Journal Multidisciplanary Research and Technology
Vol. 1 No. 1 January 2025
e-ISSN: XXXX-XXX; p-ISSN: XXXX-XXX, Hal 24-31
Available online at: https://journal.iset.or.id/index.php/J-MART/article/view/4

DESIGN AND ANALYSIS OF SHAFT STRENGTH IN OIL DRAINING MACHINE

Supriyono[1], Arden Parasi[2]
[1,2]Mechanical Engineering, Faculty of Industrial Technology, Gunadarma University, Indonesia

Abstract: The oil draining machine is designed to facilitate industries, particularly household food industries. This machine aims to optimize the process of removing excess oil from food after cooking, thereby providing time efficiency compared to the manual method of letting the oil drain passively. This study focuses on designing, developing, and analyzing the shaft of the oil draining machine, as well as conducting a torsional load test to determine the values of von Mises stress, displacement, and safety factor. The operating principle of the oil draining machine is powered by a 2 HP (1.5 kW) electric motor that generates 1400 RPM. This electric motor drives two pulleys, which in turn rotate the shaft. As the shaft rotates, it spins the filtering mechanism, causing the food inside to rotate and allowing the remaining oil to separate from the food. The shaft is made of solid steel with a diameter of Ø19 mm, using AISI 1045 cold-drawn steel as the material. From the testing and analysis conducted on the shaft, the results show a von Mises stress value of 216.1 MPa, a maximum displacement of 18.549 mm, and the smallest safety factor value of 2.5. The analysis and design were carried out using SolidWorks software.
KeyWords: Machine design, oil draining, shaft strength

INTRODUCTION

Technology in the industrial sector which is increasingly developing rapidly has led to the emergence of oil as a medium for frying food which is widely consumed by the wider community. In general, cooking oil consists of two groups, namely animal cooking oil and vegetable cooking oil. Of the two groups of oils, vegetable oil is the most widely used oil, especially for frying and is easy to obtain. Vegetable cooking oil can be made from several sources such as coconut, palm oil and soybeans.

Existing draining machines are generally still used in the food industry and there are still some shortcomings because the needs of oil drainers used in the food industry are not the same as the needs of household kitchens. Such as an unattractive design, the size is too big, it is difficult to open the lid of the draining basket, the tube frame does not have a slope so that the oil from draining will accumulate in the tube and not be channeled into the container and there is no filter to re-filter the oil from frying so that the oil comes out. clean, so as to reduce the harmful impacts of repeated use of oil.[2]

The shaft is a very important machine component because it functions as a transmitter of power and rotation from one machine component to other machine elements. Considering the very important function of the shaft, this component must be designed and ensured to be able to work well. By designing the shaft in the machine, we can determine the right material, find out the von Misses stress value and safety factor for the shaft that will be made in order to minimize all types of damage caused by a lack of good planning. Planning for making a shaft using carbon steel material (Aisi 1045 *Steel Cold Drawn*) which rests on a small pully using a pin for the hook on this oil draining machine.[8]

Therefore, in designing an oil draining machine, the following things need to be done:
Design and selection of appropriate shaft specifications for oil draining machines. Apart from that, it is also necessary to analyze the strength of the shaft looking at the values from the von Misses stress, displacement and safety factor tests.

RESEARCH METHODOLOGY

Design Flow and Shaft Strength of Oil Draining Machine

An oil drainer machine is a machine designed to simplify and speed up the process of separating oil from cooked food. This machine is made for use in the home industry, there are supporting components to support the performance of the oil drainer machine itself.

The shaft is the main component used to support the performance of the oil drainer machine, here is the flow diagram or (*flowchart*) the design process and torque testing on the oil drainer shaft using Solidwork software, as follows:

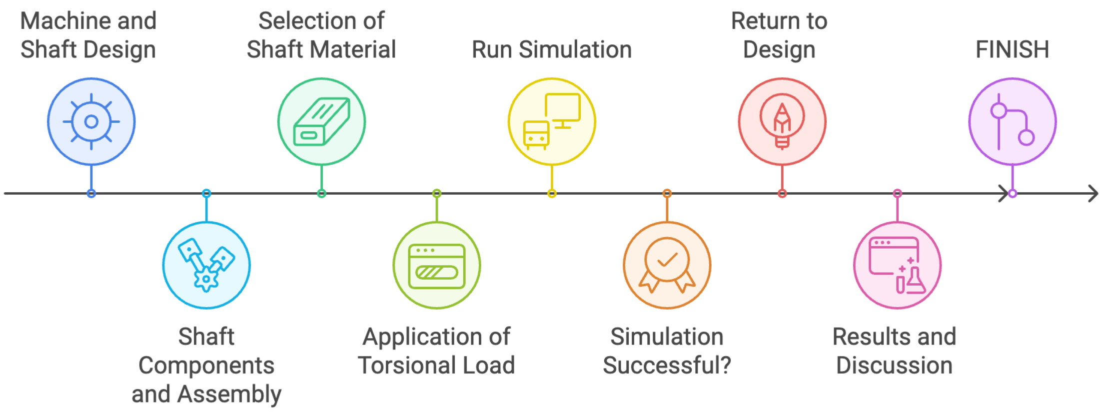

Figure 1. Flowchart for designing and simulating the strength of the oil drainer machine shaft

Machine and Shaft Design

Before the shaft design process, of course, it begins with designing the oil drainer as a whole. Meanwhile, the shaft design is carried out by paying attention to several of the most important things in shaft design so that the shaft can optimally support the work of the oil drainer machine, including:

1. Determine the size and dimensions of the shaft, such as the diameter and length of the shaft.
2. Pay attention to the materials used in shaft design.
3. Determine the rotational speed of the shaft.
4. Pay attention to the components that will be installed on the shaft.
5. Take into account the magnitude of the torque value on the shaft.

The assembly process is a process where the components used in the oil drainer will be combined using Solidworks software. The combination of these components is in accordance with the concept and design assumptions of the oil drainer machine. The following are some of the components used in designing the shaft assembly, namely:

- Shaft, material from AISI 1045, with dimensions: Ø12mm x 939mm.
- Large Pully, material from AISI 1045, with dimensions: Ø120 mm.
- Small Pully, material from AISI 1045, with dimensions: Ø60 mm
- Bearing, material from Chrome Stainless Steel, with dimensions: Ø18 mm
- V-belt transmission, material made from: Rubber, with size: 741 mm

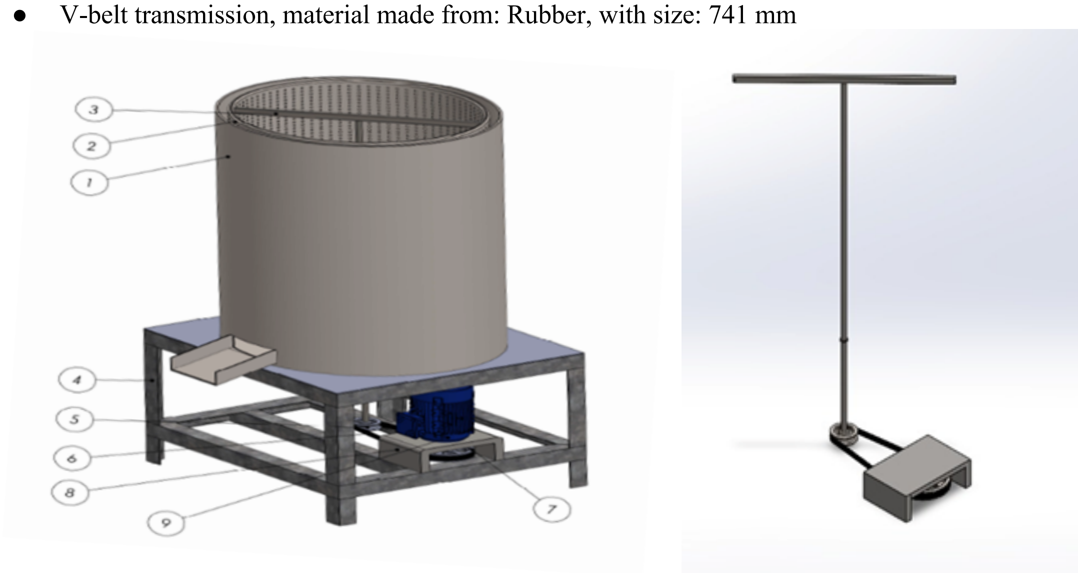

Figure 2. Design of oil drainer machine and shaft

Description of the main components of the machine:

1. Oil drain tube
2. Swivel tube
3. Oil drain shaft
4. Vertical frame of the machine
5. Horizontal frame of the machine
6. Transmission sabuk-v (V-Belt)

7. Drive pulley
8. Electric motor mount
9. Electric motor

Shaft Material Selection

At the shaft design stage, there are important things that must be considered, one of which is the type of material selected according to the needs and uses of the shaft itself. The type of material chosen for the oil drainer shaft is alloy steel (AISI 1045). The material strength specifications of AISI 1045 *Steel Cold Drawn* are as follows:

Table 1. AISI 1045 material specifications *steel cold drawn*

Property	Value
Elastic Modulus	205000 N/m^2
Poisson's Ratio	0.29 N/A
Shear Modulus	80000 N/m^2
Mass Density	7.845 Kg/m^3
Tensile Strength	625 N/m^2
Comperssive Strength	N/m^2
Yield Strength	530 N/m^2
Thermal Expansion Coefficient	1.15e-05 / K
Thermal Conductivity	42.7 W/m-K
Specific Heat	486 J/(Kg.K)

Determining the Fulcrum Point and Applying Torque Load

At the simulation process stage *fixed geometry*, the axis will be determined as a stationary fulcrum point *(fixed geometry*) on the shaft, namely the small pully part that is connected to the shaft. It is assumed that when the components are assembled, the pully is attached to the shaft.

The simulation process of applying a torque load to the shaft to determine the effect of the torque load on the strength of the shaft. Previously, the torque value to be charged was 10.22 N.m (according to the torque of the drive motor), with the direction of rotation clockwise. The torque value is obtained from the results of the electric motor power calculations carried out, the simulation of giving the torque value is carried out using Solidworks software.

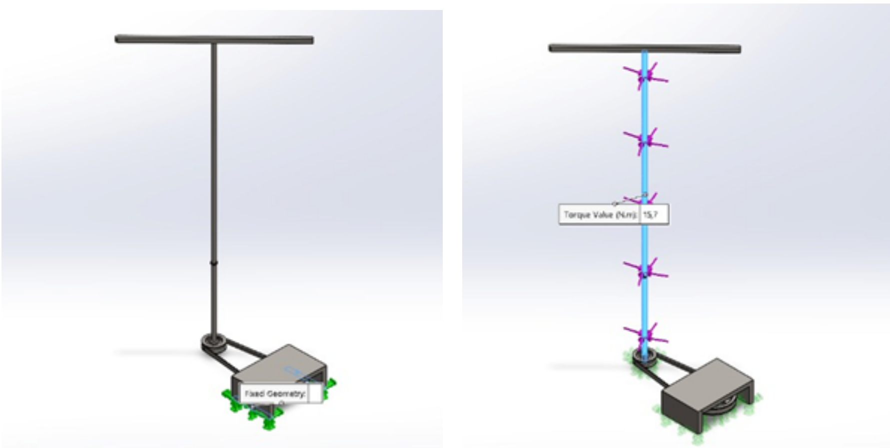

Figure 3. Fixed geometry and provision of torque loads

Run and Analysis of Simulation Results

The process of dividing the components to be analyzed into small or discrete elements (meshing), the greater the number of meshes, the better the analysis results. After the meshing process is complete, the Solidworks software will then work to analyze the overall part of the shaft component which will then display analysis results such as von misses, displacement and safety factors. The next stage is checking the results of the simulation with torque loads. If the test results show that the functionality is not good enough, if there are still deficiencies, the shaft will be re-designed. Once the redesign is complete, the shaft can be assumed to be used in the oil draining machine. After carrying out all the analyzes on the shaft, the results of each simulation are known, where you can see the results of the von misses analysis, displacement and safety factor values.

RESULTS AND DISCUSSION

Working Principle of Oil Draining Machine Shaft

The working principle of this oil draining machine shaft can work with a power source produced by an electric motor with a capacity of 2 HP (1.5 Kw) with a shaft rotation of 1400 rpm. With the capacity of the electric motor dynamo, the transmission system can move.

The power generated by the electric motor dynamo is used to move the large pully (drive) and the power generated will be transferred using a V-belt to the small pully (drive). So after all the power has been transferred by the transmission, the shaft will move clockwise which moves in conjunction with the body in the oil drainer machine. So the results of the rotational performance of the shaft can be used as a separator of oil from the food rotating in it.

V-Belt Transmission System Design

Transmission system design is a very important basis in designing a tool or machine construction. The following is the design needed to make an oil drainer machine. It is necessary to pay attention to the planning of the electric motor so that the oil draining machine can operate well. This electric motor has a big influence on the final result of the level of food oil that has been drained from the machine. Therefore, it is necessary to plan the electric motor, the power planning is needed according to the capacity of the oil drainer:
Transmitted design power (P): = 2 HP = 1.5 kw

Next, go to the calculation stage for the driven shaft (n2) using the formula:

n2 = n1xd1/d2
= 1400 x 120/60 = 2800 Rpm

Where : Drive pulley rotation (n1) = 1400 Rpm
Rotation of the driven pulley (n2) = Rpm
Drive pully diameter (d1) = 120 mm
The diameter of the driven pulley (d2) = 60 mm

V-belt transmission *(V-belt)* is the main component in the drive system where its function is to distribute power from *pully* mover to *pully* which is moved, then from that in planning *v-belt* It is necessary to calculate the type of belt used and the length of the belt to be used. The process for calculating a v-belt transmission system is as follows:

- **Plan Moment (T):**

To determine the planned moment *v-belt*, for:
Design moment on the drive pulley (T_1) = $9{,}74.10^5 \frac{p_d}{n_1}(kg.mm)$ = 1565.3 Kg.mm

Design moment on the driven pulley (T_2) = $9{,}74.10^5 \frac{p_d}{n_2}(kg.mm)$ = 782.6 Kg.mm

- **Belt Speed (V):**

To find the belt speed, use the following formula, and if the resulting value of the belt rotation speed is less than 30 m/s then it is considered good and does not exceed the permitted speed limit.

$$V = \frac{p.d.n_1}{60.1000} = \frac{3.14\times60\times1400}{60\times1000} = 4.396 \text{ m/s}$$

The results obtained for the belt rotation speed were 4,396 m/s below 30 m/s where the rotation was still below the standard v-belt rotation speed.

- **Belt Circumference Length (L):**

The belt length is calculated by the formula (L) = $2C + \frac{\pi}{2}(D_p + d_p) + \frac{1}{4c}(D_p d_p)^2$

$$= 2 \times 741 + \frac{\pi}{2}(120 + 60) + \frac{1}{4\times741}(120 - 60)^2 = 1765.95 \text{ mm}$$

- **Axis Axis Distance (C):**

To determine the axis distance on the shaft (c) based on the standard belt circumference, use the following formula:

$$b = 2L - 3{,}14\,(D_p + d_p)$$
$$= 2 \times 1765.95 - 3{,}14\,(120 + 60) = 2966.7 \text{ mm}$$

$C = \frac{b+\sqrt{b^2-8(D_p+d_p)2}}{8} \quad = \frac{2966.7+\sqrt{2966.7^2-8(120+60)2}}{8} \quad = 736.173\ mm$

- **Contact Angle (θ) :**

To determine the contact angle *v-belt* on *pully* using the formula:

$\theta = 180 - \frac{57(120+60)}{736.173} \quad = 166.063^o$

Shaft Design

In the shaft design stage, there are several things that must be considered by the designer, so that the machine shaft design is in accordance with the needs and specifications, namely:

- **Determine the shaft diameter**

To determine the diameter of the shaft, first carry out calculations using the following formula: $Ds = \left[\frac{5.1}{the} k_t c_b T\right]^{1/3}$

Where : Ds = Diameter poros (mm)
τa = Permissible stress on the shaft (kg/mm^2)
Kt = Correction factor for torsional loads of (1.5 to 3.0)
Cb = Correction factor for bending loads with a value of (1.2 to 2.3)
T = Designed twisting moment (kg/mm)

If the possibility that the shaft will receive shock and impact loads is large, then multiplied by the impact correction factor on the shaft (1.5 to 3.0), the value taken for (Kt) is 2.0. In this mechanism, it is also possible that bending loads will occur, so the value of the correction factor multiplied for bending loads (Cb) is 2.0.

To reach the value of the shaft dimensions, you must first find the value of the twisting moment of the shaft. It is known that the planned power on the shaft (P_d) is 1.5 Kw and the resulting shaft rotation (n1) is 1400 rpm. So the magnitude of the twisting moment that occurs is:

$$T = 9.74\ x\ 10^5 \frac{Pd}{n1} = 1043 \text{ Kg.mm}$$

So that the diameter of the shaft can be determined:

$$Ds = \left[\frac{5.1}{3.0} 2.0 \times 2.0 \times 1043\right]^{1/3} = 19 \text{ mm}$$

- **Calculating Torque and Stress on the Shaft**

This time the shape design uses a type of shaft with a uniform diameter that is round or solid. The planning of the material used to make the shaft using the type of material selected must be in accordance with the needs and uses of the shaft itself later. For the shaft material used in forming the shaft of the oil drainer machine, use the type of alloy steel material (AISI 1045), according to the standard JIS G4501, AISI 1045 material has a tensile strength of (σB) = 55 Kg/mm^2.

So the torque received on the shaft can be calculated from the design power of the shaft (P_d) of 1.5 Kw and shaft rotation (n_1) of 1400 rpm. The amount of shaft torque received can be calculated using the formula, namely:

$$T = \frac{60000}{\frac{22}{7}\times 2} \times \frac{pd}{n1} \quad = \frac{60000}{\frac{22}{7}\times 2} \times \frac{1.5}{1400} \quad = 10.22 \text{ Nm}$$

- **Shaft permissible voltage**

In the shaft planning, AISI 1045 type steel material was chosen with a tensile strength of 55 Kg/mm^2 = 540 N/mm^2. The AISI 1045 material shows the maximum tensile strength of the type of steel itself. For the safety factor of this type of carbon steel material then ($Sf1$) for SC material and is 6.0, the effect of stress concentration, if the shaft is provided with a keyway, is ($sf2$) safety factor due to keyway is 3.1, then the allowable stress can be calculated. Then, to find out the allowable stress value, it can be obtained using the following formula:

$$the = \frac{tB}{sf1 \times sf2} \quad = \frac{55}{6.0\ x\ 3.1} \quad = 2.95 \text{ or } 3.0 \text{ kg/mm}^2 = 30 \text{ N/mm}^2$$

- **The shear stress that occurs**

Based on the permissible shear stress in the shaft, the value is 30 N/mm^2 and the planned shaft diameter is 19 mm, then the shear stress on the shaft can be calculated as:

$$t = \frac{16 \times T \times 10^3}{3{,}14 \times ds^3} \quad = \frac{16 \times 10.22 \times 10^3}{3{,}14 \times (19^3)} = 7.6 \text{ N/mm}^2$$

So the voltage that occurs 7.6 N/mm^2 still in the safe category, because it is still below the permitted tension, namely 30 N/mm^2.

Shaft Strength Analysis Using Simulation

This analysis aims to determine the potential for failure due to torque loads, such as the voltage value (*stress*), deformation (*displacement*), and value *safety factor* which will determine whether the structure is able to withstand the given torque load or not. After carrying out the running process, the output results obtained from the simulation results are processed using *software solidworks* namely by getting value *von misses stress, displacement,* And *safety of factor* from the analyzed shaft design.

From the results of simulations carried out using *software solidwork* It was found that the maximum stress or tension on the oil drainer machine shaft was 216.1 N/mm^2 (Mpa), while for value *by mises* drinking is 21.6 N/mm^2 (Mpa).

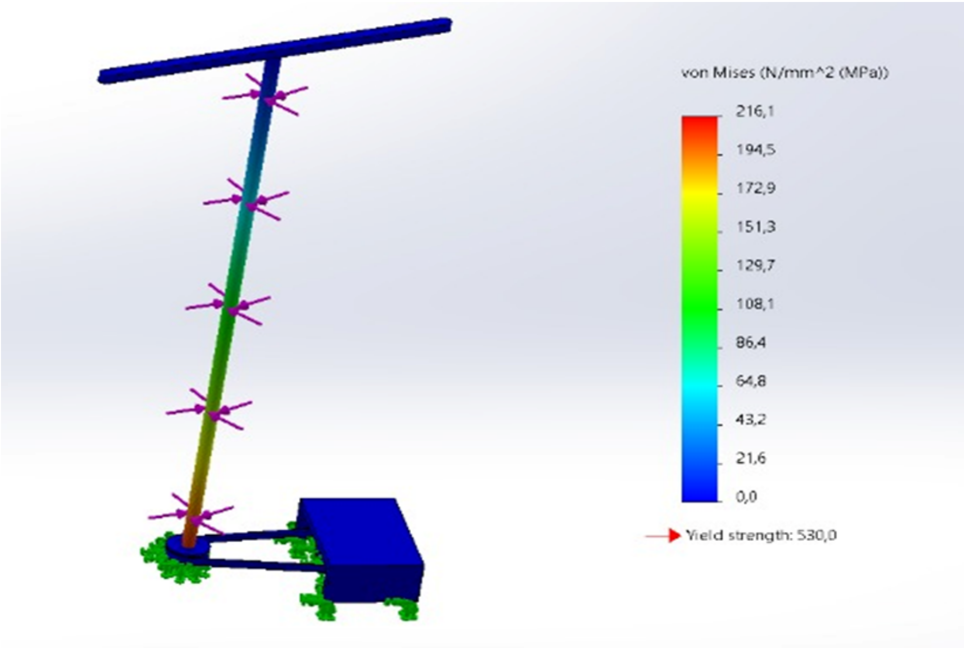

Figure 4. The maximum stress results that occur (*from misses stress*)

In the results of the displacement test analysis, the highest figure obtained shows a value of 18,549 mm and the lowest value shows a value of 1,855 mm. In the analysis of test results using Solidworks, it shows that a fairly large part experiences deformation, namely the shaft connecting with the inner body which is marked with color. red.

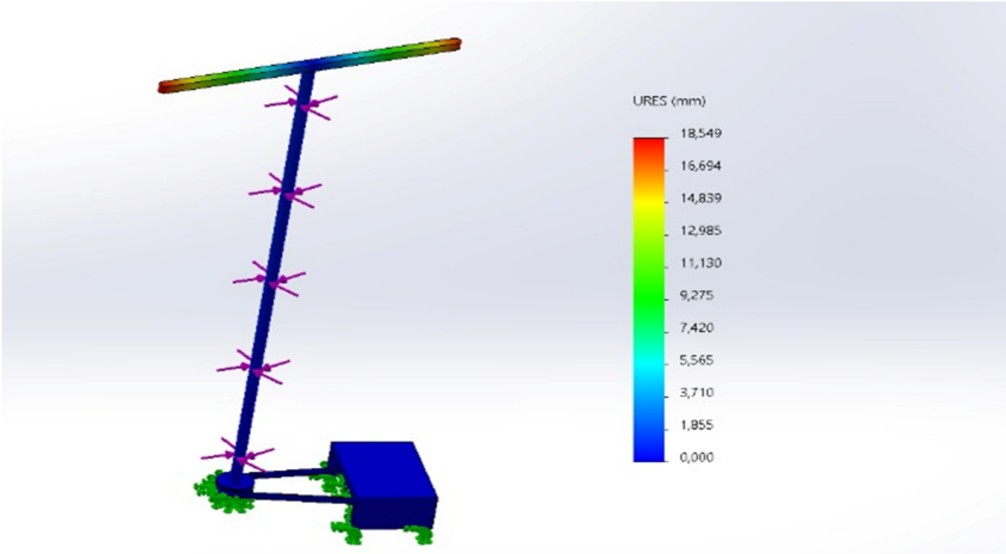

Figure 5. The result of the maximum deformation that occurs (*displacement*)

And the results obtained from the factor of safety (FOS) analysis calculated using Solidworks have an FOS value of 2.5 ul, which means that the oil drainer machine shaft is safe when given a torque load of 10.22 Nm. The following image below shows the value of the factor of safety in the design the shaft

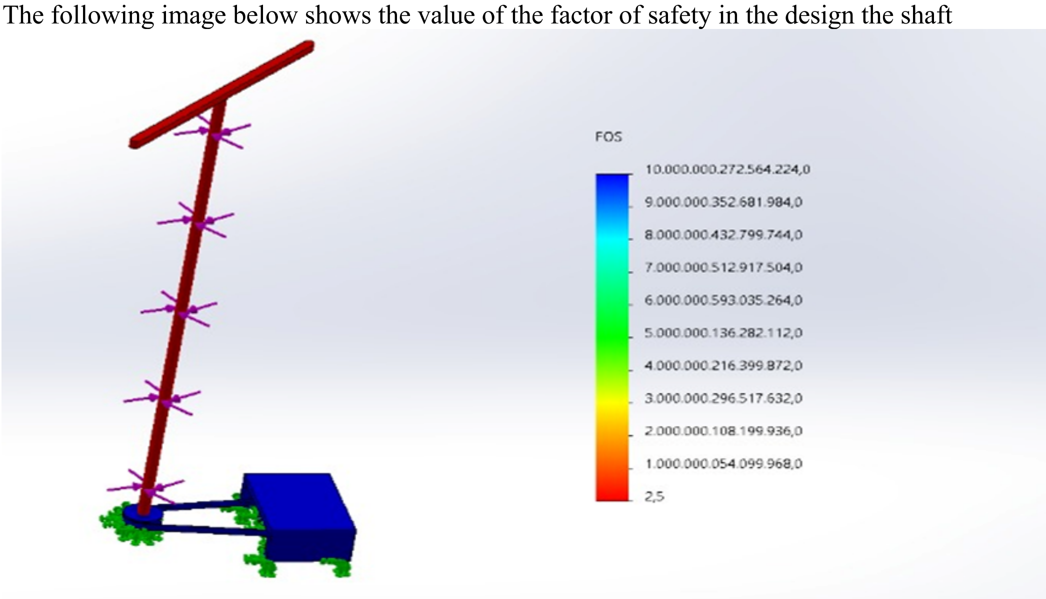

Figure 6. The result of the shaft safety factor value (*factor of safety*)

CONCLUSION

Based on the results of the strength analysis that has been carried out on the design of the oil drainer shaft with the help of Solidworks software, it can be concluded as follows:

1. In designing the oil drainer shaft from AISI 1045 steel material, with a diameter of 19 mm, which receives torque loads from an electric motor with a power of 2 HP (1.5 kW). Power and rotation are transmitted using a V-belt transmission with pulley rotation (n1) = 1400 rpm and (n2) = 2800 rpm. And then a simulation is carried out to determine the strength of the oil drainer shaft, based on the values *von misses stres, displacement dan safety of factor*.
2. Based on the simulation results obtained from the design of the oil drainer shaft with a torque load of 10.22 Nm using Solidwork software, the analysis results were obtained *from misses stress* of 216.1 N/mm^2 (MPa). Meanwhile, from the results obtained in the simulation *displacement* maximum of 18,549 mm, and value *factor of safety* the smallest of 2.5 ul is still said to be safe.

REFERENCE

[1] Huda, S. (2019), "Design of an Oil Draining Machine". Malang Institute of Technology Thesis. Poor.
[2] Jalaluddin Umar, (2009), "Theory of Mechanics and Strength Analysis", Materials, Student Library, North Sumatra.
[3] Sularso and Kiyokatsu Suga, (1997), "Basics of Planning and Selection of Machine Elements", PT Pradyna Paramita, Jakarta.
[4] Erlangga, DA., (2018), "Design of an Oil Draining Machine (Spiner) for Household Kitchen Needs Using the Triz Method", Thesis at the Islamic University of Indonesia, Yogyakarta.
[5] Permana, Y. Riyadi, S., (2021), "Design of an Oil Draining Machine Using a Rotary System", Journal of Galuh University, Ciamis.
[6] Alfhiansyah, R. Widiantoro, H., (2020), "Design of a Seroja Cake Oil Draining Machine with a Capacity of 2 Kg with a Microcontroller", Journal of Industrial Research Workshop and National Seminar, Bandung.
[7] Istiqlaliyah, H., (2015), "Design of a Machine for Draining Oil for Jackfruit Chips with a Capacity of 2.5 Kg/Minute", Journal of Universitas Nusantara PGRI Kediri, Kediri.
[8] Wahyudi, B., (2021), "Design and Analysis of Knife Shafts for Crushing Dry Leaf Waste for Compost Raw Materials Using Solidworks 2018 Software", Gunadarma University, Jakarta.
[9] Zulfadi, M., (2021), "Design of an Orange Fruit Sorting Machine with a Capacity of 800 Kg/Hr", Thesis, Muhammadiyah University of North Sumatra, Medan.
[10] Saputra, J. Fahmi, K. Endah, N., (2019), "Modification of Design and Construction of Multi-Purpose Oil Draining Machine" Thesis of Bangka Belitung State Manufacturing Polytechnic, Bangka Belitung.