

Static Loading Analysis of Chips Chopper Machine Design with Feeder Spring Addition

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ABSTRACT

This study aims to design an assorted chip chopper that can cut various kinds of raw materials for making chips such as cassava, sweet potato, taro and so on. Product design is important to carry out the production process. Product design helps estimate and analyze requirements with more accurate results than without doing this process. The design in this study was carried out using the Solidworks 2020 software. The dimensions of the machine obtained from the design results were 330 mm long, 330 mm wide, and 285 mm high with a mass of 1.59 kg. The novelty of the design that has been made is the addition of a feeding spring, so that the material input process is more stable and safer. Feeding springs can also improve the quality of the cut. In addition to making the design, a simulation of the calculation of the maximum von Mises value is also carried out with the aim of knowing the safety factor of the design that has been made. From the simulation results, the maximum von Mises Stress value of Force 1 is 1,470 MPa, and Force 2 is 9,846 MPa. This value is obtained from the provision of Force 1 32.49758 and Force 2 18.718. This value is far below the yield strength of the material (250 MPa) so it can be concluded that the design is safe to proceed to the production process.

Keywords: Design, Solidworks, Chopper Machine, Von Mises Stress

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1. Introduction

As one of the fourth largest countries after China, India, and the United States [1], Indonesia is developing in various aspects, including the micro, small and medium enterprise (MSME) sector. The MSME sector is one of the supporting sectors of the national economy with a high absorption of labor in this sector [2]. MSMEs are also one of the sectors that are able to develop and survive consistently in the national economy [3].

The big role of MSMEs in national economic stability and the creation of new jobs requires good support and regulation from the center and the regions. Navastra [4] states that one of the most appropriate policies in the development of regional potential is the local economic development policy. Where MSMEs also play an important role in the progress of the local economy.

In addition to good regulation, technological advances and the availability of population, labor, and capital also affect economic growth [5]. Aisyah added that capital, marketing, and the availability of raw materials will be obstacles to the MSME sector [6].

Empowerment of MSMEs is needed to increase the advantages and uniqueness of this sector because if a product has high competitiveness, the product will be in great demand by consumers [7]. There are several aspects

that can affect MSMEs that have an impact on performance, namely internal, external, and the perspective of business behavior itself [8].

The development of MSMEs is increasingly prominent in regional, national and even international scope. The development of the world economy in the future will be increasingly dominated by MSMEs [9]. The potential for good development of MSMEs requires an increase in the knowledge and ability of business actors as well as the quality and quantity of production.

Until now, MSME actors, especially those operating in rural areas, still rely on manual equipment which has the potential to reduce the quantity and quality of production. The process of chopping using relatively long manual equipment resulted in an increase in the production of chips business actors experiencing problems [10].

In an effort to minimize the obstacles experienced by MSME actors, it is necessary to improve the quality of raw material slices that can be adjusted in thickness using a machine [11]. Machines that are economical and have the required qualifications can help increase the competitiveness of SMEs. Synergy of technology in this case is needed in order to get maximum results.

A thorough calculation of the determination of requirements, manufacture, concept selection, component design, and detailed technical drawings is very much needed in making appropriate technology [10],

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proper calculations are also needed so that the engine capacity is in accordance with what is planned [12].

One of the calculations that must be considered in the design of the machine is to select the appropriate material for the application [13]. Material selection criteria are emphasized on the strength of the material, where this material property is no less important than other material properties such as toughness and hardness [14].

The need for appropriate technology in the MSME sector raises the level of urgency and underlies the implementation of this research. The existence of appropriate technology can accelerate the production process [15][16][17][18][19]. Before making the actual product, it is necessary to design and analyze in order to obtain a machine that suits your needs.

Machine design is a preliminary activity in an effort to make a product [20]. Machine design starts from basic mapping of needs and making machine drawings. The strength of the machine design material can be calculated and analyzed using a tensile test experiment through a numerical approach [21]. In the field of engineering, software is currently widely used to assist the process of calculating and analyzing the safety factor [22].

2. Material and Methods

The focus of this research is the design of various chips chopping machines and the analysis of the maximum Von Misses value for the frame. The design is made using CAD-based software, namely Solidworks 2020 along with the analysis. The strength of the engine frame design is analysed using the FEA (Finite Element Analysis) method where this method is a test of structural elements by dividing several parts into finite elements. Overall, the stages of the research process can be seen in Figure. 1.

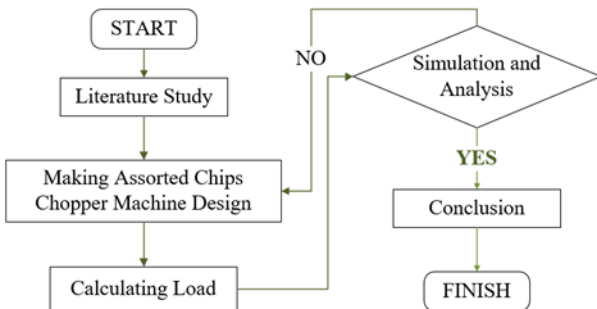



Figure 1. Research Flow Chart

2.1. Frame design specification

The material used in the design of the various chip chopper machine frame design in this study is ASTM A36 Steel. For the manufacture of the frame, an elbow profile measuring 35 mm x 35 mm with a thickness of 2 mm is used. This material was chosen because it is tough, sturdy, and has good resistance [12]. The material properties are shown in Table 1. The frame of this chip chopper is designed with a length of 330 mm, a width of 330 mm, and a height of 285 mm.

Table 1. Frame material properties

Model References	Material Properties	
	Name	: ASTM A36 Steel
	Model type	: Linear Elastic Isotropic
	Yield strength	: 250 Mpa
	Tensile strength	: 400 Mpa
	Elastic modulus	: 200000 N/m ²
	Poisson's ratio	: 0,26
	Mass density	: 7850 N/m ²

2.2. Blade design specification

The blade is one of the most important parts in this chip chopper machine. The sharpness of the blade is necessary to give a good cut of the raw material. The blade holder is designed using Aluminium 1060 Alloy material which is cast using a plate holder mold. While the blade material is made using plain carbon steel material which is treated with hardening. Table 2. Shows the specifications of the blade holder material. The diameter of the blade holder is 225 mm with a thickness of 8 mm and the length of the blade is 90 mm with a slice thickness setting.

Table 2. Blade holder material properties

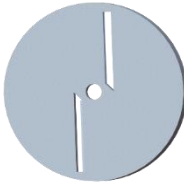

Model References	Material Properties	
	Name	: Aluminium 1060 Alloy
	Model type	: Linear Elastic Isotropic
	Yield strength	: 27,5742 Mpa
	Tensile strength	: 68,9356 Mpa
	Elastic modulus	: 69000 Mpa
	Poisson's ratio	: 0,33
	Mass density	: 2700 Mpa

Table 3. Blade material properties


Model References	Material Properties	
	Name	: Plain Carbon Steel
	Model type	: Linear Elastic Isotropic
	Yield strength	: 220,594 Mpa
	Tensile strength	: 399,826 Mpa
	Elastic modulus	: 210000 Mpa
	Poisson's ratio	: 0,28
	Mass density	: 7800 Mpa

2.3. Blade pulley design specification

Blade pulley is a driving component that connects the electric motor to the blade. The material used in the design of the blade pulley is Aluminium

1060 Alloy which is cast using a blade pulley mold. This blade pulley uses a size of 175 mm for its diameter size with a blade pulley thickness of 15 mm. Table 4 shows details of blade pulley material properties.

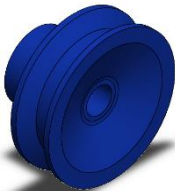
Table 4. Blade Pulley Material Properties

Model References	Material Properties	
	Name	: Aluminium 1060 Alloy
	Model type	: Linear Elastic Isotropic
	Yield strength	: 27,5742 Mpa
	Tensile strength	: 68,9356 Mpa
	Elastic modulus	: 69000 Mpa
	Poisson's ratio	: 0,33
	Mass density	: 2700 Mpa

2.4. Motor pulley design specification

Pulley motor is a component of the drive system that connects the pulley blade and electric motor. This component has a diameter of 50 mm with a thickness of 15 mm. The material used in the design of this pulley motor is Aluminium 1060 Alloy which is casted using a pulley motor mold. Table 5 shows the details of the motor pulley material properties.

Table 5. Motor pulley material properties

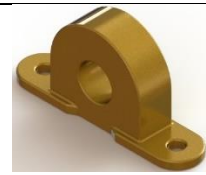
Model References	Material Properties	
	Name	: Aluminium 1060 Alloy
	Model type	: Linear Elastic Isotropic
	Yield strength	: 27,5742 Mpa
	Tensile strength	: 68,9356 Mpa
	Elastic modulus	: 69000 Mpa
	Poisson's ratio	: 0,33
	Mass density	: 2700 Mpa

2.5. Shaft Holder

The shaft holder is the shaft support that connects the blade and blade pulley. The material of this shaft seat is Cast Carbon Steel. Details of this material are shown in table 6.

Table 6. Shaft holder material properties

Model References	Material Properties	
	Name	: Cast Carbon Steel
	Model type	: Linear Elastic Isotropic




Yield strength	: 482.549 Mpa
Tensile strength	: 482.549 Mpa
Elastic modulus	: 200000 Mpa
Poisson's ratio	: 0.32
Mass density	: 7800 Mpa

2.6. Shaft

This component functions as a liaison between the blade pulley and the blade holder to transmit the power provided by the motor to the blade holder so that the machine can work and chop. The shaft uses ASTM A36 Steel material as shown in Table 7.

Table 7. Shaft material properties

Model References	Material Properties	
	Name	: ASTM A36 Steel
	Model type	: Linear Elastic Isotropic
	Yield strength	: 250 Mpa
	Tensile strength	: 400 Mpa
	Elastic modulus	: 200000 N/m ²
	Poisson's ratio	: 0,26
	Mass density	: 7850 N/m ²

2.7. Shaft

Blade cover is a component that serves as a blade protector so as not to harm the user. This component is designed using thin stainless-steel material with a thickness of 0.5 mm with a diameter of 300 mm. While the output is a component that serves as a place for the output of chopped raw materials. Like the blade cover, the output also uses the same material, namely chrome annealed stainless steel. Details of these material properties can be seen in tables 8 and 9.

Table 8. Blade cover material properties

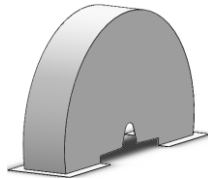
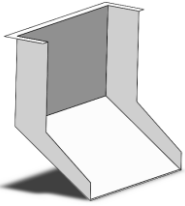
Model References	Material Properties	
	Name	: Chrome Stainless Steel
	Model type	: Linear Elastic Isotropic
	Yield strength	: 172.339 Mpa
	Tensile strength	: 413.613 Mpa
	Elastic modulus	: 200000 Mpa
	Poisson's ratio	: 0,28
	Mass density	: 7800 Mpa

Table 9. Output material properties

Model References	Material Properties	
	Name	: Chrome Stainless Steel
	Model type	: Linear Elastic Isotropic

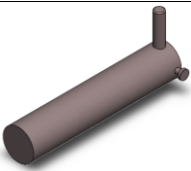


Yield strength	:	172.339 Mpa
Tensile strength	:	413.613 Mpa
Elastic modulus	:	200000 Mpa
Poisson's ratio	:	0,28
Mass density	:	7800 Mpa

2.8. Push Rod

This component serves as a driver of raw materials in the feeding system with a spring. The use of this system increases the neatness of the chopping results and the safety of the user. This component is 66.5 mm in diameter with an overall length of 320 mm. The material used in the design of this component is plain carbon steel. The details of the push rod material are shown in Table 10.


Table 10. Push rod material properties

Model References	Material Properties	
	Name	: Plain Carbon Steel
	Model type	: Linear Elastic Isotropic
	Yield strength	: 220,594 Mpa
	Tensile strength	: 399,826 Mpa
	Elastic modulus	: 210000 Mpa
	Poisson's ratio	: 0,28
	Mass density	: 7800 Mpa

2.9. Spring

The function of this component is to pull the push rod so that it can apply pressure to the raw material so that it can move forward towards the blade. The material used is plain carbon steel. Material details are shown in Table 11.

Table 11. Spring material properties

Model References	Material Properties	
	Name	: Plain Carbon Steel
	Model type	: Linear Elastic Isotropic
	Yield strength	: 220,594 Mpa
	Tensile strength	: 399,826 Mpa
	Elastic modulus	: 210000 Mpa
	Poisson's ratio	: 0,28
	Mass density	: 7800 Mpa

2.10. Load Analysis

Load analysis is used to determine the force that will be applied to the engine frame. In this calculation the mass of raw materials is not included in the calculation. Furthermore, the known mass is divided into two parts, namely Mass 1 and Mass 2. This division is designed according to the location of the given loading. Furthermore, to determine the Maximum von

Misses in the frame, the mass will be converted into a force that is influenced by gravity which adheres to Newton's Law as in form 1 which will then also be grouped into two according to its mass, Force 1 and Force 2.

$$F = m \cdot g \quad (1)$$

Details of the total mass and the calculation of the forces acting on the frame are shown in Table 12. And the loading of Force 1 and Force 2 can be seen in Fig. 2.

No.	Components	Mass	Force
1	Frame	6,383	62,5534
2	Blade Holder	0,442	4,3316
3	Blade	0,02167	0,212366
4	Blade Pulley	0,33071	3,240958
5	Motor Pulley	0,07034	0,689332
6	Shaft Holder	0,77028	7,548744
7	Shaft	0,34526	3,383548
8	Blade Cover	0,46613	4,568074
9	Output	0,18345	1,79781
10	Push Rod	0,65252	6,394696
11	Spring	0,01705	0,16709
Mass 1 and Force 1 (No. 2-11)		3,31608	32,49758
12	Electric Motor	1,91	18,718
Mass 2 and Force 2 (No. 12)		1,91	18,718
Total Mass		11,59241	

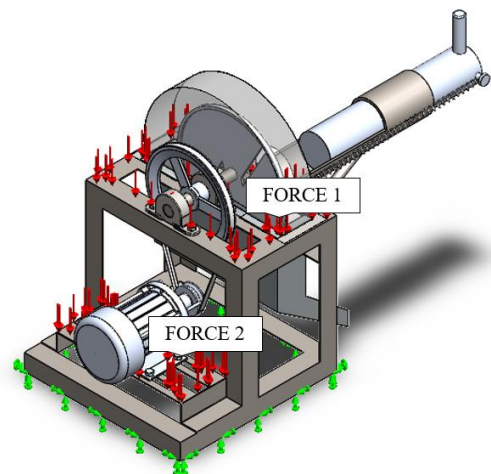


Figure 2. External load

3. Results and discussions

The mass of the assorted chips chopper based on the design that has been made is 11.59 kg (shown in Table 12. The overall design is shown in fig. 3.

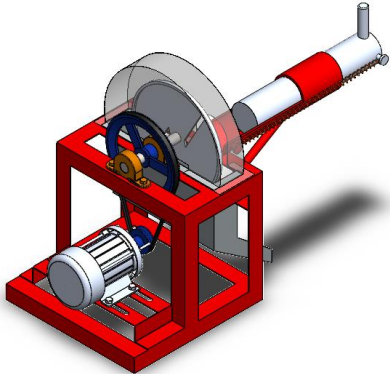


Figure 3. Design of assorted chips chopper machine

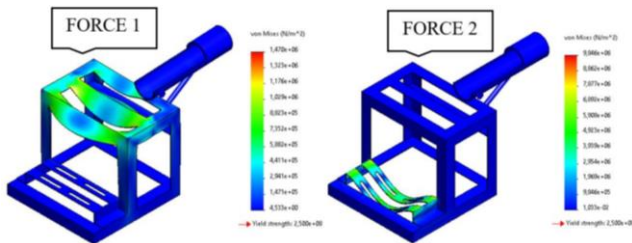


Figure 4. Von mises stress maximum

From the simulation results of static load analysis, the value of Von Mises Stress Maximum Force 1 is 1,470 MPa, and the value of Von Mises Stress Maximum Force 2 is 9,846 MPa. The maximum Von Mises Stress value obtained is far below the yield strength value, so the frame design that has been made can be categorized as safe.

While the resultant displacement values for Force 1 and Force 2 are 0.0124 mm and 0.1088 mm. The value of the bending that occurs in the frame of the assorted chips chopper machine for both Force 1 and Force 2 is very small, below 1 mm so that it seems that there is no bending.

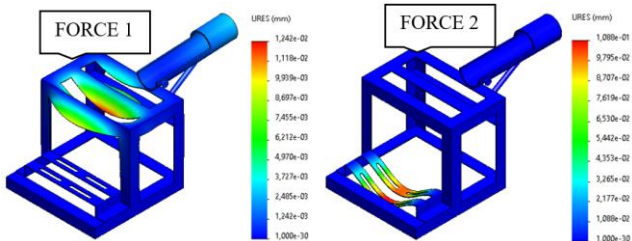


Figure 5. Force displacement

4. Conclusion

The conclusions obtained from this research are (1) The design of the various chips chopper machine has been completed with a length of 330 mm, a width of 330 mm, and a height of 285 mm and a total mass of 11.59 kg (2) The force acting on plane 1 (Force 1) is 32.49758 N and plane 2 (Force 2) is 18.718 N (3) Maximum Von Mises Stress value of Force 1 is 1.470 MPa, and Force 2 is 9.846 MPa (4) Von Mises stress value of the two loads on the frame is far below the yield strength value of the material, so it can be concluded that the design that has been made is a safe design to proceed to the production process (5) Static load analysis using Solidworks 2020 software can help provide an initial analysis of the calculation of the safety factor of the design that has been made.

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REFERENCES

- [1] Kurniawati E and Sugiyanto C 2021 The Effect of Population Age Structure on Economic Growth in Indonesia (Jurnal Ekonomi dan Pembangunan Indonesia) pp 41–58
- [2] Gunartin 2017 Penguatan UMKM sebagai pilar membangun ekonomi bangsa (EDUKA Jurnal Pendidikan, Hukum dan Bisnis) pp 59-74
- [3] Halim A 2020 Pengaruh pertumbuhan usaha mikro, kecil dan menengah terhadap pertumbuhan ekonomi kabupaten Mamuju (GROWTH: Jurnal Ilmiah Ekonomi Pembangunan) vol. 1 (2), pp 157-172
- [4] Navastara 2014 Indonesia dalam Menghadapi Era Baru Ekonomi Kreatif (PT. Bumi, Jakarta) pp 26
- [5] Todaro A M P and Smith S C 2014 Economic development 12th edn. (Pearson, New Jersey)
- [6] Aisyah 2015 Pengembangan Industri Kreatif Di Kota Batu (Studi Tentang Industri Kreatif Sektor Kerajinan di Kota Batu) (Universitas Brawijaya, Malang) pp 26
- [7] Wirawan 2012 Ekonomi untuk negara-negara berkembang (Bumi Aksara, Jakarta) pp 47
- [8] Barney 2009 Industri kreatif usaha mikro, kecil dan menengah, (Inkubator Industri dan Bisnis, ITB Bandung) pp 64
- [9] Naisbit and John 1994 Global Paradox: The Bigger the World Economy, The More powerful it's Smallest Players (William Morrow and Company, New York)
- [10] Husman and Sugeng A 2018 Rancang Bangun Mesin Pengiris Singkong (Jurnal Manutech) pp 34-69
- [11] Shigley J E and Mitchell L 1996 Perencanaan Teknik Mesin (Erlangga, Jakarta)
- [12] Sapto D A and Argeswara I 2021 Perancangan Desain Rangka dan Analisis Pembebanan Statik Mesin Pencetak Pelet (Jurnal Teknik Mesin Universitas Gunadharma Depok)
- [13] Sofyan A Glusevic J A J Zulfikar U B 2019 Analysis of Frame Strength on Onion Dryer Machine with Ansys APDL 15.0 Software, JMEMME (Journal of Mechanical Engineering, Manufactures, Materials and Energy) pp 20-28

- [14] Chen S J Chen C Y and Lin M R 2018 Risk Factors for Crash Involvement in Older Motorcycle Riders. *Accident Analysis and Prevention* (National Library of Medicine) pp 109-114
- [15] Kesya A G and Sudjatmiko 2016 Rancang bangun mesin pengiris tempe multi fungsi pada UKM Sanan – Malang (Senaspro: Seminar Nasional dan Gelar Produk)
- [16] Uslianti S E Listiana and Sedianingsih P 2015 Rancang Bangun Mesin Pengiris Tempe untuk Kelompok Usaha Dusun Karya I (Jurnal Elektronik Khatulistiwa) vol. 7 (2)
- [17] Sukanto and Erwanto 2014 Rancang Bangun Mesin Pencetak Profil Pelat Lantai Mobil dengan Ketebalan Pelat 0,8-1,2 mm (Prosiding Seminar Nasional Aplikasi Sains & Teknologi) pp. A93-99
- [18] Napitupulu R M Subkhan L Dwi N 2014 Rancang Bangun Mesin Pencacah Sampah Plastik *Jurnal Manutech* vol. 6 (2)
- [19] Sugandi W K Herwanto T and Yudi A P 2018 Rancang Bangun Mesin Pembersih dan Pengupas Kentang (*Jurnal Agrikultura*) vol. 29 (2) pp 110-118
- [20] Harsokoesoemo H D 1999 Pengantar Perancangan Teknik (Direktorat Jenderal Pendidikan Tinggi Departemen Pendidikan Nasional)
- [21] Hidajat R and Lulus L 2005 Teori dan Penerapan Metode Elemen Hingga (UNS Press, Surakarta)
- [22] Kalikate S M Patil S R and Sawant S M 2018 Simulation-Based Estimation of An Automotive magnetorheological brake system performance (*Journal of Advanced Research*) pp. 43-51