# Numerical Analysis of the Influence Iron Type on Von Mises Stress and Safety Parameters for Compost Processing Machine Frame Construction

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# Numerical Analysis of the Influence Iron Type on Von Mises Stress and Safety Parameters for Compost Processing Machine Frame Construction

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### Abstract

The installation of other engine parts, such as the engine, transmission, shaft, blade, and cover, includes the engine frame. The engine frame must be developed and constructed with the strength to support other components. The building of the waste processing machine frame with variants of square tube type and angle bar type will be analyzed in this study, with a focus on the analysis of von Mises's stress and safety aspects. Using Solidworks software, finite element analysis is the research methodology used. The examination of the waste processing machine's frame modelling using square tubes and angular bars yielded maximum von Mises stress values of 3.77e+7 N/m2 and 3.162e+4 N/m2, respectively. The maximum deformation values for the square tube iron and angular bar used in the modelling analysis of the waste processing machine frame are 2,499e+1mm and 9,725e+1mm, respectively. and 8.5 and 1 is the required minimum safety factor value for modelling the frame of a waste processing machine made of square tube iron. The safety factor value of 2-3 is the primary criterion for a suitable design. It is safe and advised to utilize the waste processing machine frame made of square tube iron for this purpose.

**Keywords**: Solidowork, Von Misses, Safety Factor, Static Structure.

## 1. INTRODUCTION

It takes a machine to efficiently and cheaply process garbage to turn it into compost [1]. Waste management technology was developed as a result of the quick development of technology to produce a secure and pleasant environment. Composting, using organic waste as fuel, and bioenergy plants are three ways to recycle garbage [2]. It is vital to have the machinery to grind and shred organic waste into small bits for degradation of materials by microorganisms to improve and accelerate the composting process and generate compost [3]. Different composting devices are created and intended to make it easier to process organic waste for composting to reduce kitchen waste, etc. [2]. The machine for decomposing agricultural trash to create compost from coir and areca leaves was also invented, according to another study [4]. To improve and develop agricultural production economically, another study created machinery to crush crop leftovers [5].

The waste processing device is made up of many parts, such as engine frames, transmission systems, hoppers, and knife housings. The installation of other engine parts, such as the engine, transmission, shaft, blade, and cover, includes the engine frame. The engine frame must be sturdy and well-designed for it to sustain other parts that are attached to it. It was outlined in earlier research that ease, security, and comfort during use particularly concerning the engine framework are characteristics that need to be taken into account when designing the design [6]. The supplied load must also be taken into account while designing the engine because it may result in vibration, excessive thrust, or overload, which would exert an inertial force on the entire frame [7].

The primary steps in the manufacture of machines with the aid of CAD technology are chosen to reduce the likelihood of errors occurring during the creation of a product's design [8]. Additionally, design flaws can be reduced by improving the design using numerical simulation [9]. Construction, mechanical, and other structural businesses frequently use this technique [10]. Software like Solidwork and ANSYS [11], [12] are just two examples of the various tools available to designers to assist them to overcome technical issues.

The goal of this study is to perform dynamic analysis, particularly the analysis of von Mises stress and safety factors for the construction of the waste processing machine frame with variations in the type of square tube and type of angle bar used in making the waste processing machine frame, under the

description given above. We require the use of SolidWorks software and a finite element technique to analyze the stresses and strengths of the proposed design. According to research [12], the software is a useful tool for using finite element analysis techniques to solve challenging situations. Researchers frequently use this technique to study stress [13], von misses, displacement, and safety factors [14], [15], optimize design, perform theoretical calculations [16], forecast a material's strength, and validate a force [17] using numerical simulations.

## 2. METHODOLOGY

Pre-processing, processing, and post-processing are the simulation techniques for modelling the waste processing machine framework using ANSYS software [18]–[21]. Using CAD software, the design is modelled during the pre-processing step, together with the material choices and physical attributes. Design modelling will be done at the processing stage using a math solver that follows the laws of elementary physics. The results of the calculations performed by the Solidwork program will be examined and verified by specialists during the post-processing phase, which is the final stage [15].

### 2.1 Pemodelan Simulasi

With the use of SolidWorks 2022 software, a compost processing machine frame simulation was created for this study. Next, the computational domain division (mesh) was performed to obtain convergent results when the analysis was run [19]. Tetrahedral mesh is the type of mesh used in this study since it makes calculations simpler. Mild steel was chosen as the material because it is affordable and strong [22]. As illustrated in Figure 1, the square tube type and the angle bar type of frames are used in the waste processing machine that will be compared. The next steps are parameter selection, pedestal positioning, and loading selection. Table 1 provides an overview of this study's parameters.

**Table 1**. Parameters for skeletal simulation modelling

| Description | Type Square Tube | Type Angle Bar |
|---|---|---|
| Young's Modulus | 200 GPa | 200 GPa |
| Poisson's Ratio | 0,31 | 0,31 |
| Density | 7750 Kg/m$^3$ | 7750 Kg/m$^3$ |
| Tensile Yield Strength | 320 MPa | 320 MPa |
| Tensile Ultimate Strength | 400 MPa | 400 MPa |
| Analysis Type | Static | Static |
| Node | 326 | 456 |
| Element | 316 | 446 |
| Load Machine | 800 N | 800 N |
| Load Shaft | 100 N | 100 N |
| Type Mesh | Tetrahedral Mesh | Tetrahedral Mesh |
| Length | 40 mm | 35 mm |
| Width | 40 mm | 35 mm |
| Thickness | 4 mm | 5 mm |

### 2.2 Finite Element Method

Differential equations with a mechanical continuum can be used to describe occurrences in the scientific and engineering fields. Due to the nature of the material, boundary conditions, and structure, it is typically highly challenging to solve a partial differential equation analytically [23]. Physical issues are among the issues that the finite element approach can resolve. The finite element approach can be used to tackle the following categories of physical issues: structural analysis, buckling analysis, and vibration analysis [24], [25]. Structural analysis is a common application of the finite element method, which was chosen because the types of structures utilized don't just include those found in buildings and bridges but also include aeronautical, naval, and mechanical structures. Linear or nonlinear static structural analysis is possible [26], [27]. It is possible to assess a structure's failure to reduce the error function, generate a stable solution, and address technical issues [27].
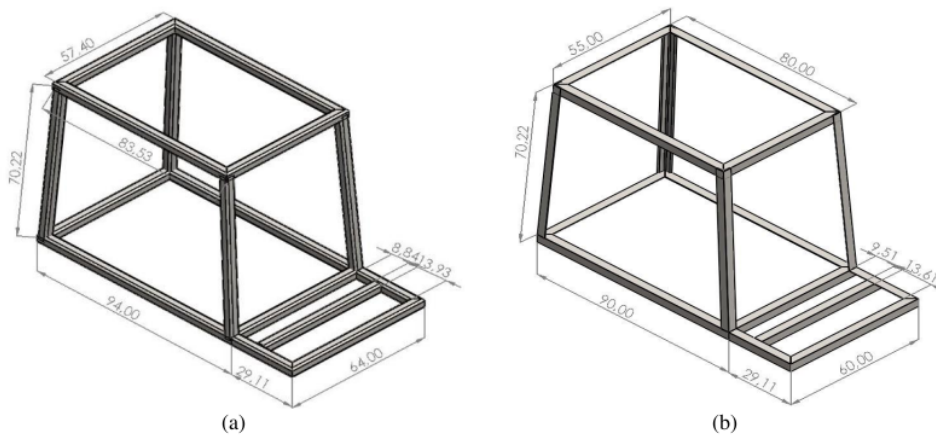
(a)          (b)

**Figure 1**. Iron is used to build the frame of the waste processing equipment
(a) Square tube and (b) Angle bar.

## 3. RESULTS AND DISCUSSION
### 3.1 Von Mises Stress
The equivalent von Mises stress and equivalent plastic strain show that von Mises stress and strain play a significant role in numerical simulations for the ductile fracture of metal [28]. When the process is operating, the von Mises stress determines if a material is secure or will fail [29]. If the stress value exceeds the material's strength, the von Mises stress is said to have failed [15]. Figure 2 depicts the distribution of the static stress contour on the waste processing machine's frame made of an angle bar and a square tube iron. When compared to Figure 2 (b) on the left, the colour contour in Figure 2 (a) on the left lower frame tends to be light blue. A voltage differential is shown by the left lower frame's propensity to be dark blue in hue [15].
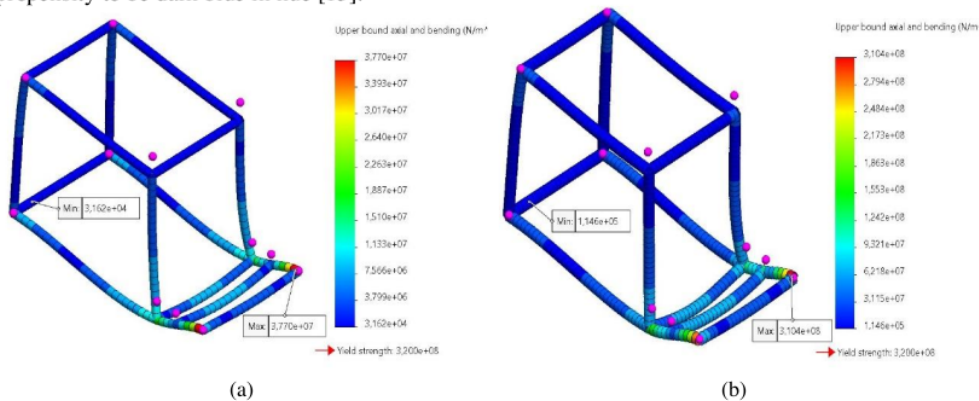


(a)          (b)

**Figure 2**. Results of the static stress distribution on the iron frame of the waste processing machine
(a) Square tube and (b) Angle bar.

The maximum and minimum von misses stress values in the simulation modelling the waste processing machine frame using a square tube type of iron with a load of 100N and 750N are 3.77e+7 N/m2 and 3.162e+4 N/m2, while these values are 3.104e+8 N/m$^2$ and 1.146e+5 N/m$^2$ in the simulation of the same frame without the square tube type of iron and the two loads. As the provided load is increased, the value of von misses will also increase, and the stress value is inversely related to the applied force [30].

### 3.2 Deformation
One of the key markers of whether a material can bear a load is deformation. When an object experiences force, deformation may result [31]. Figure 3 displays the simulation outcomes for modelling the waste processing machine frame using a square tube and an angle bar with loads of 100N

and 750N. Figure 3(arrange )'s colour contour on the lower right frame of the contour and Figure 3 (yellowish )'s colour contour on the right frame beneath the contour show that the form has changed as a result of the loading and the design of the frame utilized.
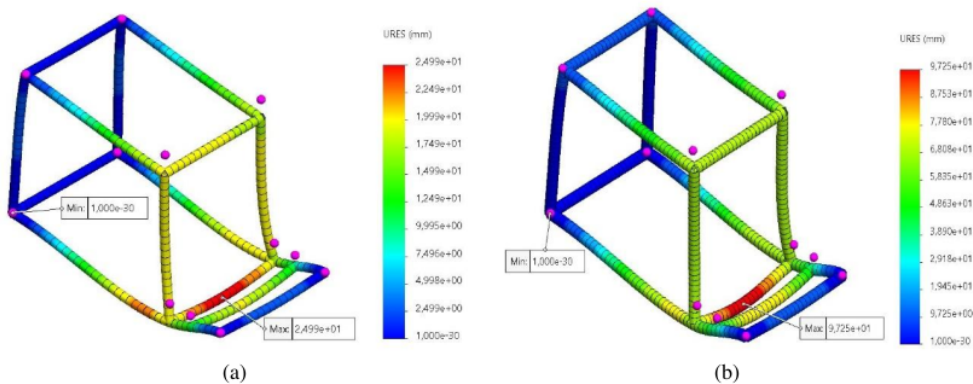


| (a) | (b) |

**Figure 3.** The outcomes of the displacement dispersion of the iron-framed waste processing machine
(a) Square tube and (b) Angle bar

While the maximum and minimum von misses stress values in the simulation modelling of the waste processing machine frame use an iron type. angle bar with a load of 100N and 750N of 9.725e+1 mm and 1e-30mm, respectively, the maximum and minimum displacement values use a square tube type of iron with a load of 100N and 750N of 2.499e+1mm and 1e-30mm. This demonstrates that a large load on the component does not result in significant deformation and that the component will be damaged if the frame cannot support the load [31].

### 3.3 Safety Factor

A designer will use the safety factor as a starting point when determining how much stress an object can withstand [32]. Figure 4 displays the simulation outcomes for modelling the waste processing machine frame utilizing square tube iron and angle bar with loads of 100N and 750N. Figure 4 (a) right frame colour contour is yellowish, whereas Figure 4 (b) frame colour contour is red, indicating that the shape of the contour has changed as a result of loading and the design of the frame utilized.
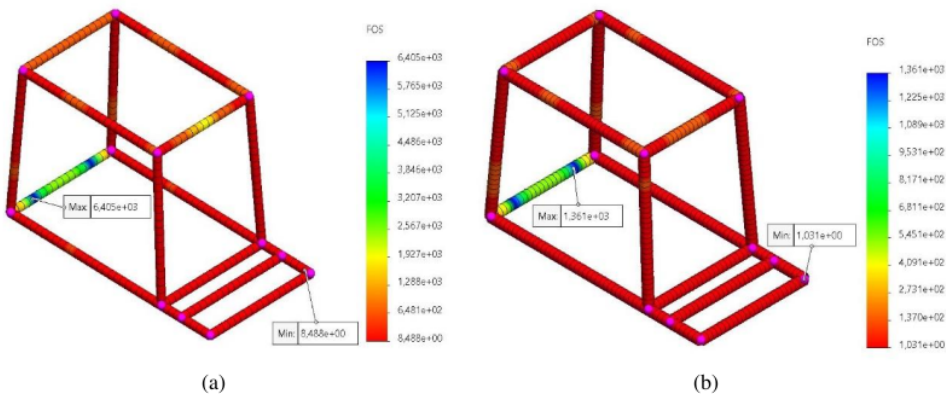


| (a) | (b) |

**Figure 4.** The outcomes of distributing the safety factor of an iron-framed waste processing machine
(a) Square tube and (b) Angle bar

When employing square tube iron, the waste processing machine's frame must have a minimum safety factor of 8.5, whereas an angle bar iron frame must have a minimum safety factor of 1. A material that can endure dynamic loads has a safety value between 2-3 [33]. This demonstrates that while the waste processing machine frame made of angle bar iron is not safe to use for the waste processing machine frame, the simulation modelling of the waste processing machine frame made of square tube iron has a safety factor value that is. Numerous elements affect the safety factor when designing a modelling

simulation. [32] The accuracy of the calculated load, the usage environment, the material's quality and craft, and the requirements for plastic deformation and stiffness, according to scholars, may be grouped into four categories as the primary factors.

## 4. CONCLUSION

Based on the results of the analysis and simulation of the modelling of the waste processing machine frame using the type of iron square tube and angular bar, it can be concluded that:

1. The maximum von mises stress value for the frame of the waste processing machine using square tube and angular bar iron is 3.77e+7 N/mˆ2 and 3.162e+4 N/mˆ2.
2. The maximum deformation value of the frame of the waste processing machine using a square tube and angular bar is 2,499e+1mm and 9,725e+1mm.
3. The minimum safety factor value for the frame of the waste processing machine using square tube iron and angular bar is 8.5 and 1.
4. In this research simulation, the safest and most recommended waste processing machine frame is to use a square tube iron type because the safety factor value is above 2-3. Meanwhile, the frame of an unsafe waste processing machine is to use angular bar iron because the safety factor value is below the required value, namely 2-3.

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