Jurnal Dinamis (*Scientific Journal of Mechanical Engineering*)
Journal homepage: https://talenta.usu.ac.id/dinamis/

Design Analysis of The Welding Fume Blower Bracket in The Welding Laboratory at Politeknik Sinar Mas Berau Coal

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ARTICLE INFO

Article history:
Received October 23th 2024
Revised October 30th 2024
Accepted December 10th 2024
Available online December 11th 2024

E-ISSN: 2809-3410

How to cite:
Ilmawan Suryapradana, Dewi Safitriani, Kris Adi Nugraha, Haksa Fadilman Sinambela, Musliadi. “Design Analysis of The Welding Fume Blower Bracket in The Welding Laboratory at Politeknik Sinar Mas Berau Coal”. Jurnal Dinamis (*Scientific Journal of Mechanical Engineering*), Vol. 12 No 2, 55-64, December. 2024.

ABSTRACT

Politeknik Sinar Mas Berau Coal is equipping the welding laboratory with the installation of a blower according to standards and requires a bracket as a mount. For its design, ASTM A36 material is required and a simulation analysis process for the welding fume blow bracket with a 5x5 cm angle iron size. The creation of a sturdy and strong bracket within the specified tolerance limits involves planning and modeling the frame, simulating, and calculating theoretically. With a load of 186.778, stable results were obtained and the process can proceed to welding. The results compare theory and simulation. At a yield stress value of 248.225 MPa, the von Mises stress simulation yielded 51.64 MPa and the theoretical value was 45.88 MPa, resulting in a deviation of 11.29%. For displacement, the theoretical value was 0.02247 and the simulation yielded 0.09468, with a deviation of 3.21%. For the safety factor, the theoretical value was 4.80 and the simulation yielded 5.41, with a deviation of 12.56%. The deviation between the theoretical calculations and the inventor application data does not exceed 50% and is proven to be within the safe tolerance limit where the material strength (fume blower) is less than the bucket stress.

Keywords: *Blower, Bracket Design, Autodesk Inventor 2018, Stress Analysis and Simulation, Theoretical Calculation, ASTM A36.*

ABSTRAK

Politeknik Sinar Mas Berau Coal melengkapi laboratorium welding dengan pemasangan blower sesuai standar dan membutuhkan bracket sebagai dudukan. Untuk perancangannya dibutuhkan jenis material ASTM A36 dan proses analisa simulasi bracket welding fume blow dengan ukuran besi siku 5x5 cm. Pembuatan bracket yang kokoh dan kuat dalam batas toleransi yang dijelaskan sebagai berikut yakni perencanaan dan model rangka, mensimulasikan dan memperhitungan secara teori. Dengan pembebanan 186,778 didapatkan hasil stabil dan dapat dilanjutkan pada proses pengelasan. Hasil tersebut membandingkan teori dan simulasi. Pada nilai yield stress 248,225 MPa, didapatkan simulasi von mises stress yaitu 51,64 MPa dan teori sebesar 45,88 MPa, dengan hasil deviasi 11,29%. Untuk displacement secara teori yakni 0,02247 dan simulasi mendapatkan nilai 0,09468 mempunyai hasil deviasi 3,21%. Untuk nilai safety factor dengan teori 4,80 dan dengan simulasi 5,41, dengan deviasi sebesar 12,56 %. Deviasi perhitungan teori dan data aplikasi inventor tidak melebihi 50% dan dibuktikan masih dalam ambang batas toleransi aman dimana kekuatan material (*fume blower*) lebih kecil dari tegangan *bucket*.

Kata kunci: Blower, Perancangan Braket, Autodeks Inventor 2018, Analisis dan Simulasi Tegangan, Perhitungan Teori, ASTM A36.

http://doi.org/10.32734/dinamis.v12i2.18660

1. Introduction

A blower is a high-speed centrifugal machine that functions as a blower by utilizing air or gas with centrifugal force until the final pressure is achieved. The air or gas in this centrifugal machine is driven by the dynamic action of the rotating blades of one or more impellers. At the Sinar Mas Berau Coal Polytechnic, there is a welding laboratory. In this welding laboratory, welding activities are carried out by the teaching factory, internship students, KPI students, and students performing welding practices. The teaching and learning process takes place in the welding laboratory (bays6). Based on observations, there is no smoke exhaust duct resulting from the welding process. Welding fumes are highly hazardous to the health of those performing the welding.

The dangers of inhaling welding fumes include particles being trapped by nasal hairs or respiratory tract hair, while finer particles can reach the lungs, and some are exhaled again. Smoke dust that remains and adheres to the air sacs in the lungs can cause various diseases, such as shortness of breath and others. Therefore, it is necessary to install a blower in the welding laboratory. This blower machine functions to suck welding fumes, which is crucial for each student conducting practical activities or other welding work.

1.1. Autodesk Inventor Professional Software

Autodesk Inventor Professional 2018 is a CAD (Computer-Aided Design) software used for designing, creating 3D models, simulation, and technical documentation for manufacturing products. This software is developed by Autodesk and is mainly used by engineers, product designers, and manufacturing professionals to create digital prototypes, test design performance, and produce accurate technical drawings [1].

Autodesk Inventor provides facilities for visualizing models in 3D, assembly drawings, and animations of digitally created objects. These digital documents assist designers in visualizing, simulating, and analyzing product designs. Autodesk Inventor offers several advantages that simplify the design process, as materials can be arranged to resemble real materials [2], [3].

Figure 1.1 Autodeks Inventor Professional 2018

Autodesk Inventor Professional 2018 offers the following key advantages:

a) The capability to assemble components, conduct simulations, and perform structural analysis
b) The ability to design and modify models in both 2D and 3D formats
c) The functionality to convert part designs into detailed technical drawings
d) The ability to create animations or videos from assembled components

1.2. Von Mises Stress

Von Mises stress is a theoretical criterion used in material mechanics and structural engineering to assess whether a material will experience plastic (permanent) deformation under applied load. It is extensively applied in material failure analysis, particularly in the design and assessment of engineering components. Rather than being measured directly, Von Mises stress is derived from the stresses present in three orthogonal directions (normal and shear stresses) within the material. The resultant Von Mises stress provides a singular value that can be compared to the material's yield strength, determining whether the material will yield plastically or remain in its elastic state [4].

1.3. Displacement

In the context of physics and engineering, displacement refers to the change in position of an object from one point to another in space. It is a vector quantity, possessing both magnitude and direction. Displacement specifically measures the straight-line distance and direction from the object's initial position to its final position, in contrast to distance, which measures the total path traveled without regard to direction.

1.4. Safety Factor

The safety factor, or factor of safety (FoS), is a design parameter used to ensure that a structure or component can endure loads and operational conditions beyond those anticipated during normal use. It is defined as the ratio between the material's maximum capacity and the highest expected load during operation [5]. The inclusion of a safety factor ensures an additional margin for uncertainties such as material defects, manufacturing errors, environmental variations, or unexpected load changes.

2. Methodology

Bracket design involves the development of components that serve to support, connect, or secure other parts of a structural system or device. Brackets find application in various fields, including automotive, construction, and electronics. The general procedure for bracket design includes the following steps:

2.1 Identification of Requirements and Specifications

The first step involves defining the primary function of the bracket, such as supporting a specific load, securing components in place, or connecting two parts. Additionally, specifications such as dimensions, material selection, and operating environment (temperature, humidity, corrosion resistance) are established.

2.2 Load Analysis

This step involves identifying all the loads acting on the bracket, including static loads (constant loads), dynamic loads (varying loads), and environmental loads (such as wind or vibration). Accurate calculations are performed to determine the magnitudes of these loads.

2.3 Material Selection

Material selection is based on criteria such as strength, stiffness, corrosion resistance, and manufacturability. Common materials for bracket design include structural steels. Most structural steels are specified using ASTM standards, as established by the ASTM (American Society for Testing and Materials). One frequently used grade is ASTM A36, which has a minimum yield strength of 36,000 psi (284 MPa) and is known for its high ductility. This low-carbon, hot-rolled steel is available in various forms, including plates, bars, and structural shapes such as wide-flange beams, channels, and angles [6].

ASTM A36 steel plates provide adequate strength and exhibit additional properties, such as machinability and weldability. These steel plates can be galvanized or coated to enhance corrosion resistance, making them suitable for various applications depending on plate thickness and corrosion resistance requirements.

2.4 Strength and Stiffness Analysis

For the analysis of complex components, Finite Element Analysis (FEA) is employed, which breaks down the component into numerous smaller elements for detailed evaluation. Autodesk Inventor’s Stress Analysis tool leverages this technique to enable users to assess the design based on the predefined parameters [7].

Users of Autodesk Inventor 2018 can utilize the stress analysis module to evaluate material strength and stress distribution. The accuracy of the analysis is influenced by material properties, applied constraints, and loads. Therefore, it is crucial to ensure that the material properties used in the analysis reflect the actual materials employed in the construction of the component. Additionally, the operational conditions of the component must be accurately represented through proper application of constraints and loads.

A flowchart detailing the processes undertaken in this research can be found in the Figure 2.1.

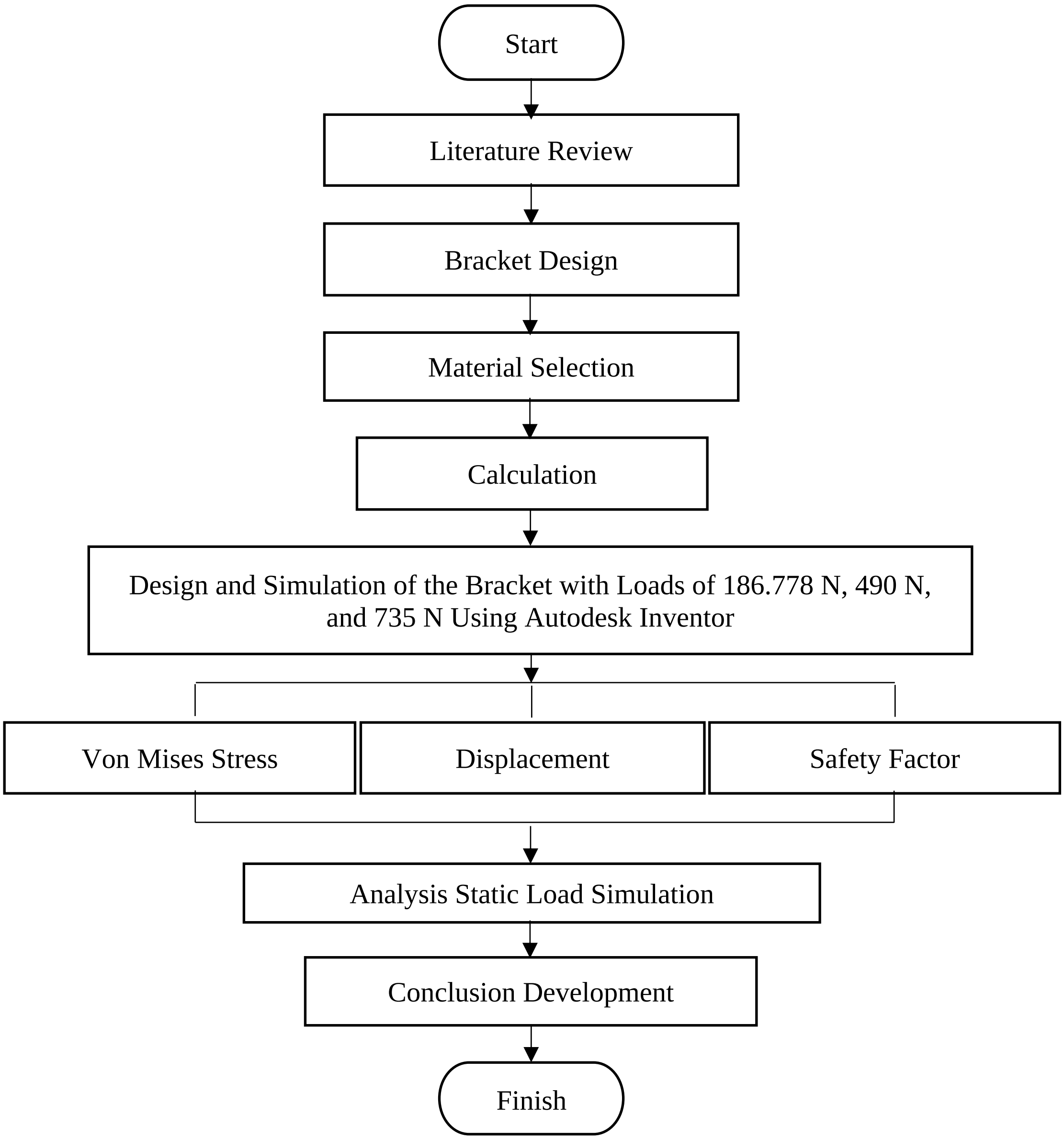

Figure 2.1 Flowchart Process

3. Result and Discussion

The design of the welding fume blower bracket in this study has the dimensions and shape shown in Figure 3.1.

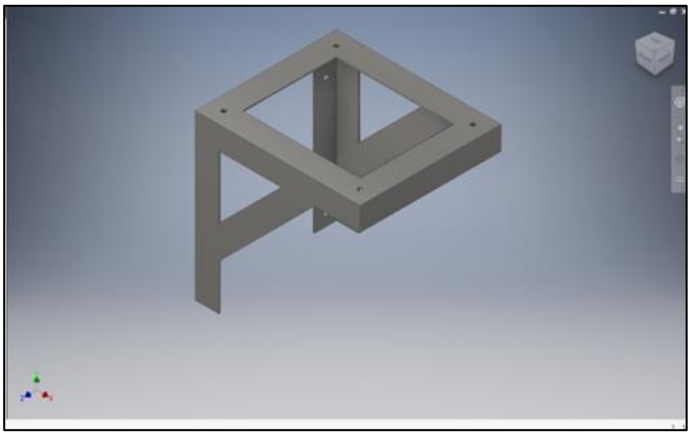

Figure 3.1 Bracket Welding Fume Blower

Table 3.1 presents the dimensions of the welding fume blower bracket as follows [8].

Table 3.1 Bracket Size

Dimension	Size
Length	360 mm
Height	360 mm
Width	335 mm

3.1. Load Application

In stress analysis, one of the key aspects is the application of loads to the design. The load applied is expressed in newtons. Since the design is intended to support the weight of the blower, which is 186.778 newtons, the load distribution can be seen more clearly in Figure 3.2.

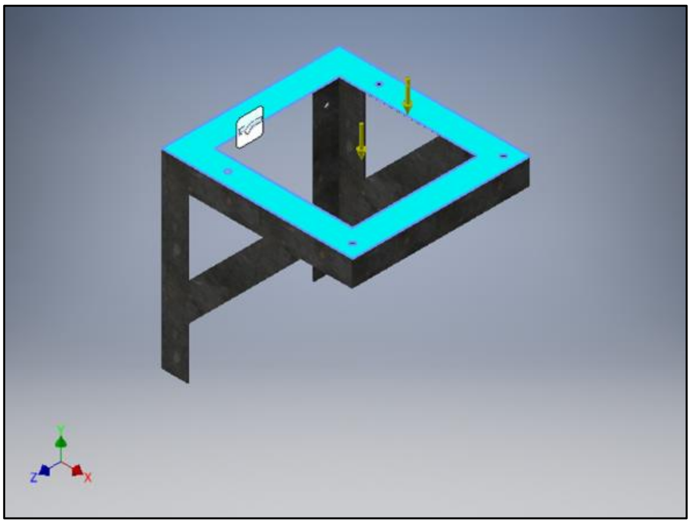

Figure 3.2 Simulation of Load Application Points on the Bracket

3.2. Material Specifications for the Welding Fume Blower Bracket Design

It is crucial to select an appropriate material to ensure product quality, especially for components that come into direct contact with the product. The material must be durable and heat-resistant. For the construction of the welding fume blower bracket, ASTM A36 material is chosen, which is highly suitable for this application. The physical characteristics of the designed welding fume blower bracket are as follows: mass of 19 kg, surface area of 511.842 mm², and volume of 748.289 mm³.

3.3. ASTM A36 Material

The analysis results also demonstrate the strength of the ASTM A36 material by assessing its maximum strength capacity.

Table 3.2 ASTM A36 Material Specifications

Properties	Value
Elastic Modulus	200000 N/mm^2
Poisson' Ratio	0.3 ul
Mass Density	7.85 g/cm^3
Tensile Strength	400 N/mm^2
Yield Strength	248.225 Mpa

3.4. Results of Simulation and Theoretical Calculations

After inputting the data into the analysis application, the simulation results will provide the minimum to maximum stress values, along with theoretical calculations covering Von Mises stress, displacement, and the safety factor. These results will allow conclusions to be drawn regarding the safety of the design, ensuring that no failure occurs when the material is utilized.

3.4.1. Simulation and Theoretical Results for a Load of 186.778 N

a. Von mises stress

The Von Mises stress is derived from the distortion energy failure theory. If the Von Mises stress value exceeds the yield strength of the material, the design will fail. In the stress simulation, the Von Mises stress distribution is visualized by color changes, where red indicates the highest stress concentration, and blue indicates areas under no stress, as shown in Figure 3.3.

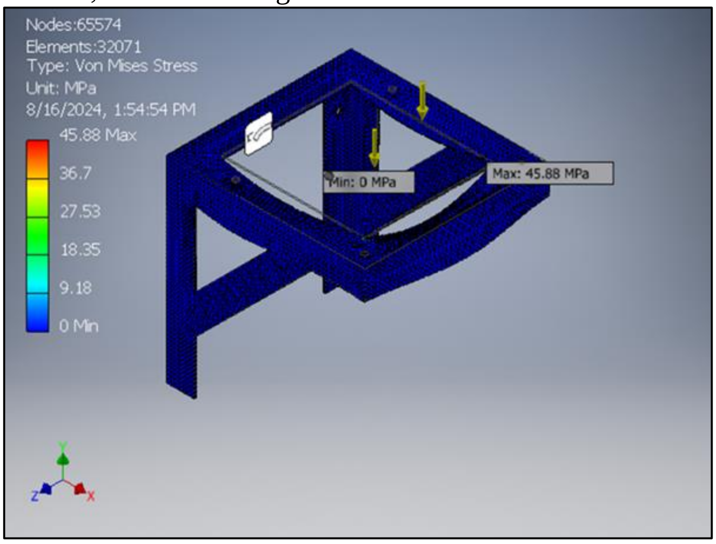

Figure 3.3 Von Mises Stress Simulation Result

From the simulation conducted, the maximum Von Mises stress under the applied load is 45.88 MPa, while the minimum stress is 0 MPa. These stress values occur at specific points, typically near the load application area, and do not exceed the yield strength of ASTM A36, which is 248.225 MPa. Most of the stress analysis results for the welding fume blower bracket design remain in the blue color range, indicating that the Von Mises stress is within the safe limit [9].

Meanwhile, the theoretical calculation of the loading force is based on the total mass or load, approximately 19.06 kg for the blower machine. The calculation is as follows:

F = m × g

= 19.06 x 9.8 m/s

= 186.778 N

Calculation for load applied over surface area

A =P x L

= 360 mm x 335 mm

= 120.600 mm^2

$$\tau_{xy} = \frac{M}{2.A.b}. = \frac{186.778\ x\ 360\ mm}{2\ x\ 120600\ m^2 x\ 3\ mm} = \frac{67243.68\ Nmm}{723600\ mm^3} = 0.092929$$

Calculation for center of gravity of the angle iron

$C = \frac{h}{2}$.

$= \frac{50 \text{ mm}}{2}$

= 25 mm

Calculation for moment of inertia (i)

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

$I = \frac{25 \times (25 \text{ mm})^3}{12}$. $I = 32552.08 \text{ mm}^4$.

Calculation for Normal stress ($\sigma_t \; x \; \sigma_x$).

$\sigma_t = \frac{m \cdot c}{I}$. $\sigma_t = \frac{67243{,}68 \times 25 \text{ mm}}{32552{,}08 \text{ mm}}$. =51.64 Mpa

$\sigma_t = \sigma_x$

The calculated σ_x value is 11.79 MPa, and the maximum Von Mises stress (σ_{Max}) is determined accordingly.

$$(\sigma_{max}) = \frac{\sigma_x + \sigma_y}{2} + \sqrt{(\frac{\sigma_x + \sigma_y}{2})^2 + (T_{xy})^2}$$

$$(\sigma_{max}) = \frac{51.64 \text{ Mpa} + 0}{2} + \sqrt{(\frac{51.64 \text{ Mpa} + 0}{2})^2 + (0.092929)^2}$$

$(\sigma_{max}) = 25.82 + 25.82$

$(\sigma_{max}) = 51.64$ Mpa

$$n = \frac{\text{von mises theory-von mises simulation}}{\text{von mises theory}} \times 100\%$$

$$n = \frac{51{,}64 - 45{,}88}{51{,}64}$$

n=11.29 %

b. Displacement

Displacement refers to the deformation or deflection of the design after load application. In the stress simulation, displacement values can be observed through color changes in the design. Red indicates the farthest displacement from the initial point, as shown in Figure 3.4. From the simulation, the maximum displacement under load was 0.09468 mm, while the minimum value was 0 mm, which is still far below the yield strength of ASTM A36 material (248.225 MPa). This means that the displacement is still within the elastic region. With such a small value, this displacement is considered acceptable.

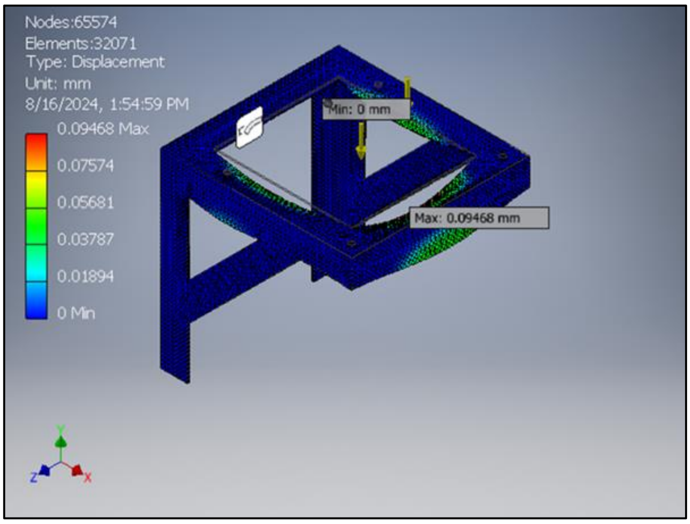

Figure 3.4 Simulation Results for Displacement

The theoretical calculation of displacement is as follows:

$\delta = \frac{P.L^3}{48.E.L}$ $\delta = \frac{186.778 \ x \ (335)^3}{48 \ x \ 200000 \ x \ 32552.08}$ $\delta = \frac{7021988951.75}{312499968000}$ $\delta = 0.02247$

$n = \frac{\text{displacement teori-displacement simulasi}}{\text{displacment teori}} \text{ x } 100 \ \%$

$n = \frac{0,02247-0,09468}{0,09468} \text{ x } 100 \ \%$ $n = 3.21 \ \%$

c. Safety Factor

The safety factor is a measure used to evaluate the safety of a design. The range typically extends from 1 to 15, with a good safety factor being greater than 1 to prevent design failure [10]. Blue indicates the safest areas of the design, while red indicates areas outside the safety limits. The safety factor from the analysis ranges from 5.41 to 15, meaning the weakest part of the design can withstand 5.41 times the allowed load. However, as shown in Figure 3.5, most of the plate insert cavity is colored blue, indicating that the majority of the design has a safety factor above the allowable load.

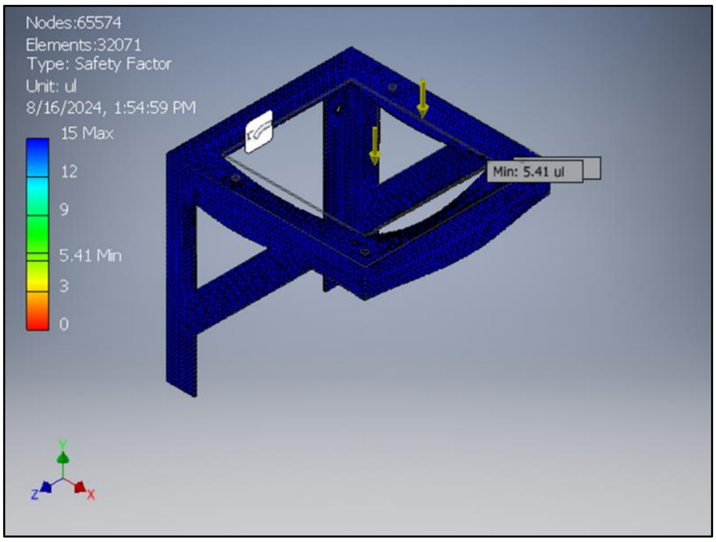

Figure 3.5 Simulation Results Using Safety Factor

The theoretical calculation for the Safety Factor (SF) is as follows:

$SF = \frac{S_y}{\sigma_{max}}$

$SF = \frac{248.225 \text{ MPa}}{51.64}$ $SF = 4.80$

$n = \frac{\text{SF theory-SF simulation}}{\text{SF theory}} \text{ x} 100 \ \%$ $n = \frac{4.80-5.41}{4.80} \text{ x } 100 \ \%$ $n = 12.56 \ \%$

Table 3.3 shows the comparison between theoretical and simulation results under a load of 186.778 N.

Table 1.3 Simulation and Calculation Results for 186.778 N

Analysis Used	Theoretical Calculation Result	Simulation Result	Deviation (%)
Von mises stress	51.64 Mpa	45.88 Mpa	11.29 %
displacement	0.02247 mm	0.09468 mm	3.21%
Saftey factor	4.80	5.41	12.56 %

4. Conclusion

Based on the design and simulation results, the conclusion is that the design and testing of the welding smoke blower bracket using Autodesk Inventor 2018 under a load of 186.778 N, with bracket dimensions of 360 mm length, 335 mm width, 3 mm thickness, and 360 mm height, evaluated the maximum and minimum Von Mises stress, displacement, and safety factor. Stable results were obtained and can be applied in the manufacturing of smoke blower brackets in the welding process.

The results of the simulation and theoretical calculations are for ASTM A36 material, which has a yield strength of 248.225 MPa, resulting in a Von Mises stress value of 51.64 MPa in the simulation and 45.88 MPa in the theoretical calculation. The deviation between the simulated and theoretical Von Mises stress values is 11.29%. The displacement results yield a theoretical value of 0.02247 mm and a simulation value of 0.09468 mm using ASTM A36 material. The displacement deviation between the simulation and theoretical calculation is 3.21%. The safety factor analysis using software and theoretical calculations for the welding fume blower bracket with ASTM A36 material results in a safety factor of 4.80 in the theoretical calculation and 5.41 in the Autodesk Inventor 2018 simulation. The deviation between the safety factors from the simulation and theory is 12.56%. The deviation between the theoretical calculations and the data generated from the Inventor application does not exceed 50% and is still proven to be within the safe tolerance threshold where the material strength (fume blower) is less than the bracket stress.

5. Acknowledgement

The authors would like to extend their heartfelt thanks to the entire academic community of Politeknik Sinar Mas Berau Coal. Their moral and material support made this research possible. We hope that this work serves as a valuable reference for welding activities and future research development.

References

[1] J. Beno, A. . Silen, And M. Yanti, “No 主観的健康感を中心とした在宅高齢者における 健康関連指標に関する共分散構造分析title,” *Braz Dent J.*, Vol. 33, No. 1, Pp. 1–12, 2022.

[2] A. Suardi *Et Al.*, “Powerplant,” No. 4, 2017.

[3] R. F. Ramadhana, *Analisis Pembebanan Pada Desain Chassis Prototype Mobil Listrik Hemat Energi Menggunakan Software Autodesk Inventor 2019*. 2024.

[4] L. A. N. Wibawa, “Desain Dan Analisis Kekuatan Dudukan (Bracket) Ac Outdoor Menggunakan Metode Elemen Hingga,” *J. Crankshaft*, Vol. 2, No. 1, Pp. 19–24, 2019, Doi: 10.24176/Crankshaft.V2i1.2688.

[5] B. Setyono, “Perancangan Dan Analisis Kekuatan Frame Sepeda Hibrid ‘Trisona’ Menggunakan Software Autodesk Inventor,” *J. Iptek*, Vol. 20, No. 2, P. 37, 2016, Doi: 10.31284/J.Iptek.2016.V20i2.43.

[6] M. A. Hendrawan, P. I. Purboputro, M. A. Saputro, And W. Setiyadi, “Perancangan Chassis Mobil Listrik Prototype ‘ Ababil ’ Dan Simulasi Pembebanan Statik Dengan Menggunakan Solidworks Premium 2016,” *7th Univ. Res. Colloq. 2018*, Pp. 96–105, 2018.

[7] F. Engelmann, K. H. Grote, And T. Guthmann, “Machine Elements,” *Springer Handbooks*, Pp. 503–628, 2021, Doi: 10.1007/978-3-030-47035-7_15.

[8] J. Pratomo, “Analisa Numerik Pembebanan Statis Pada Rangka Penghancur Limbah Kayu Kapasitas 15 Kg/Jam,” 2019.

[9] Sandy Suryady And Eko Aprianto Nugroho, “Simulasi Faktor Keamanadan Pembebanan Statik Rangka Pada Turbin Angin Savonius,” *J. Ilm. Multidisiplin*, Vol. 1, No. 2, Pp. 42–48, 2022, Doi: 10.56127/Jukim.V1i2.94.

[10] M. R. Firdaus, “Analisis Perbandingan 3 Material Shaft Driver Hammer Mill Tepung Beras Dengan Kecepatan 1465 Rpm Menggunakan Aplikasi Software ‘Autodesk Inventor Professional 2015,’” *Mechonversio Mech. Eng. J.*, Vol. 2, No. 2, P. 11, 2019, Doi: 10.51804/Mmej.V2i2.899.