research will serve as a basis for the development of more sophisticated and optimal designs in the peanut processing industry, with the potential to have a positive impact on product quality and overall process efficiency. [3].

2. Method And Material

The method applied in this research is the Finite Element Analysis (FEA) Method. FEA is a very effective numerical technique for solving complex mathematical problems by dividing them into smaller elements, enabling accurate simulation of the structural behavior of an object [2]. In this study, FEA was chosen as an approach to investigate the design and analyze the strength of the bean washer frame. This technique has proven to be a reliable means of analyzing complex structures or systems,

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such as machines, vehicles and buildings. To provide a clearer picture, this research will outline the methodological steps through a flow diagram that depicts a series of research processes using FEA as the main analytical basis.

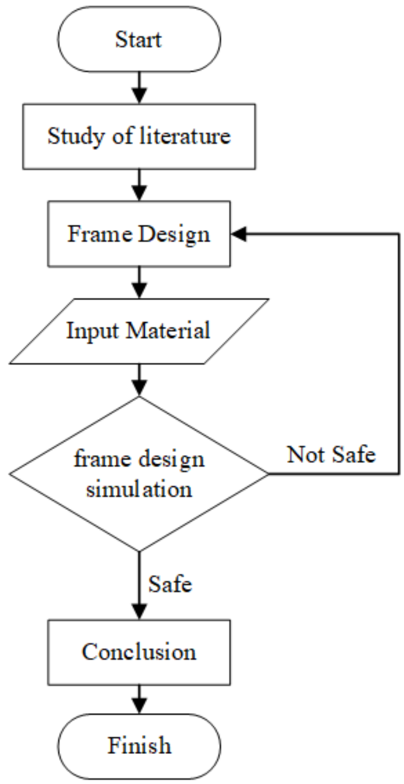

Figure 1. Research Flow Chart

After appropriate material selection, the material properties are integrated into the simulation program. By applying this simulation, researchers can understand and measure the response of structures to certain pressures and loads.

The simulation is then run, and the results are carefully evaluated. If the simulation results match expectations and meet the desired strength standards, then the material used in the simulation will be considered valid for further application in the design of the bean washer frame. This process helps ensure that the structural design produced through the FEA Method can meet the desired strength and safety requirements before its physical implementation.

2.1. Software Analysis Methods

The software analysis method applied in this research uses Solidworks, a leading simulation software that provides the best simulation tool for strength analysis of nut washer frame. Using the static features of SolidWorks Premium 2021, simulation analysis was carried out to calculate and prove the validity of the frame design. The results of this static feature analysis provide very significant parameters, including strain, displacement, stress, and safety factor [4].

The importance of using an analysis method such as Solidworks Premium 2021 lies in its ability to provide significant results in measuring structural performance. However, to understand more about the structural characteristics and their response to certain loads, this research involves the application of finite elements. Finite elements are numerical procedures that allow researchers to obtain solutions to engineering problems involving stress analysis, heat transfer, electromagnetism, and fluid flow [5]. Numerical methods allow approximate approaches that reach exact solutions only at discrete points called nodes. Thus, the combined use of Solidworks and finite elements strengthens a comprehensive analytical approach in understanding and improving bean washer frame design.

2.2. Bean Washing Machine Design

The design of this machine involves a main frame made of L Angle iron with dimensions of 1160 mm x 724 mm x 700 mm. The selection of these dimensions is based on considerations of material strength and the overall size of the machine. The frame is designed to optimally support the main components of the machine, maintaining stability and safety during operation. By considering the dimensions of this frame, it is hoped that the machine can function efficiently according to the desired technical requirements.

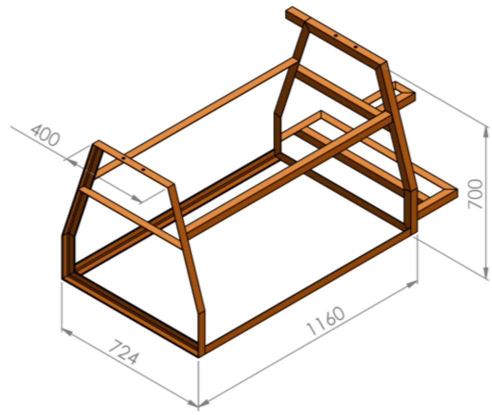

Figure 2. Bean Washing Machine Frame Design

2.3. Bean Washing Machine Frame Material

In this research, the material used in the nut washing machine frame is ASTM A36 Steel with an L angle L40x40 shape with a thickness of 3mm. ASTM A36 Steel is a type of low carbon steel that has good capabilities for welding processes. This steel is often used in various sectors, such as industry, automotive, design and transportation [6]. The properties of ASTM A36 steel can be explained in more detail through the elements contained in it, which can be found in Table 1 [7].

Table 1. Elements of ASTM A36 Steel

Elements	Percentage Rate (%)
Carbom (C)	0,14
Silicone (Si)	0,244
Manganese (Mn)	0,64
Phosphorus (P)	0,012
Sulfur (S)	0,0066
Copper (Cu)	0,01

The characteristics of the ASTM A36 Steel material used in the Bean Washing Machine Design Frame are as shown in Table 2.

Table 2. ASTM A36 Steel Material Characteristics

Property	Value
Mass Density	7850 kg/m^3
Yield Strength	250.000 Gpa
Ultimate Tensile Strenght	400.000 Gpa
Young's Modulus	200 Gpa
Poisson's Ratio	0,26 ul
Shear Modulus	79.300 Gpa

2.4. Static Analysis

In this static analysis, the steps that need to be taken are applying fixtures and applying loads to the frame to be analyzed. The following Figure 3 is a picture of the nut washing machine as a whole.

Figure 3 Nut Washing Machine Assembly

2.4.1. Fixture

At this stage, clamping or fixtures are carried out as the first step. Fixture in this context refers to a design that uses special symbolization to make it easier to identify the function of each part of the fixture, where the part is arranged so that it does not move. In general, the part selected for clamping is at the frame leg [8]. This clamping process is implemented on the four frame legs, as can be seen in the figure below. This process aims to ensure the stability and correct position of the fixture in relation to the frame, providing a solid foundation for subsequent analysis steps.

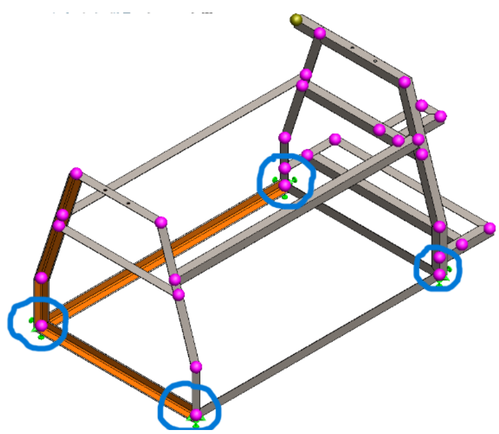

Figure 4. Input Fixture

2.4.2. Assigned Loading Area

In the image below, the position of the load is clearly depicted as shown by the purple arrow. Loading in this research is conceptualized as static loading, which refers to a fixed load that is slowly applied to a structure. Static loading has steady-state properties, where the magnitude (intensity), working point, and direction of the line of action remain consistent during the application of the load [9]. Thus, this static loading approach provides an idea of how the structure will respond stably to the applied load.

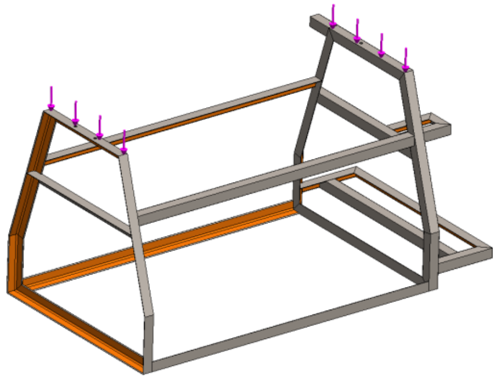

Figure 5. Assign Load

In the frame of this bean washing machine there are two loading areas with the same load value of 670.5 N or 68,372 Kg. The load assumptions for several components and the nuts themselves are as shown in table 3 below.

Table 3. Assumed loads on the machine frame

Jenis beban	Mass (Kg)
Drums	24
Bean	100
Shaft	4
Pulleys	1,5
Bearing Blocks	2
Drum Covers	5
Cover closing lever	0,5

3. Result And Discussions

The results of this research show the results of static simulation analysis using Solidworks 2021 software. This analysis includes calculations of stress, displacement and safety factor on the bean washing machine frame. The results of this simulation provide an idea of how the component will respond to its operational load. The results of the static simulation analysis are as follows:

3.1. Stress Simulation Data Results

From the results of the stress simulation analysis, it can be observed in Figure 6 which displays the stress distribution on the bean washing machine frame. The colors displayed in the image reflect the magnitude of the stress values associated with the frame structure. The red area indicates the highest stress, reaching a stress value of 46.93 MPa, this value is still below the yield strength value of the frame material. Conversely, the blue area shows the lowest stress with a value of 0 MPa.

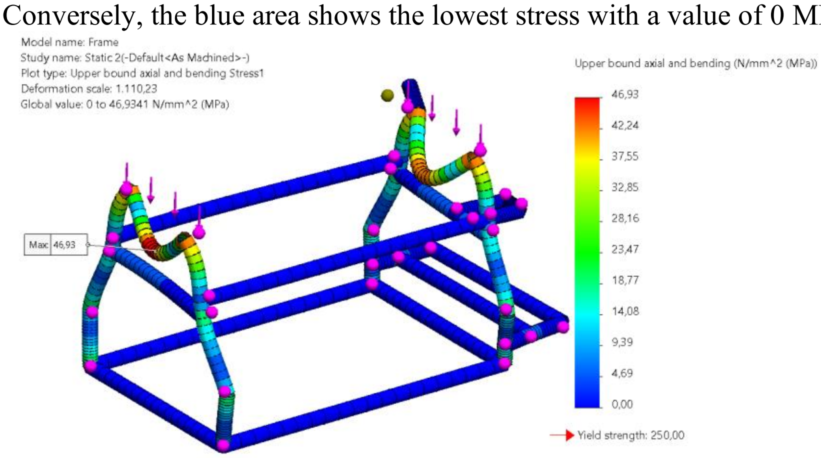

Figure 6. Stress Simulation Results

3.2. Displacement Simulation Data Results

From the results of the simulation analysis, the displacement value of the machine frame is 0.143 mm, as seen in Figure 7. This figure reflects the extent to which the frame experiences displacement. The colors in the image below visualize the Displacement value, with the red color being the largest displacement in the middle of the machine frame. This information provides a clear visual understanding of how the frame responds to operational loads and where the greatest displacements occur in the machine structure.

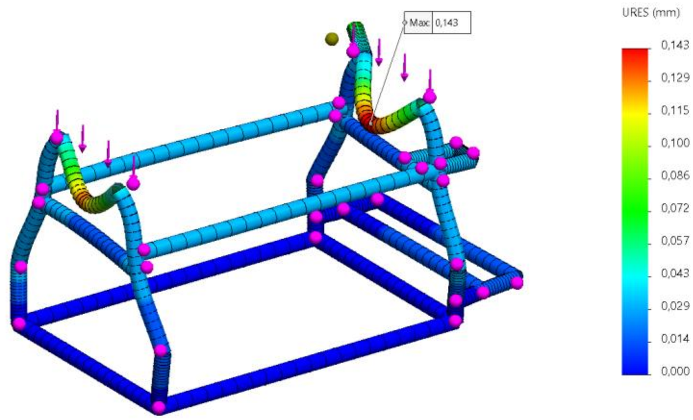

Figure 7. Displacement Simulation Results

3.3. Safety Factor Simulation Data Results

The safety factor can be based on either the maximum tensile stress limit or the yield stress of the material. The safety factor at yield strength aims to prevent detrimental deformation, while the safety factor at maximum tensile strength aims to prevent collapse, and can only be done with software. From the safety factor simulation results, we can compare the results using the following equation

$$Safety\ factor = \frac{\sigma\ yield}{\sigma\ calculated\ stress}$$

The safety factor of the nut washing machine frame, which was calculated based on the results of static simulation analysis, was found to reach 5.33, exceeding the recommended safety factor provided by the International Organization for Standardization (ISO). According to these standards, the ideal safety factor for designing machine elements is between 1.25 to 2 for static loads, and 2.0 to 3 for dynamic loads, which indicates that the machine frame has an excellent level of safety. [10].

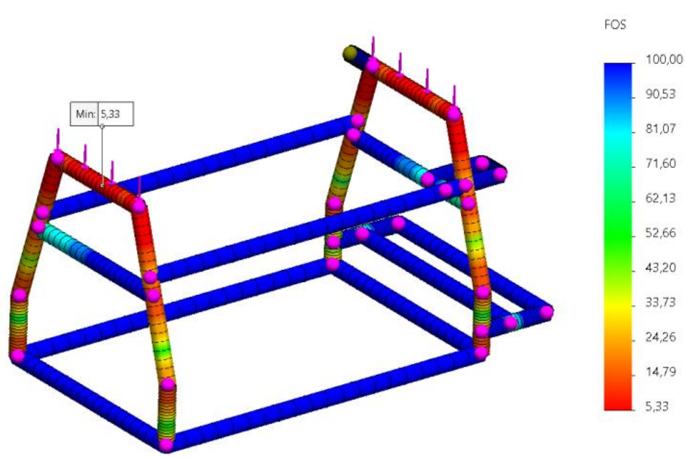

Figure 8. Safety factor Results

Visually, in Figure 8 you can see parts of the frame model shown in blue, indicating that the frame is well designed and able to support the machine load safely during the operational process. This significant safety factor provides additional confidence in the reliability and stability of the bean washer frame, ensuring that the machine can function properly without risk of failure or structural damage during normal use.

Based on analysis using the finite element method in Solidworks 2021, the results show that there are no significant changes in the stress, strain and deformation values. Thus, there are no critical conditions or areas that require design changes or optimization. Therefore, it can be concluded that the machine frame that uses ASTM A36 material for the peanut washing machine can be considered safe and able to bear the load according to the results of the static analysis simulation. This conclusion is strengthened by the safety factor value which was recorded to be higher than the specified tolerance.

4. Conclusion

1. The stress results on the frame are shown with a maximum value of 46.93 Mpa and a minimum of 0 Mpa.
2. The displacement results from the simulation obtained a value of 0.143 mm in the middle of the frame, shown in red.
3. The safety factor value resulting from the simulation process shows a good value of 5.33 ul, this value is above the specified value
4. From the simulation that has been carried out, it can be concluded that the frame design of this bean washing machine is strong enough to support the load given during operation.

References

[1] Y. Kai, M. Baruwadi, and W. K. Tolinggi, “Analisis Distribusi Dan Margin Pemasaran Usahatani Kacang Tanah Di Kecamatan Pulubala Kabupaten Gorontalo,” *AGRINESIA J. Ilm. Agribisnis*, vol. I, no. 1, pp. 70–78, 2016.

[2] I. T. Maulana, A. Zohari, A. S. Wardoyo, and P. A. Heryanto, “Analisa Desain Rangka Alat Compact Heat Induction Press Menggunakan Metode Finite Element Analysis,” *J. Engine Energi, Manufaktur, dan Mater.*, vol. 5, no. 2, p. 83, 2021, doi: 10.30588/jeemm.v5i2.894.

[3] G. E. Pramono, A. Hidayat, and R. Waluyo, “Perancangan dan Simulasi Desain Rangka Sepeda Motor Listrik Tipe Trellis Menggunakan Finite Element Analysis,” *JTERA (Jurnal Teknol. Rekayasa)*, vol. 5, no. 2, p. 319, 2020, doi: 10.31544/jtera.v5.i2.2020.319-326.

[4] J. E. Akin, “Finite element analysis concepts: Via solidworks,” *Finite Elem. Anal. Concepts Via Solidworks*, pp. 1–335, 2010, doi: 10.1142/7785.

[5] H. Suharto, A., & Rahardjo, “Analisis kekuatan struktur dengan metode elemen hingga,” *Anal. kekuatan Strukt. dengan Metod. Elem. hingga*, 2014.

[6] F. Mohamad and U. Syahrul, “Analisis Kekuatan Dan Kualitas Sambungan Las Dengan Variasi Pendinginan Oli Dan Udara Pada Material ASTM A36 Dengan Pengujian NDT (Non Destructive Test),” *Bina Tek.*, vol. 14, no. 2, pp. 131–138, 2018.

[7] M. Jordi, H. Yudo, and S. Jokosisworo, “Analisa Pengaruh Proses Quenching Dengan Media Berbeda Terhadap Kekuatan Tarik dan Kekerasan Baja St 36 Dengan Pengelasan SMAW,” *J. Tek. Perkapalan*, vol. 5, no. 4, p. 785, 2017, [Online]. Available: http://ejournal3.undip.ac.id/index.php/naval.

[8] D. A. N. Cover *et al.*, “Teknologi Rekayasa Perancangan Manufaktur , Politeknik Manufaktur Bandung 1 Komara , Asep Indra . , dkk ; Perancangan Ulang Machining Fixture Untuk Produk Cylinder Head Dan Cover Crankcase Tipe 168 2 Komara , Asep Indra . , dkk ; Perancangan Ulang Machini,” vol. 6, no. 1, pp. 1–7, 2020.

[9] S. Moaveni, “Finite Element Analysis : Theory and Application with ANSYS,” *Harlow: Prentice Hall,* vol. 3 Rd, 2007, [Online]. Available: http://hermes.survey.ntua.gr/NaTUReS_Lab/ZZZ_Books/CS_IT/Moaveni_S._Finite_Element_Analysis._Theory_and_Application_with_ANSYS_4ed_2015.pdf.

[10] D. Rhakasywi, A. Marasabessy, M. R. Hatuwe, and S. Kotahatuhaha, “Safety factor of pump vibrations on ships based on the natural frequency of pump vibrations according to ISO 10816-3,” *J. Mech. Eng. Res. Dev.*, vol. 43, no. 7, pp. 180–192, 2020.