http://jurnal.unmer.ac.id/index.php/jtmt
TRANSMISI
ISSN (print): 9-772580-228020
ISSN (online): 2580-2283

Strength Analysis of Cane Cutter Knives at PG Krebet Baru I Using ANSYS Workbench 2025 R1

Rahmat Fahil Fadilillah 1[a*], Agus Iswantoko 2[a], Sufiyanto 3[a]

Program Studi Teknik Mesin Universitas Merdeka Malang,Jl, Terusan Dieng No 62-64 Klojen,Pisang Candi Sukun,Malang 65146, JawaTimur,Indonesia.
**Corresponding author email: fahilrf@gmail.com*

ARTICLE INFORMATION

Received: 1 August 2025
Revised: 3 August 2025
Accepted: 25 August 2025
Published: 1 September 2025

ABSTRACT

The blade on the cane cutter machine is the part most susceptible to damage because it operates under dynamic conditions with high impact loads, continuous friction, and rapid rotation. Blade damage on the cane cutter at PG Krebet Baru I is a recurring problem, with replacement frequency reaching six times per milling season. The topic of this research is to analyze the strength of the cane cutter blade at PG Krebet Baru I using ANSYS Workbench 2025 R1 software. The blade strength analysis includes stress distribution, deformation, and safety factor for each load variable using ANSYS Workbench 2025 R1. The limitations of this study include: simulations conducted only on the cane cutter blade under static load conditions, and data used as the basis for the simulation include blade dimensions, material type, and rotation speed of the cane cutter machine at PG Krebet Baru I. The results of the calculations obtained the loads applied for the simulation, namely a minimum load of 5,707 N, an average load of 8,561 N, and a maximum load of 11,415 N. The simulation results of the cane cutter blade showed that at a minimum load of 5,707 N, the Maximum Total Deformation was 0.048 mm, the Maximum (von-Mises) Stress was 22.3 MPa, the Maximum Shear Stress was 12.9 MPa, and the Safety Factor was 11.2. At the average load of 8,561 N, the Maximum Total Deformation was 0.073 mm, the Maximum (von-Mises) Stress was 33.4 MPa, the Maximum Shear Stress was 19.3 MPa, and the Safety Factor was 7.4. And at the maximum load of 11,415 N, the Maximum Total Deformation was 0.097 mm, the Maximum (von-Mises) Stress was 44.6 MPa, the Maximum Shear Stress was 25.7 MPa, and the Safety Factor was 5.6.

Keywords: *Cane Cutter, ANSYS Simulation, Strength Analysis, Stress & Deformation, Safety Factor*.

DOI: 10.26905/jtmt.v21i2.16379

1. Introduction

The sugar industry plays a vital role in maintaining national food security. Sugar cane, as the primary raw material, is cultivated across more than 400,000 hectares, with a production output of approximately 25 million tons in 2024 (BPS, 2024). In the sugar cane processing workflow, the cane cutter machine is a crucial element that determines production quality and efficiency. This machine functions to shred sugarcane stalks into small pieces to enhance the juice extraction process. The cane cutter blades are the components most vulnerable to damage due to high shock loads, intensive friction, and rapid rotation. At PG Krebet Baru I, blade failure is a common issue, requiring an average of six replacements per grinding season (PG Krebet Baru I Data, 2024). This damage is triggered by wear, cracking, and fractures resulting from the use of materials inconsistent with the workload and a lack of numerical analysis in their design.

Computer-based simulation technologies, such as the Finite Element Method (FEM) using ANSYS software, allow for the virtual analysis of stress distribution and deformation with high accuracy. These simulations help predict component failure before production begins.

Research by Siahaan (2024) demonstrated the capability of ANSYS in identifying fracture-prone points on composite shredder blades, which can also be applied to cane cutter blades. [5]

The central problem addressed in this study is the strength analysis of the cane cutter blades at PG Krebet Baru I using ANSYS Workbench software, and how the stress and deformation distributions result from the simulation. Based on this problem, the author has defined the following scope:

The data used as the simulation baseline includes blade dimensions, material types, and the rotation speed of the cane cutter machine at PG Krebet Baru I.

The loading applied during the simulation is limited to static load conditions.

The strength analysis of the cane cutter blade is based on simulation results, specifically maximum stress, maximum deformation, and the factor of safety.

Accordingly, this study aims to analyze the strength of cane cutter blades through simulations using ANSYS Workbench to identify stress distribution, deformation, and the factor of safety, as well as to pinpoint critical areas prone to damage.

.

1.1 Cane Cutter Machine

A cane cutter is a machine designed to shred sugarcane into small pieces, typically reaching sizes of 20–25 cm. This cutting process aims to facilitate further disintegration of the sugarcane by the unigrator machine, thereby increasing the efficiency of the juice extraction process. [1] The machine is equipped with sharp blades that can be arranged vertically or horizontally and is driven by a rotational or reciprocating mechanism to ensure the cutting process proceeds efficiently.

Figure 1. Cane Cutter

The working principle of a cane cutter is based on the use of cutting blades mounted on a rotor or shaft. This rotor is driven mechanically by a prime mover, such as a diesel engine or an electric motor. The drive system transmits power from the engine to the cutting blades via drive belts or gears, causing the blades to rotate and cut the sugarcane stalks efficiently. A feeding system, known as a cane carrier, directs the stalks into the cutting area. Once shredded by the cane cutter blades, the sugarcane pieces are conveyed to the unigrator to be further disintegrated until the stalk cells open, making it easier to separate the juice from the bagasse.

1.2 Machine Specifications of the Cane Cutter at PG Krebet Baru I

Tabel 1. Cane Cutter Specifications

No	Description	Specification Data
1	Merk	Dresser Turbodyne–Terry Type 703 WB
2	Serial number	D 3136
3	Power	932 Kw; Rpm: 4500
4	Input Press (N)	15 Kg/cm^2; Exh (N) 0,8 Kg/cm^2.g
5	Input Press (M)	17 Kg/cm^2; Exh (M) 0,8 Kg/cm^2.g
6	Input Temperatur (N)	350°C; Exh Temp (N) 184°C
7	Input Temperatur (M)	350°C; Exh Temp (M) 187°C
8	Triip Rpm	5198
9	Max Count Rpm	4725 1 ST Critical 7580 Rpm

Tabel 2. *Gear Box* Specifications

No	Description	Specification Data
1	Merk	Formosa ex Taiwan
2	Model	TA–400–SPC–LP
3	Power	1750 HP
4	Input Speed	4500 Rpm
5	Rotation	CCW (*Center Clock Wise*)
6	Service Factor	1,5 (min)
7	Output Speed	750 Rpm
8	Ratio	4500/750 = 6:1

Tabel 3. Rotor Specifications

No	Description	Specification Data
1	Number of Blades	12 x 4 = 48 Bit
2	Bearing	23152 CCK
3	Adapter Sleeve	H 3152
4	Bloc Bearing	SD 3152
5	Coupling Ls	Talk Gear Kopling 1060
6	Shaft	Ø 265 x 3740 mm
7	Holder (12 bh)	Lentgh 1060 x 139 mm

At the PG Krebet Baru I sugar factory, the cane cutter machine features blades mounted onto a housing or holder. These holders are installed on the shaft in a threaded or grooved arrangement. The cane cutter at PG Krebet Baru I utilizes a total of 48 blades, with each individual blade weighing approximately 18 kg. Each holder contains 2 blades, resulting in a total of 24 holders positioned at 90° intervals (perpendicular to the shaft) with a spacing of 10–20 cm between each holder. The blades are secured to the holder using three bolts: two reinforcing bolts at the bottom and one retaining bolt at the top.

The primary components within the cane cutter machine include:

1. Blade: Used to cut and shred the sugarcane.
2. Bolt: Acts as a fastener between the blade and the holder.
3. Holder: Serves as the housing or mounting base for the blades.
4. Shaft (Axle): Serves as the mounting seat for the holders, bearings, and other machine components.

5. Spacer/Ring: Used to retain and secure the components mounted on the shaft.
6. Nut: Used to lock the components installed on the shaft
7. Bearing: Supports the shaft to allow rotation without excessive friction

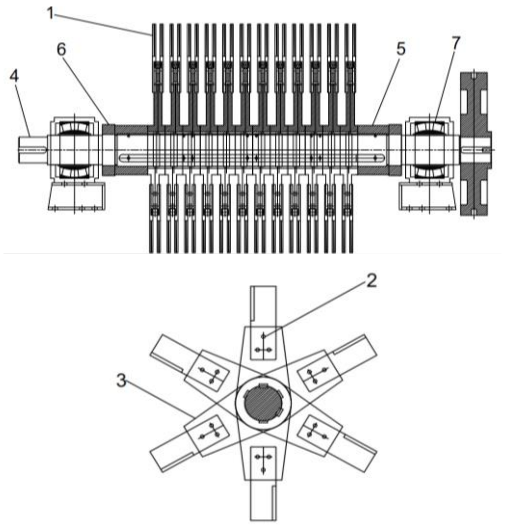


Figure 2. Cane Cutter Blade Installation

1.3 ANSYS Workbench

ANSYS Workbench is a computer software capable of solving problems based on the Finite Element Method (FEM), covering everything from modeling to analysis [9]. The fundamental advantage of ANSYS lies in its ability to divide complex structural models into smaller elements through a process called meshing, allowing it to calculate reactions resulting from loads under specified boundary conditions. This makes it highly effective and efficient for determining the magnitude of Von-Mises stress, deformation, and the factor of safety.

The ANSYS workflow begins with the pre-processing stage, which involves the initial creation of the model, assigning material properties, and performing the meshing process. This is followed by applying loads and defining boundary conditions before proceeding to the solving stage [8] Once the analysis is complete, the results can be presented in the form of contours, plots, animations, and graphs, facilitating a comprehensive analysis.

1.4 Deformation

Deformation refers to the change in shape and size of an object or surface caused by applied forces. The resulting deformation is typically non-uniform throughout the entire volume, leading to changes in each geometric line segment that vary substantially along its length [7] There are two types of deformation: elastic deformation and plastic deformation. The theory of deformation can be formulated as shown in Equation 1 below:

$$\delta l = \frac{F \,.\, l}{A \,.\, E} \ (m)$$

Dimana: δl = Deformasi (m)
F = Gaya pemotongan (N)
L = Panjang (m)
A = Luas penampang (m^2)
E = Modulus elastisitas (MPa)

1.5 Von-Mises Stress

Von Mises (1913) stated that yielding will occur when the second invariant of the stress deviator J2 exceeds a certain critical value. In other words, yielding occurs when the distortion energy or shear strain energy of the material reaches a specific critical point. Simply put, distortion energy is the portion of the total strain energy per unit volume involved in the change of shape (deformation)

$$J_2 = k_2$$

In materials science and engineering, the Von-Mises yield criterion can also be formulated in terms of Von-Mises stress or equivalent tensile stress. This scalar stress value can be calculated from the stress tensor. In this context, a material is said to begin yielding when the Von-Mises stress reaches a critical value known as the yield strength. Von-Mises stress is used to predict the yielding of a material under complex loading conditions based on results from a simple uniaxial tensile test. In general, the mathematical equation for Von-Mises stress is shown in Equation 3:

$$\sigma_v = \sqrt{1/2\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right]}$$

1.6 Safety Factor

The factor of safety is a dimensionless value derived from the ratio between the material's strength (yield tensile strength) and the working stress or maximum stress.The factor of safety is a specific method used to measure the allowable load capacity; therefore, a safety factor value (n) is required based on the specified load testing. According to [2] safety factors are categorized into three types based on the load type: static loads n = 1,25 – 2, dynamic loads = 2 – 3, and shock loads = 3 – 5. Mathematically, the equation for calculating the factor of safety is shown in Equation 4:

$$Faktor\ keamanan\ (FoS) = \frac{kekuatan\ material}{tegangan\ maksimum} \quad \text{... (4)}$$

2. Methodology of Research

2.1 Flowchart

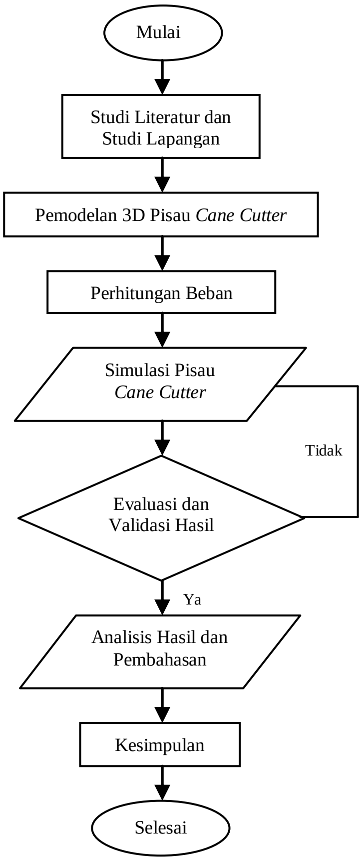


Figure 3. Flowchart

2.2 Research

This study began with a literature review and technical data collection through field studies at PG Krebet Baru I. Data such as blade dimensions, material specifications, power, and rotation speed of the cane cutter machine were used to create a 3D model of the blade using SolidWorks 2023 software. This model was subsequently simulated in ANSYS Workbench under variations of minimum, average, and maximum loading.

The simulation process initiated with material selection, followed by meshing, establishing constraints, and applying static loads to the cane cutter blade. The simulation outputs include von-Mises stress distribution, total deformation, maximum shear stress, and the factor of safety. Finally, the simulation results are analyzed to determine whether the cane cutter blade remains within safe operating limits or not

2.2.1 Research Variables

1. Independent Variables
    - Applied loads during the simulation.
2. Dependent Variables
    - Cane cutter blade material.
    - Cane cutter blade dimensions.
    - Power and rotation speed of the cane cutter machine.
    - Stress distribution, deformation, and factor of safety.

2.3 Research Location and Time

The data collection for this final project was conducted at PG Krebet Baru I, Bululawang, Malang. Meanwhile, the simulation and data processing were carried out at the Mechanical Engineering Department building, University of Merdeka Malang, on April 27, 2025.

2.4 Research Tools and Materials

2.4.1 Research Tools Used

Figure 4. Laptop

Laptop Specifications:
1. Laptop : Acer Nitro 5 AN515-57
2. *CPU* : Intel Core^{TM} i70-11800H
3. RAM : 16 GB DDR4
4. *Storage* : 512 GB SSD NVMe
5. *Dimension* : 363 mm x 255 mm x 23,9 mm
6. *Weight* : 2700 gram

2.4.2 Software Used

Figure 5. *Software* SolidWorks 2023

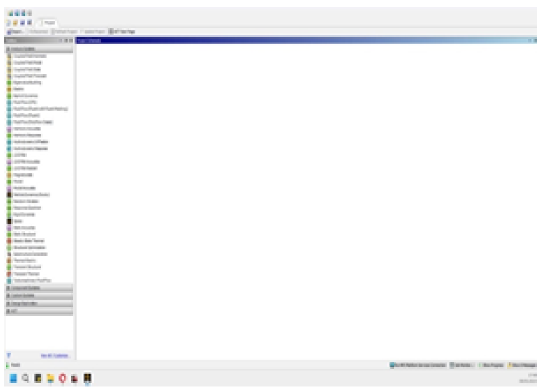


Figure 6. *Software* ANSYS Workbench 2025 R1

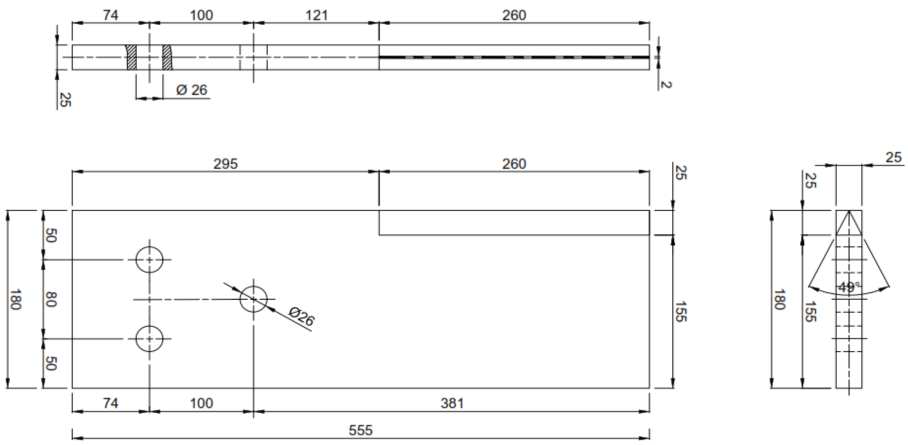


Figure 7. Engineering Drawing of the Cane Cutter Blade

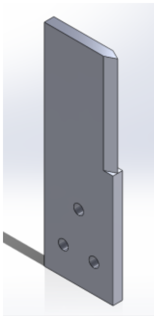


Figure 8. Cane Cutter Blade Model Design

2.5 Load Calculation

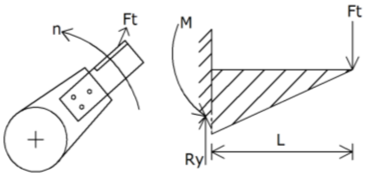


Figure 9. *Free Body Diagram* (FBD) Pisau *Cane Cutter*

Before conducting the simulation on the cane cutter blade, the loads to be applied must be calculated. The applied loads consist of minimum, average, and maximum loads, distributed uniformly across the cutting edge of the blade. To determine the maximum load, the torque formula is utilized, and the result is divided by four, corresponding to the number of blades in contact with the sugarcane during a single cutting stroke. Meanwhile, the minimum and average loads are calculated as 50% and 75% of the obtained maximum load, respectively. Based on the Free Body Diagram (FBD) above, the maximum load is calculated using the following formula:

$$T = 9{,}74 \times 10^5 \times \frac{P}{n}\ (kg.mm) \qquad \text{....... (5)}$$

Where: P: Motor power (kW)
n: Shaft speed (Rpm)

To calculate the torque value:

$$T = 9{,}74 \times 10^5 \times P/n$$
$$T = 9{,}74 \times 10^5 \times 932/750 = 1.210.357 \text{ kg.mm}$$

Where: P: Motor power (kW) = 932 kW (Tabel 1)
n: Shaft speed (Rpm) = 750 Rpm (Tabel 2)

$$T = M$$
$$T = Ft \times L \rightarrow Ft = T/L\ (kg)$$
$$Ft = 1.210.357/260$$
$$Ft = 4655{,}2 \text{ kg}$$

Where: T: Torsion (kg.mm) : 1.210.357 kg.mm
L: Length *cane cutter* (mm)
: 260 mm (Figure 7)

Thus, to determine the maximum load: (F_{maks}) :

$$F_{maks} = 4655{,}2 / 4$$
$$F_{maks} = 1164 \text{ kg} = 11.415 \text{ N}$$

Thus, the minimum load (F_{min}) and the average load ($F_{average}$):

$$F_{min} = 11415 \times 50\% = 5.707 \text{ N}$$
$$F_{average} = 11415 \times 75\% = 8.561 \text{ N}$$

2.6 Material Selection and Meshing Process

The material used for the cane cutter blade simulation is ST-60 Steel, whose physical properties are listed in Table 4. In ANSYS, ST-60 Steel is equivalent to Structural Steel, as shown in Figure 10.

Table 4. Physical Properties of ST-60 Steel

Parameters	Value
Elastic Modulus (MPa)	200000
Poisson's of Ratio	0,3
Shear Modulus (MPa)	76920
Yield Strength (MPa)	250
Mass Density (kg/m^3)	7850

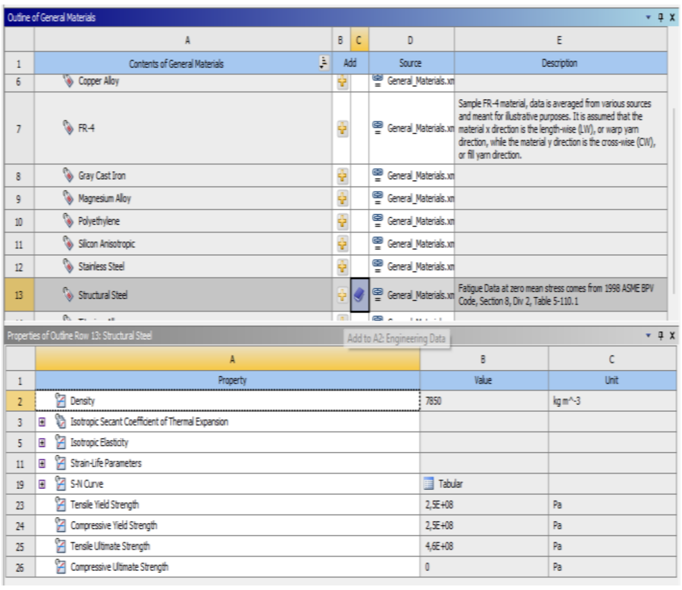


Figure 10. Inputting Material in Engineering Data

Next, the meshing process is performed, where the cane cutter blade design is divided into small elements to facilitate the software's iteration process. The simulation utilizes a mesh with an element size of 5 mm. The resulting number of nodes and elements can be seen in Figure 11..

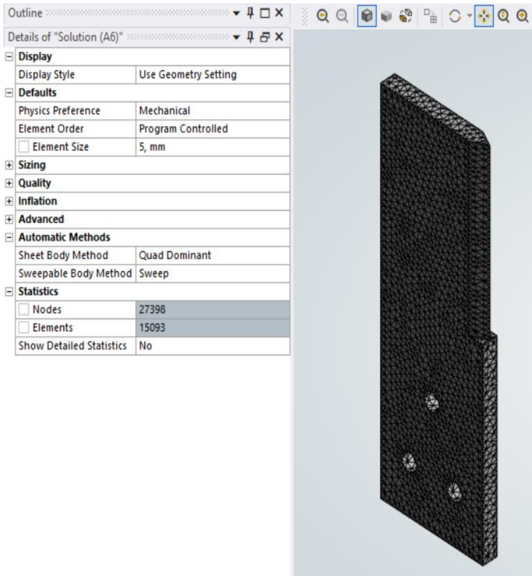


Figure 11. Hasil *Meshing Result*

2.7 Boundary Condition

The initial conditions for the model are defined using fixed supports, as shown in Figure 12. These fixed supports are applied to the bolt holes of the cane cutter blade, as this section serves as the blade's connection point to the holder. Meanwhile, the loads are applied to the cutting edge of the cane cutter blade, representing the forces encountered during operation. The loading setup is illustrated in Figure 13, featuring the load variations derived from previous calculations.

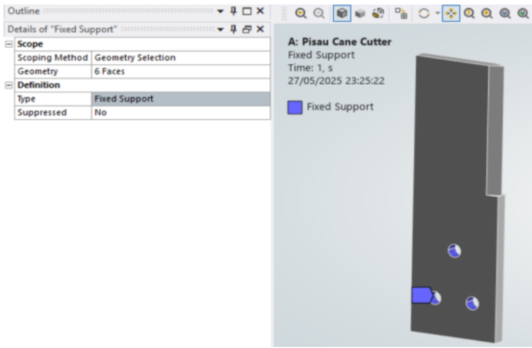


Figure 12. *Fixed Support*

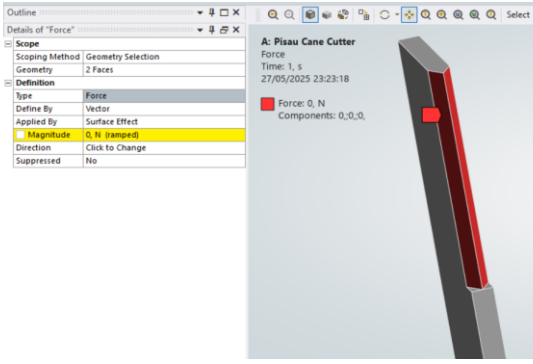


Figure 13. *Force*

3. Result and Discussion

3.1 Summary of Simulation Results

Table 5 presents the summary of the cane cutter blade simulation results, including the Maximum Total Deformation, Equivalent (von-Mises) Stress, Maximum Shear Stress, and Safety Factor under applied loads of 5,707 N, 8,561 N, and 11,415 N.

Table 5. Summary of Simulation Results *Cane Cutter*

No	Force (N)	Maximum Total Deformation (mm)	*Equivalent (Von-Mises) Stress (MPa)*	*Maximum Shear Stress (MPa)*	*Safety Factor*
1	5707	0,048	22,3	12,9	11,2
2	8561	0,073	33,4	19,3	7,4
3	11415	0,097	44,6	25,7	5,6

3.2 Maximum Deformation Analysis Results

Figures 14, 15, and 16 illustrate the maximum total deformation results relative to the loading variables. The maximum deformation values for the applied loads of 5,707 N, 8,561 N, and 11,415 N are 0.048 mm, 0.073 mm, and 0.097 mm, respectively. All maximum deformations occur at the cutting edge of the cane cutter blade, indicated by the red color in the simulation results.

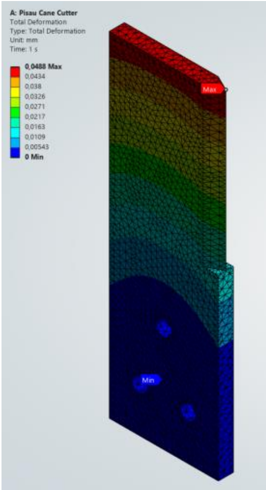


Figure 14. Maximum Deformation of the Cane Cutter Blade under 5,707 N Load

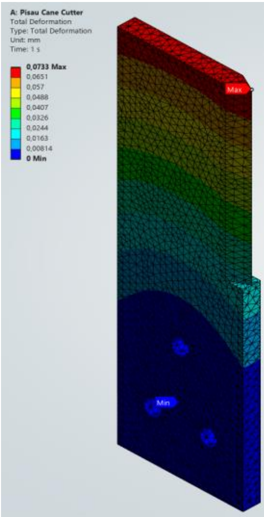


Figure 15. Maximum Deformation of the Cane Cutter Blade under 8.561 N N Load

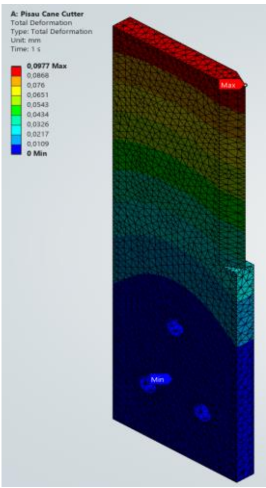
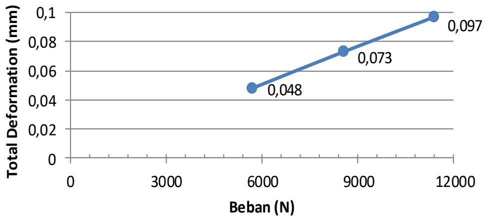


Figure 16. Maximum Deformation of the Cane Cutter Blade under 11,415 N Load



Graph 1. Relationship Between Total Deformation and Loading Variables

Based on Graph 1, which illustrates the relationship between Total Deformation and the loading variables, it can be observed that as the load increases, the resulting deformation also increases. This indicates that the relationship between Total Deformation and the loading variables is directly proportional.

3.3 Equivalent (von-Mises) Stress Analysis Results

Figures 17, 18, and 19 show the Equivalent (von-Mises) Stress results relative to the loading variables. The maximum von-Mises stress values for the loads of 5,707 N, 8,561 N, and 11,415 N are 22.3 MPa, 33.4 MPa, and 44.6 MPa, respectively. All maximum stresses occur around the upper bolt holes, indicated by the red color in the simulation results. This area serves as the contact point (support) between the cane cutter blade and the holder; therefore, when the load is applied, the stress becomes concentrated in this region.

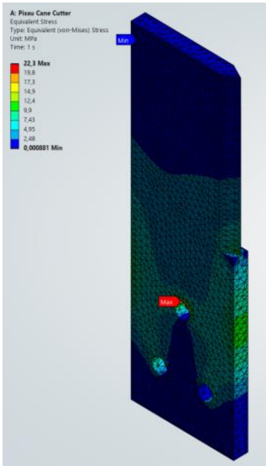


Figure 17. Maximum Equivalent (von-Mises) Stress of the Cane Cutter Blade under 5,707 N Load

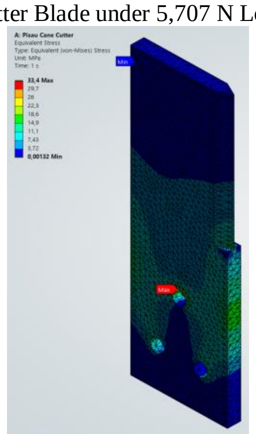


Figure 18. Maximum Equivalent (von-Mises) Stress of the Cane Cutter Blade under 8.561 N Load

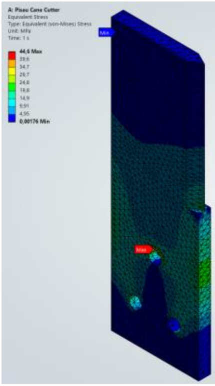
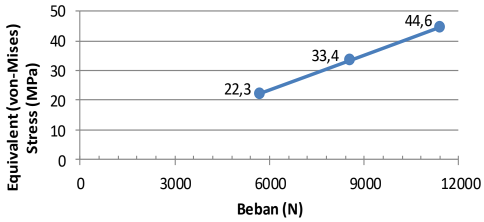


Figure 19. Maximum Equivalent (von-Mises) Stress of the Cane Cutter Blade under 11.415 N Load



Graph 2. Relationship Between Equivalent (von-Mises) Stress and Loading Variables

Based on Graph 2, which illustrates the relationship between Equivalent (von-Mises) Stress and the loading variables, it can be observed that as the load increases, the resulting stress also increases. This indicates that the relationship between von-Mises stress and the loading variables is directly proportional. Based on these results, the maximum stress values remain within the safe limit, as they are well below the material's allowable stress (yield strength) of 250 MPa.

Maximum Shear Stress Analysis Results

Figures 20, 21, and 22 show the Maximum Shear Stress results relative to the loading variables. The maximum shear stress values for the loads of 5,707 N, 8,561 N, and 11,415 N are 12.9 MPa, 19.3 MPa, and 25.7 MPa, respectively. All maximum shear stresses occur around the upper bolt holes, indicated by the red color in the simulation results. This area serves as the contact point between the cane cutter blade and the holder. Consequently, during loading, a high stress concentration occurs within the small area of the bolt holes

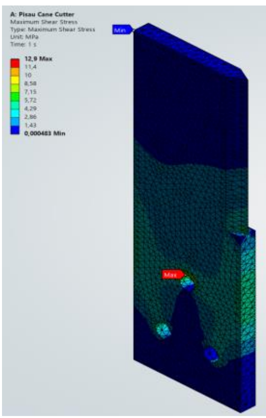


Figure 20. Maximum Shear Stress of the Cane Cutter Blade under 5,707 N Load

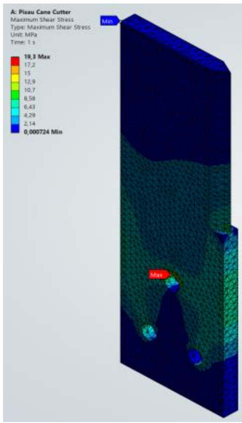


Figure 21. Maximum Shear Stress of the Cane Cutter Blade under 8.561 **N Load**

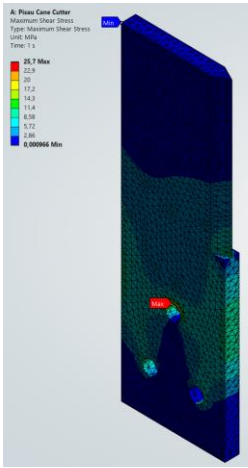
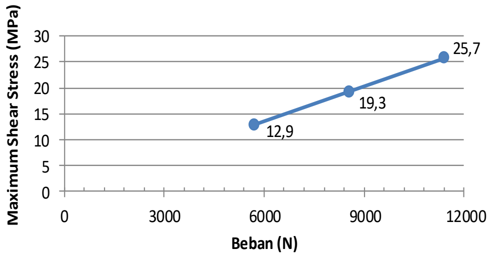


Figure 21. Maximum Shear Stress of the Cane Cutter Blade under 11.415 N N Load



Graph 3. Relationship Between Maximum Shear Stress and Loading Variables

Based on Graph 3, which illustrates the relationship between Maximum Shear Stress and the loading variables, it can be observed that as the load increases, the resulting shear stress also increases. This indicates that the relationship between Maximum Shear Stress and the loading variables is directly proportional. Based on the maximum shear stress results, the stress values remain within the safe limit, as they are significantly below the material's allowable shear limit (derived from the Shear Modulus of 76,920 Mpa.

Safety Factor Analysis Results

Figures 23, 24, and 25 show the Safety Factor results relative to the loading variables. The safety factor values for the loads of 5,707 N, 8,561 N, and 11,415 N are 11.2, 7.4, and 5.6, respectively. The minimum safety factor occurs at the upper bolt hole area, which serves as the contact point (support) between the blade and the holder

Figure 22. Safety Factor of the Cane Cutter Blade under 5,707 N Load

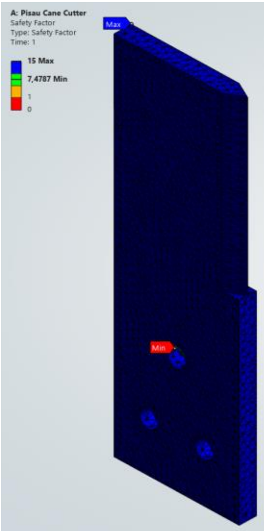


Figure 23. Safety Factor of the Cane Cutter Blade under 8.561 N Load

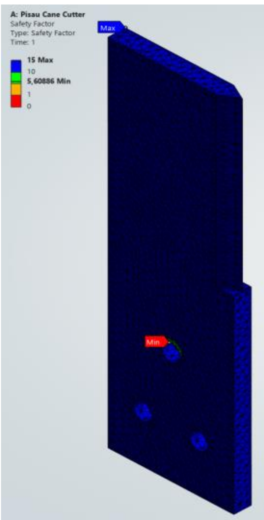
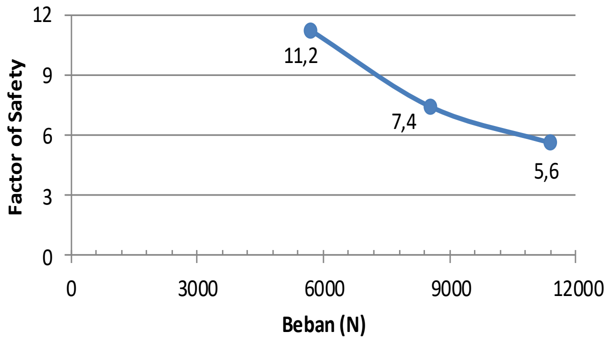


Figure 24. Safety Factor of the Cane Cutter Blade under 11.41 N Load



Graph 4. Relationship Between Safety Factor and Loading Variables

Based on Graph 4, which illustrates the relationship between the Safety Factor and the loading variables, it can be observed that as the load increases, the safety factor decreases. This indicates that the relationship between the Safety Factor and the loading variables is inversely proportional. Based on these safety factor simulation results, the cane cutter blade is considered capable of withstanding the applied loads of 5,707 N, 8,561 N, and 11,415 N.

4. Conclusion

Based on the simulation results and discussion, it can be concluded that as the load increases, the deformation, equivalent (von-Mises) stress, and shear stress also increase. Conversely, the factor of safety (safety factor) decreases. The highest values for maximum deformation, maximum von-Mises stress, and maximum shear stress all occur under the peak load of 11,415 N. From the maximum von-Mises and shear stress analysis across all loading variables, the cane cutter blade remains within safe limits, as the values are significantly below the material's allowable stress and shear limit. Furthermore, based on the safety factors obtained for the loads of 5,707 N, 8,561 N, and 11,415 N, the cane cutter blade is confirmed to be capable of withstanding these operating loads.

References

[1] A. Chumaidy, "Analisa gangguan pemutus tenaga mesin cane cutter I," SAINTECH: Jurnal Penelitian dan Pengkajian Sains dan Teknologi, vol. 28, no. 2, 2018.

[2] A. P. Wijatna and A. E. Purkoncoro, "Analisa kepal cepat fuel engine remote control menggunakan ANSYS seri 14.5," Final Project Report, Dept. Mech. Eng., Institut Teknologi Nasional Malang, Malang, Indonesia, 2019.

[3] Badan Pusat Statistik, "Statistik gula nasional tahun 2024," 2024. [Online]. Available: https://www.bps.go.id

[4] V. Dobrovolsky et al., Machine Elements: A Textbook. Moscow, USSR: Peace Publisher, 1978.

[5] M. P. Siahaan, "Analisis tegangan pada pisau mesin pencacah komposit kapasitas skala laboratorium," Undergraduate Thesis, Universitas Medan Area, Medan, Indonesia, 2024. [Online]. Available: https://repositori.uma.ac.id/jspui/handle/123456789/25852

[6] PG Krebet Baru I, "Laporan kerusakan pisau cane cutter musim giling 2024," Internal Report, Malang, East Java, 2024.

[7] R. C. Hibbeler, Mechanics of Materials, 14th ed. India: Pearson Education, 2005.

[8] R. von Mises, "Göttingen nachrichten, math. phys. klasse," pp. 582, 1913.

[9] Zulfikar, Dasar-dasar Pemakaian Software ANSYS 5.4. Medan, Indonesia: Program Studi Teknik Mesin Universitas Medan Area, 2018. [Online]. Available: http://repository.umsu.ac.id/xmlui/handle/123456789/762