Static Strength Analysis Of Meat Grinder Frame

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Abstract.
Meat is one of the agricultural commodities needed to meet protein needs, because meat contains high quality protein, which is able to contribute complete essential amino acids. The purpose of this paper is to design, analyze the static strength of the frame based on theoretical calculations and simulations on solidwork 2018 software. This machine consists of a frame, reservoir, grinding shaft, transmission, and electric motor. The results of the design obtained a Meat Grinding Machine with Length: 610 mm, Width: 500 mm and Height: 750 mm. The material used is 2024-O Alloy with a modulus of elasticity of 72,400 N/mm². The load force obtained is 576.32 N. And the value from the analysis is the displacement value of 0.174 mm and for theoretical calculations, the displacement value is 0.176 mm. So, the value of the percentage error is 1.176%. For the von Mises value of 68,970 MPa, and for calculations based on the theory, the von Mises value is 52,499 MPa. So, the value of the error percentage is 0.238%. And for the value of the safety factor obtained a value of 1,087, and for calculations based on the theory, the value of the safety factor is 1.428. So, the value of the error percentage is 0.313%.

Keywords: *Meat Grinding Machine, Skeleton, Design, Solidworks*

I. INTRODUCTION

Meat is one type of livestock products that can hardly be separated from human life. As a food ingredient, meat is a source of animal protein with a fairly complete nutritional content. The use of meat in the food industry in Indonesia is currently showing very rapid progress. This can be seen from the emergence of various innovations made by both large-scale entrepreneurs and home industries, to produce food products that have high selling power, one of which is shredded. In the current era of globalization requires people to play an active role, use creativity and the ability to innovate to produce a quality product. Therefore, many parties are competing to create or develop technology that has benefits and is more economical.

Many new tools are made by people. This is intended to assist and simplify the work process. In addition in the working process, the production also demanded quick results, lower costs, and meet customer demands so that the business can continue to run.Based on observations conducted by the author, one of the constraints experienced by the public at large is the length of the process penyuwiran meat and the destruction of meat collision . This affects the need for large human resources and limited production, so that the shredded industry players often find it difficult to meet consumer demand. The development and application of technology such as a meat grinder for shredded production is expected to be able to support and advance small and medium-sized industries, especially in Indonesia.

II. METHODS

methods that will be applied as the basis of this research in achieving the objectives are:

1. Literature study

Collecting and studying theory and material from reference books and journals related to the problems to be discussed. Especially various things related to the analysis of static loads on the frame.

2. Field Study

The data collection method is carried out by analyzing the design of machine elements.

One part of a machine is the frame. The frame functions as a machine/tool. The frame serves as a holder for the components of a machine/tool. The frame is a flat structure consisting of a number of rods which are connected to each other at the ends with the existing splicing technology. The connection will form a solid frame where the external force and the reaction are considered to be in the same plane and only act on the load-bearing places.

Von Misses, Displacement and Safety Factor

Weight of Machine Components

Before entering into the theoretical calculations, the first step is to calculate the loading force. So that we can find out the value of the loading force that will be given to the upper surface of the meat grinding machine frame. The formula below is an equation with formula (1).

$$W = mxg \quad \text{.................................} \quad (1)$$

Where by static calculation w = *F*

$$F = mxg \quad \text{.................................} \quad (2)$$

Where

F = Compressive *Force* (N)

m = Mass of Object (Kg)

g = Gravity (m / s2)

Voltage *Misses Von*

Von misses stress that would occur lulu bilaman normal stress it is independent of orientation or angle (second invariant stress deviator *jj2* exceeds the particular evaluate constants *k* and relate it to yield in uniaxial tensile test occurs when $\sigma\sigma_1 = \sigma\sigma_0$, $\sigma\sigma_2 = \sigma\sigma_3 = 0$. The following is the formula to get the value of *Von misses stress* :

$$\sigma_{max} = \frac{\sigma x + \sigma y}{2} + \sqrt{\frac{\sigma x + \sigma y}{2}} + (\tau_{xy})^2 \quad \text{.............................} \quad (3)$$

Displacement

All structures when subjected to external loads will change slightly from their initial shape, either changing shape or changing size, which is called deformation. An increase in the size of a structure is called an elongation or elongation, while a structure that experiences a reduction in length or shrinkage is called a contraction

$$\delta = \frac{P \cdot L^3}{48 \cdot E \cdot I} \quad \text{.......................................} \quad (4)$$

Safety Factor

Theoretically this *safety factor* will serve as the basic material for making a new design of a construction. In addition, the *safety factor* will be a measure of efficiency in the use of materials used. Theoretically, the *safety factor* used on an industrial scale is between 2 – 4.

Actual

Strength Required Strength

Research Flowchart

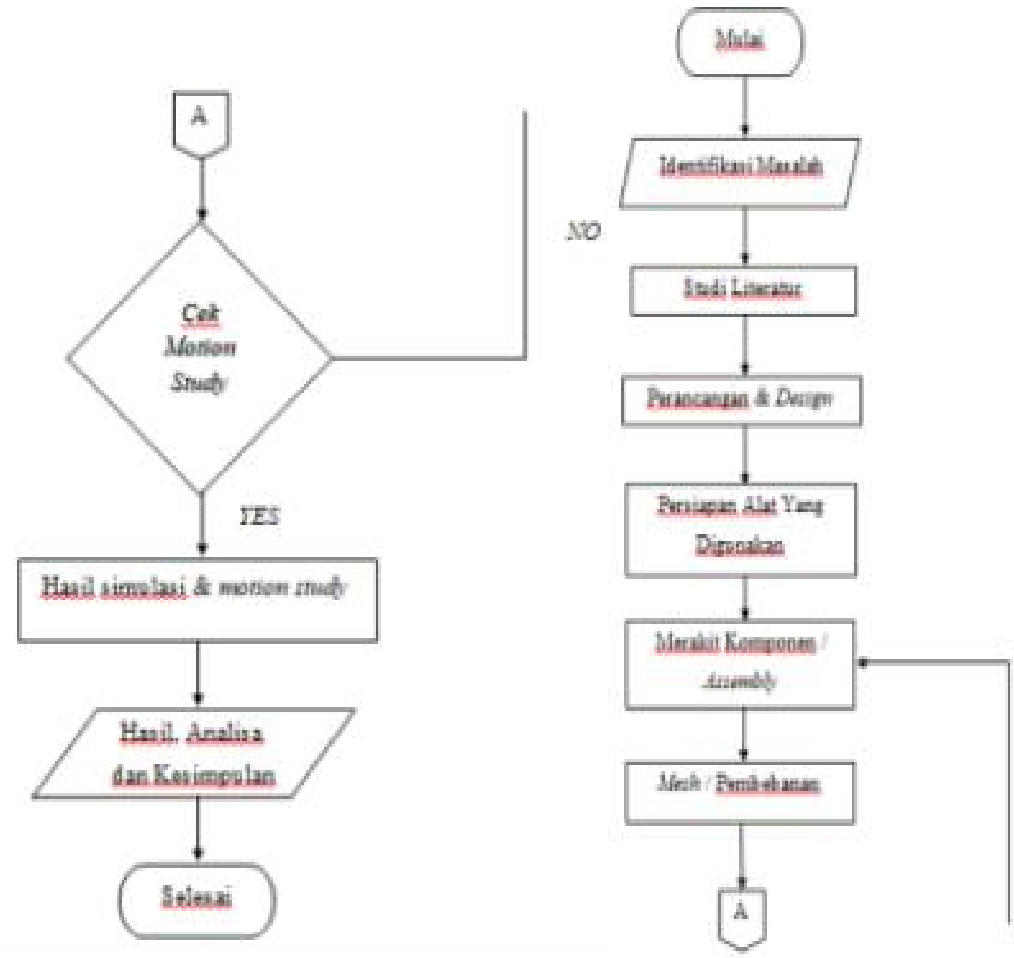

Image Flowchart

Data Calculation and Analysis of
Specifications for Meat Grinding Machine Frame

To predict the strength and quality of the meat grinding machine frame, analysis must be carried out . The analysis carried out on the meat grinding machine frame isanalysis *static* using thefeatures *simulation* available in the *solidworkssoftware.* 2018analysis *static* Thisaims to determine the *Von Misses Stress*, *Displacement* and *Safety Factor* of the meat grinding machine frame. The following is thedata *material* used for the shredder machine frame. The engine frame consists of 40 x 40 x 4 mm square iron with *2024-O alloy* material. This material is known as a ductile material, which means it has formability, besides that the material above has excellent strength for the engine frame.

Length : 610 mm
Width : 500 mm
Height : 750 mm
Material : *2024-O Alloy*
Load Force : 576.32 N
Modulus of Elasticity : 72400 N/mm^2
Cross-sectional area: 1600 mm^2
Hollow Structure : 40 x 40 x 4

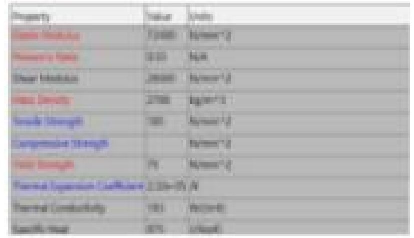

Fig1. Of Material Specification *2024-O Alloy*

Calculation of the total Mass of Meat Grinding Machine Components

Before entering into the theoretical calculations, the first step is to calculate the loading force. So that we can find out the value of the loading force that will be given to the upper surface of the meat grinding machine frame. The formula below is an equation with formula (2). $F = mxg$

$F = 58.7\ Kg\ x\ 9.81\ m/s^2$

$F = 576.32\ N$

Calculation *Displacement* With Theoretical Method

Table 1. Gravity Produced Component

No	Component	Mass Component (kg)	Component Force (N)
1	Container	55.2 kg	541.32 N
2	Shaft	3.35 kg	32.85 N
3	Bearing	0.25 kg	0.5 N
4	Bearing House	0.84 kg	1.65 N
5	Meat	10 kg	98.06 N
5	Total Mass	58.7 kg	576.32 N

The cross-sectional shape analyzed is a square 40 x 40, so the moment of inertia equation uses the equation:

$$I = \frac{b.h^3}{12}$$

$$I_{Luar} = \frac{40\ x\ (40)^3}{12}$$

$$= \frac{40\ x\ 64000}{12}$$

$$= 213333.33\ mm^4$$

After knowing the results of the *moment of inertia*, then calculate the value of the *deflection*i on the meat grinding machine with the following formula:

$$\delta = \frac{P\ x\ L^3}{48\ .E.I}$$

$$= \frac{567.32\ x\ 610^3}{48.72400.213333,33}$$

$$= 0.176\ mm$$

For the results of the *displacement* using the theoretical method that the frame can accept the load and will experience a *displacement* of 0.176 mm.

Calculation *Displacement* withSimulation *Solidworks*

In the framework there are various values of the displacement distance that occur which are marked with light blue, green, yellow, and red colors. These colors have their respective values that can be seen in the color indicators in thesimulation image *displacement* using *Solidworks* 2018.

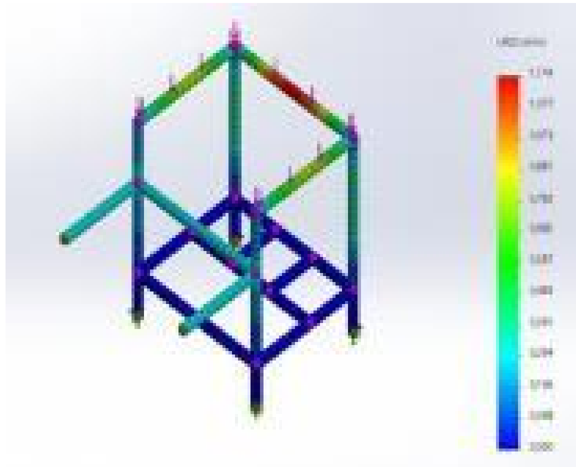

Fig 2. *Displacement* in the Meat Grinding Machine Frame The

value *displacement* maximumin the meat grinding machine frame generated in thesimulation is *Solidworks* 20180.174 mm. *The percentage of* tools from manual calculations withcalculations *software* can be calculated using the formula using the following equation:

$$\text{Error} = \frac{\textit{Dispalecemt}\ \text{Teori} - \textit{Displacement}\ \text{Simulasi}}{\textit{Displacement}\ \text{Simulasi}} \times 100\%$$

$$\text{Error} = \frac{0.176 - 1{,}174}{1{,}174} \times 100\%$$

Error = 1.176 %

Calculation *Von Mises* With TheTheory Method

Von Mises is the stress that occurs on the surface of the object as a result of loading, in this case the one affected by the load is the frame on the Meat Slicing Machine with the received load of 576.32 N. To get From theresults *von Mises* , the shear stress and normal stress were calculated first. And shear stress formula used is in accordance with the formula equation:

$$\tau_{xy} = \frac{T}{2.Am.t} = \frac{576.32 \times 610}{2 \times 1600 \times 4} = 27.465\ \text{N/mm}^2$$

Where:

T = F x L

A = Cross-sectional Area (mm2)

t = Hollow Thickness

After getting the shear stress value, then the next calculation is carried out to determine the value of the normal stress. And for the normal stress formula used is in accordance with the equation: $\sigma_t = \frac{M.y}{I}$

Where :

t = Normal Stress N/mm^2

M = Moment that occurs (N.mm)

y = Equation of center of gravity for square shape (mm)

I = *Moment of Inertia* (mm^4)

The value of center of gravity of y axis is :

y = $^{40}2$

y = 20 mm

So, σt = ^{My}

��

= $^{351555,2x\ 20}$

213333.33

= 32,958 N/mm^2

Results of shear and normal stresses will be used in the equation voltage *Von*misses,adapaun formula as follows:

$$\sigma_{min} = \frac{\sigma x + \sigma y}{2} + \sqrt{\frac{\sigma x + \sigma y}{2} + (\tau xy)^2}$$

Where:
max = Maximum normal
force acting x
= Force acting on the x axis y = Force acting on the y axis
xy = Shear Stress

So to get thestress *von Mises* maximumis: $_2$+ √$^{+2}$+ ()^2

$$\sigma max = \frac{\sigma x + \sigma y}{2} + \sqrt{\frac{\sigma x + \sigma y^2 + (\tau xy)^2}{2}}$$

$$\sigma max = \frac{32.958}{2} + \sqrt{\frac{32.958^2 + (27,465)^2}{2}}$$

16 479 N / mm^2 + √543.114 + 754 326

σmax = 16 479 N / mm^2 + √1297.44

max = 16,479 N/mm^2 + 36.02 N/mm^2

max = 52,499 N/mm^2 (Mpa)

Calculation *Von Mises* WithSimulation *Solidworks*

The results of the analysis using *Solidworks* 2018 can be seen from the frame simulation results that the maximum stress experienced by the frame is 68,970 MPa and the minimum is 0.000 MPa.

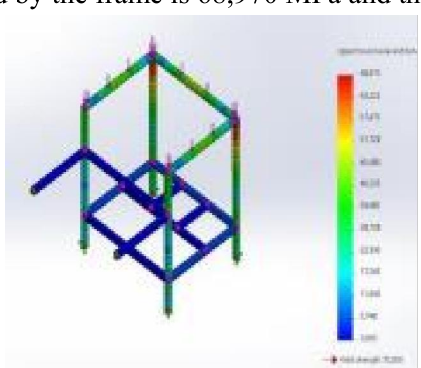

Fig 3. of *Von Misses* on the Frame of a Meat Grinding Machine

Then the percentage of manual calculations with results from analysis using *Solidworkssoftware* 2018using the equation:

$$\text{Error} = \frac{\textit{Von Mises}\ \text{Teori} - \textit{Von Mises}\ \text{Simulasi}}{\text{Von Mises Simulasi}} \text{ x } 100\%$$

$$= \frac{52.499 - 68.970}{68.970} \text{ x } 100$$

= 0.238 %

Calculation of *Safety Factor* Using Theoretical Method

The safety factor in the theoretical calculation is using the formula for maximum stress divided by *yield strength*.

$$SF = \frac{Yield\ strength}{Max\ Stress}$$

$$SF = \frac{75}{52{,}499}$$

$SF =$ 1.428

Calculation of *Safety Factor* withSimulation *Solidworks*

analysis result can be seen in its minimum limit order has a value of 1,087 is very safe for a given load

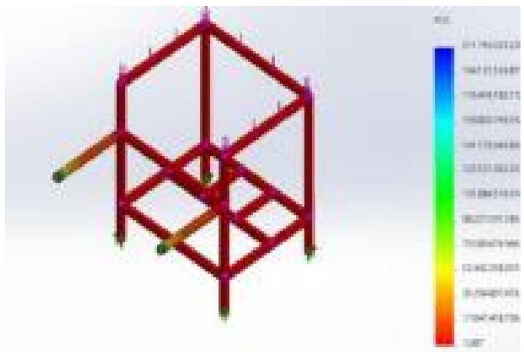

Fig 4. *Safety Factor* frame Machinein Meat grinder

From this analysis it was found that SF is equal to 3,003 then with so this SF value is still safe after being loaded.

$$\eta = \frac{Safety\ Factor\ Teori - Safety\ Factor\ Simulasi}{afety\ Factor\ Simulasi} \times 100\%$$

$$= \frac{1.428 - 1.087}{1.087} \times 100$$

$= 0.313\ \%$

ComparisonThe

Resultsresults from the simulation produce several analyzes, as shown in the table:

Table 4.2 Comparison Results of Theory and Simulation Calculations

No.	Types of	Theory	Simulation	Comparison Results
1	*Displacement*	0.176 mm	1.174 mm	1.176 %
2	*Von Mises*	52.499 Mpa	68.970 Mpa	0.238 %
3	*Safety Factor*	1.428	1.087	0.313 %

Based on the data in the table, it is known that there are still differences in the results of the Solidworks software simulation and the results of manual theoretical calculations as indicated by the absolute error percentage, it can be seen that thevalue *absolute error* cannot be said to be very low, many factors are involved. greatly affects the value of thesimulation results *software* and manual theoretical calculations, for example, such as the size of the meshing value in the input data simulation *software*, and also the use of rounding decimal numbers in manual theoretical calculations, these numbers are quite small, especially in thevalues *displacement*, differences on the 3rd digit in after the comma can greatly affect the final value. But in general thevalue is *absolute error* still relatively low, which is still below 50%.

III. CONCLUSION

Conclusion

Based on the simulation results on the frame of the meat shredding machine using *solidworks software,* several conclusions were obtained, namely:

1. The design of a meat shredding machine was obtained with a length: 610 mm, width: 500 mm and height: 750 mm. The material used is *2024-O Alloy* with a *modulus of elasticity* of 72,400 N/mm^2. The load force obtained is 576.32 N.

2. The most important thing in the design stage of a mechanical component is knowledge of the load acting on the mechanical component. After getting the results from the *software,* then a comparison is made with manual calculations. Comparison of the results of manual calculations with the calculation results of *software* thisaims to see the percentage of errors in calculations, because the calculation process on the computer is only a process of approaching the right answer. This manual calculation uses the basic formulas of stress, strain and factor of safety to determine the *Stress*, *Displacement* and *Safety Factor.*

3. Based on the simulation that has been carried out on theframe/*chassis* Meat Grinding Machineusing the *Solidworkssoftware* 2018, the results of thecalculation are obtained *displacement* using the theoretical method that the frame can accept the load and will experience a *displacement*of 0.176 mm. While the results of the calculation *software*

Get 0.174 mm. Based on the simulation that has been carried out using the *Solidworks 2018 software*, the results of thecalculation *von Mises* using the theoretical method are 52,499 MPa, and for thecalculation the *software* results are 68,970 MPa. Based on the simulations that have been carried out using the *Solidworkssoftware* 2018, the results of the calculation of the *safety factor* using the theoretical method are 1,428, and for the results of thecalculations, the *software* results are 1,087.

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