Design and Development of Affordable Salted Fish Drying Machine

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Abstract

This paper presents the development and testing of a prototype salted fish drying machine aimed at enhancing the efficiency and productivity of Small and Medium Industries (SMIs) involved in fish drying. The research encompasses the design, fabrication, and comprehensive testing of the prototype. Performance testing demonstrated significant improvements in drying efficiency and product consistency. This study contributes to the advancement of food processing technology by providing a reliable solution for the fish drying industry.

1. Introduction

The traditional method of drying salted fish in Malaysia, primarily involving open-air sun drying, faces numerous challenges due to the region's tropical climate. Sudden changes in weather, such as unexpected rain and high humidity, can interrupt the drying process, leading to inconsistent product quality and potential spoilage. Additionally, the open-air drying method exposes the fish to various contaminants, including dust, insects, and microbial growth, which pose significant health risks and decrease the marketability of the final product. The labor-intensive nature of this method, requiring constant monitoring and manual handling, further exacerbates production costs and limits scalability, especially for small and medium-sized enterprises (SMEs) .In response to these challenges, there is a critical need for innovative solutions to modernize the fish drying process. The development of an advanced salted fish drying machine represents a significant step forward in this field. This machine utilizes modern technology such as automated temperature and humidity controls, efficient air circulation systems, and user-friendly interfaces to provide a more reliable, efficient, and hygienic drying process. Automated controls ensure consistent drying conditions, minimizing the impact of weather fluctuations and reducing spoilage risk. Moreover, the machine's enclosed design protects the fish from external contaminants, enhancing product safety and quality. By improving drying efficiency and reducing time, the machine not only increases production capacity but also lowers operational costs, offering substantial benefits to SMEs. This advancement opens new market opportunities both domestically and internationally, contributing to regional economic development and food security.

2. Methods

The methodology for developing the salted fish drying machine involved several key stages, each meticulously planned to ensure the prototype met the targeted objectives of efficiency, consistency, and user-friendliness. The approach combined theoretical research, practical engineering, and iterative testing.

The project began with a comprehensive literature review to gather insights from existing studies on fish drying methods and technology. This review focused on identifying common challenges and limitations in traditional drying processes. Additionally, a market analysis was conducted to examine current commercial drying machines, assessing their features, performance metrics, and pricing. This step helped identify gaps in the market and potential areas for innovation.

Based on the findings from the literature review and market analysis, the design phase commenced. Initial sketches and conceptual designs were created, incorporating features such as automated temperature and humidity control, efficient air circulation, and a user-friendly interface. The design also considered scalability to ensure the machine could be adapted for different production volumes. A scaled prototype (1:3 scale) was fabricated using high-quality materials and components. Key elements included a heating coil, multiple fans for air circulation, temperature and humidity sensors, and a control panel with an LCD screen and keypad. The prototype also featured caster wheels for mobility and a transparent glass door for monitoring the drying process.

The prototype underwent extensive performance testing to evaluate its effectiveness under various conditions. Controlled experiments were designed to measure several key parameters: drying time, energy consumption, uniformity of drying, and product quality. The prototype's drying time was compared to traditional methods to assess the reduction in time required to achieve optimal drying. Power usage was monitored throughout the drying cycles to evaluate the machine's energy efficiency. Moisture content was measured at multiple points within the drying chamber to ensure even drying across all samples. The quality of the dried fish was assessed based on texture, colour, moisture content, and overall appearance.

Data from the performance tests were systematically recorded and analysed. Statistical tools were used to interpret the results, focusing on identifying trends and evaluating the prototype's performance against predefined benchmarks. The analysis helped highlight the prototype's strengths and pinpoint areas needing improvement. To ensure the prototype met user needs, feedback was collected from industry professionals and potential users. Surveys and interviews provided valuable insights into the practical aspects of operating the machine, such as ease of use, maintenance requirements, and overall satisfaction. This feedback informed iterative design improvements, leading to modifications in the prototype to enhance functionality and user experience.

The final stage involved a comprehensive evaluation of the prototype's performance and the incorporation of user feedback. A detailed report was prepared, documenting the entire development process, test results, and design iterations. This report also included recommendations for further research and development, focusing on scaling up the prototype for commercial production and exploring additional features such as remote monitoring and advanced automation. Through this systematic and thorough approach, the project successfully developed a prototype salted fish drying machine that addresses the limitations of traditional methods, offering a viable solution for improving efficiency, consistency, and overall productivity in the fish drying industry.

3. Materials and Equipment

The project utilized a range of high-quality materials and advanced equipment to fabricate and test the salted fish drying machine prototype. The structural frame was constructed from aluminum, chosen for its lightweight properties, corrosion resistance, and durability. Energy-efficient heating coils were used as the primary heating elements, complemented by high-grade thermal insulation to minimize heat loss and ensure efficient operation. The drying racks, made from food-grade aluminum, provided a safe and hygienic surface for the fish. Precision temperature and humidity sensors were integrated to facilitate accurate monitoring and control of the drying conditions. The control panel featured an LCD screen, keypad, and indicator lights, offering a user-friendly interface for operators. A transparent glass door was installed to allow for easy monitoring of the drying process without needing to open the chamber, thus maintaining a controlled environment. For mobility, the prototype was equipped with caster wheels, making it easy to move as needed.

The equipment used in the project included an Arduino Mega microcontroller, which automated the drying process and ensured precise control of the system. Multiple high-efficiency fans were installed to optimize air circulation within the drying chamber, promoting uniform drying of the fish. A stable power supply unit was employed to ensure consistent operation. During testing, data logging devices were used to record performance metrics, and moisture meters along with thermal cameras were utilized to evaluate drying uniformity and efficiency. Fabrication tools, such as welding machines, cutting tools, and assembly jigs, were essential for constructing the prototype. These carefully selected materials and equipment ensured that the prototype was robust, efficient, and capable of delivering consistent drying performance.

4. Result and Analysis

In the endeavor to create an advanced salted fish drying machine, the project commenced with initial sketches that laid the groundwork for the machine's conceptualization and development. Several sketches were

considered, including Sketch 1, Sketch 2, and Sketch 3, each evaluated against criteria such as safety, mobility, cost-effectiveness, maintenance requirements, drying efficiency, and drying capacity. Among these, Sketch 1 emerged as the optimal choice due to its comprehensive design features, which included effective air circulation facilitated by an external fan and precise temperature regulation through integrated sensors. This selection marked a pivotal step in refining the machine's design towards its final form.

a)

b)

c)

d)
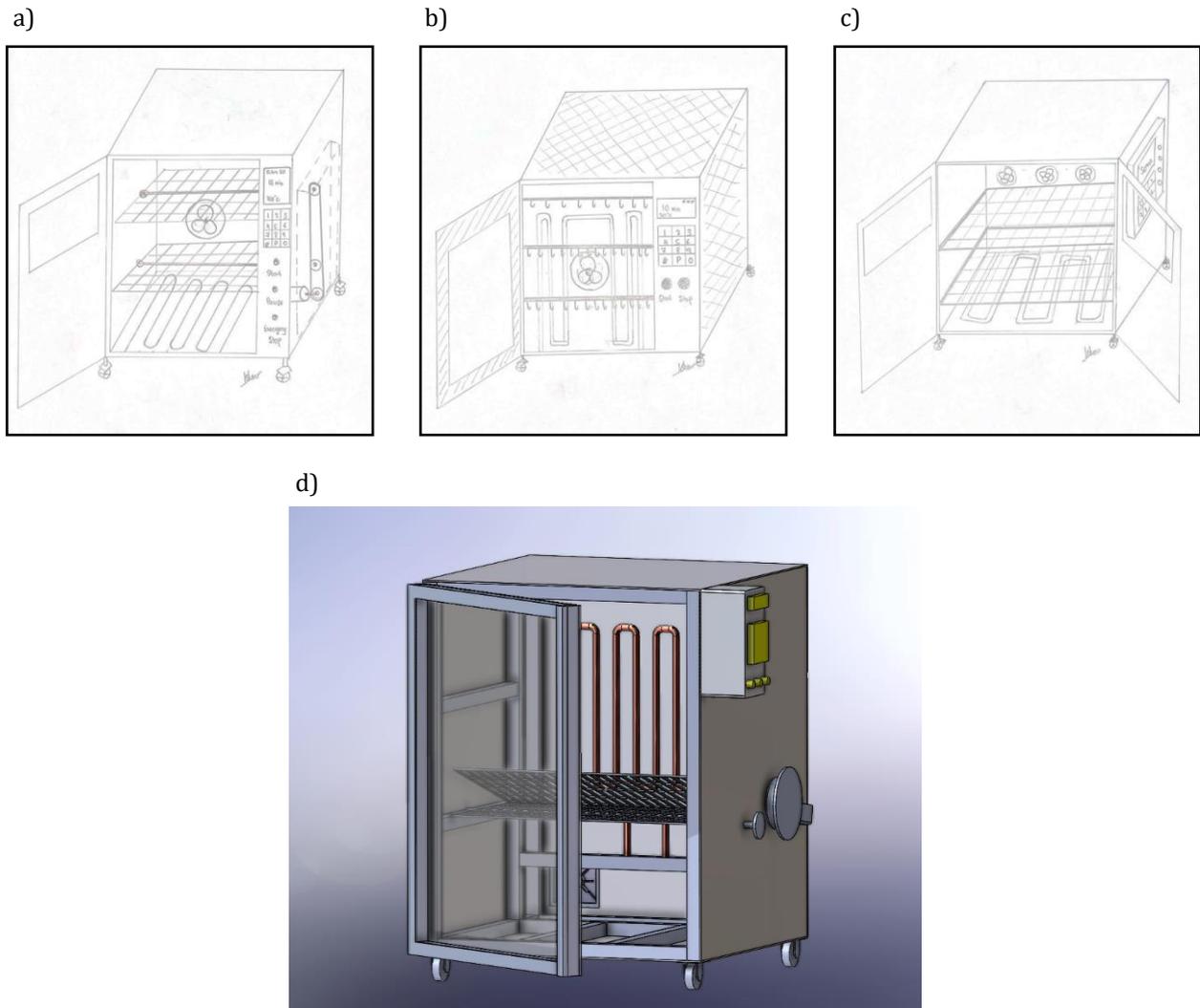
Fig. 1 *a) Sketch 1 b) Sketch 2 c) Sketch 3 d) Final Design*

The progression from initial sketches to final designs involved meticulous detailing and refinement to integrate mechanical and structural elements seamlessly. The final sketches incorporated robust frameworks designed to withstand the stresses of operation, with detailed stress tests conducted using Finite Element Analysis (FEA) to ensure structural integrity and safety under varying loads. The choice of material, aluminum, was validated through FEA simulations, confirming its suitability for maintaining durability and reliability in the machine's operational context.
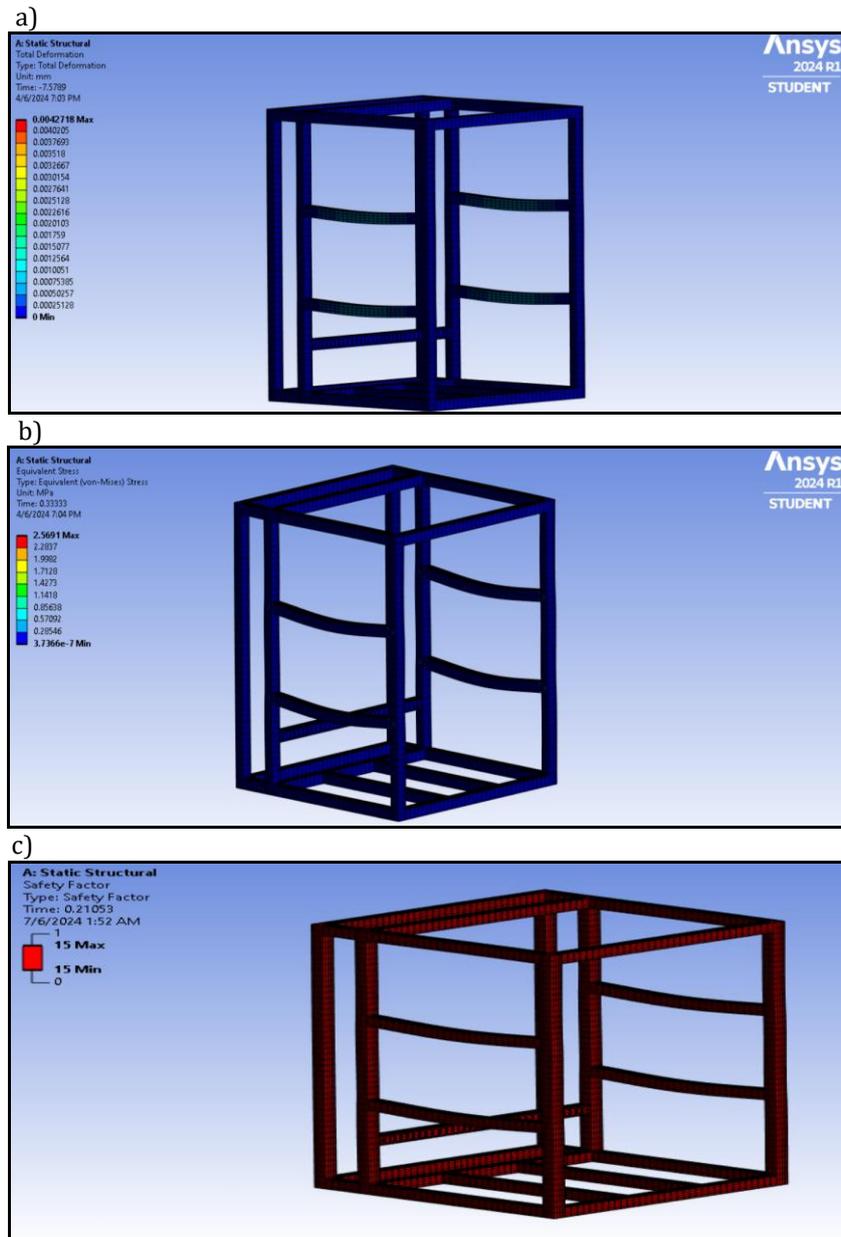
a)

b)

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Fig. 2 *a) Total Deformation b) Equivalent Stress c) Safety Factor*

Electrical connections were critical components of the machine's functionality, featuring advanced elements such as the Arduino Mega 2560 microcontroller, sensors for real-time monitoring of temperature and humidity levels, LCD displays for intuitive user interface, and power supplies ensuring consistent operation. These components were intricately integrated into the system to provide precise control over drying parameters, enhancing both operational efficiency and user accessibility.

a)
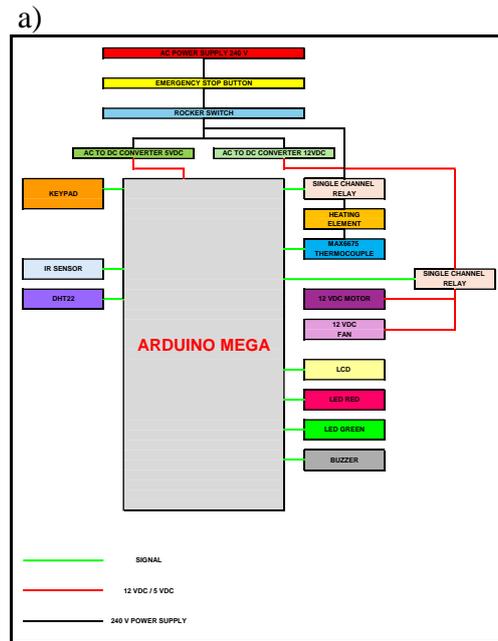
Fig. 3 *a) Block Diagram*

The user interface design was meticulously crafted to facilitate straightforward interaction, enabling operators to effortlessly set and monitor drying conditions. Detailed block diagrams and interface architectures were developed to illustrate the layout and functionality of the control panel, highlighting features such as adjustable temperature settings and programmable drying cycles essential for achieving consistent and high-quality drying results. This intuitive interface not only streamlined operational processes but also contributed significantly to overall efficiency.

a)
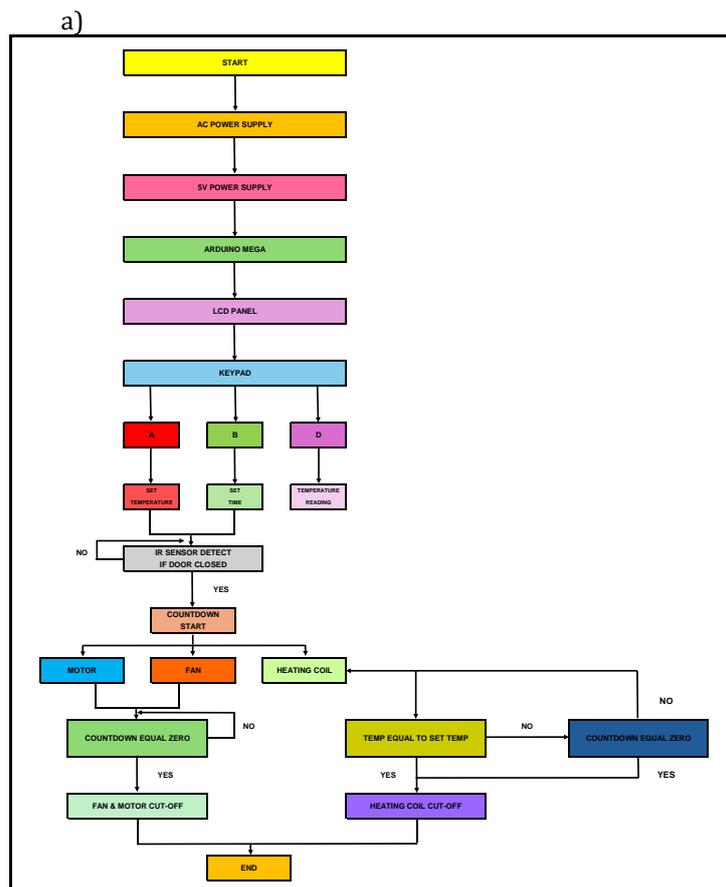
Fig. 4 *a) Flow Chart*

In testing the machine's performance, comprehensive trials were conducted using actual salted fish samples to validate its effectiveness across different weights and moisture levels. These rigorous tests aimed to ensure uniform drying outcomes while maintaining the fish's optimal texture and flavor profile. The results from these trials affirmed the machine's capability to consistently deliver desired drying results, thereby validating its reliability and suitability for industrial-scale applications.

Table 1 *a) Different Mass of Fish b) Mass of the Fish Within a Range Of 100 To 106 g*

a)

Sample	1	2	3	4	5
Wet Mass (g)	310	190	420	110	370
Dry Mass (g)	201	95	195	38	223

b)

Sample	1	2	3	4	5
Wet Mass (g)	101	103	102	106	100
Dry Mass (g)	32	36	37	39	34

Throughout the development process, environmental sustainability considerations were paramount. Emphasis was placed on the recyclability of materials used, with aluminum chosen not only for its durability but also for its environmentally friendly properties. This commitment to sustainability underscored the project's broader objectives of reducing environmental impact while ensuring long-term operational efficiency and durability.

By integrating advanced design principles, precise electrical configurations, user-friendly interfaces, and rigorous testing protocols, the salted fish drying machine project successfully achieved its goals of efficiency, reliability, and sustainability in meeting industrial drying needs.

5. Conclusion

The development of the prototype salted fish drying machine marks a significant advancement in the field of food processing technology for SMIs. The machine's design and performance testing indicate substantial improvements in drying efficiency, product consistency, and energy consumption. By addressing the limitations of traditional drying methods, the prototype offers a reliable and cost-effective solution for the fish drying industry.

Future work will involve scaling up the prototype for commercial production and conducting extensive field tests to validate its performance in diverse operational environments. Further research may also explore additional features, such as advanced automation and remote monitoring capabilities, to enhance the machine's functionality and user experience.

Overall, this study demonstrates the potential of innovative drying technology to support the economic resilience of coastal communities and preserve cultural heritage through improved food preservation methods.
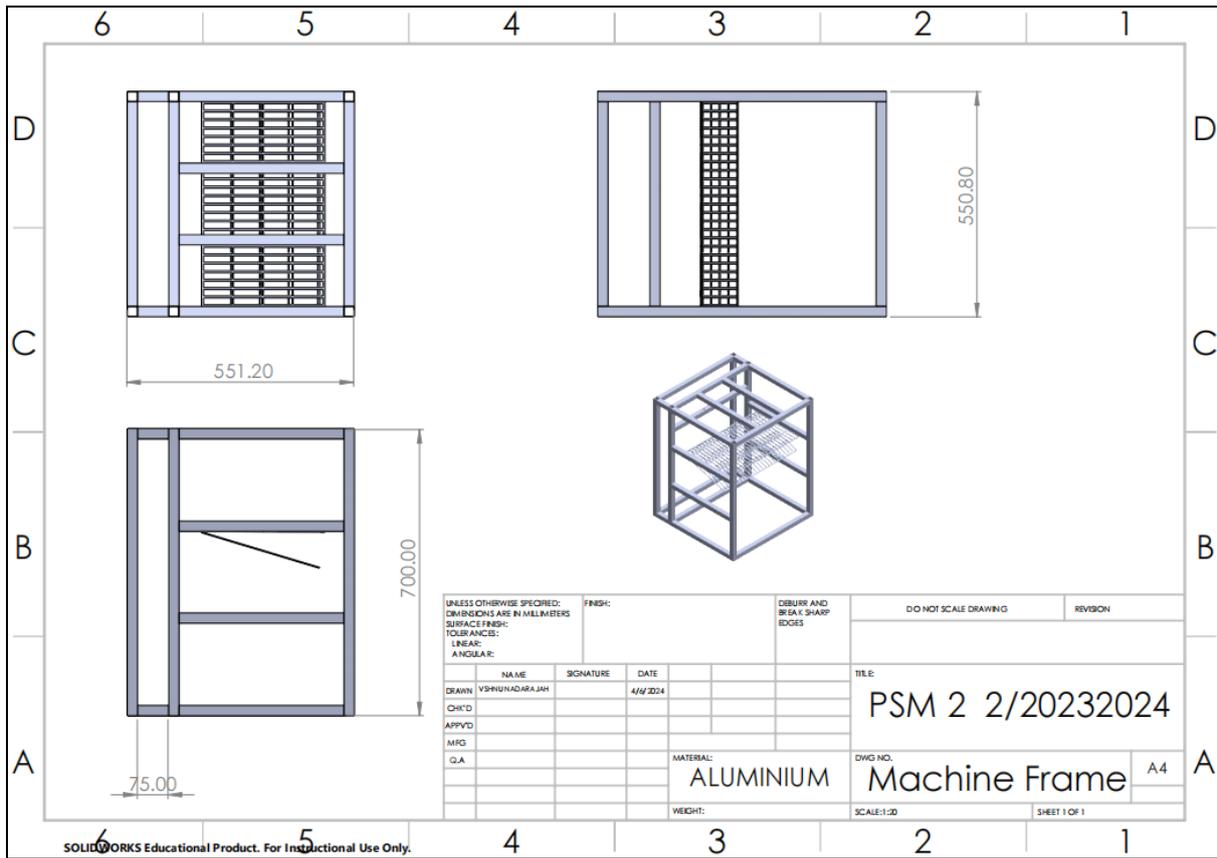
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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.
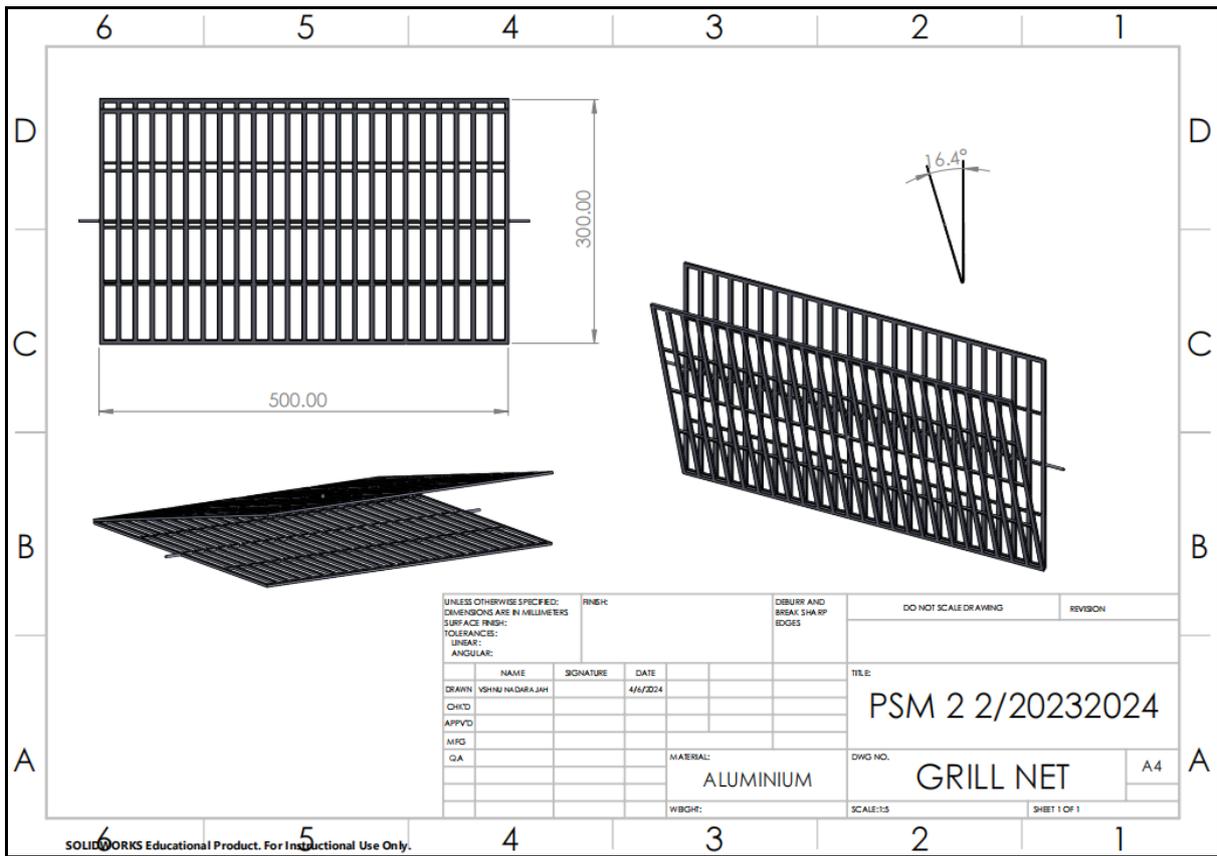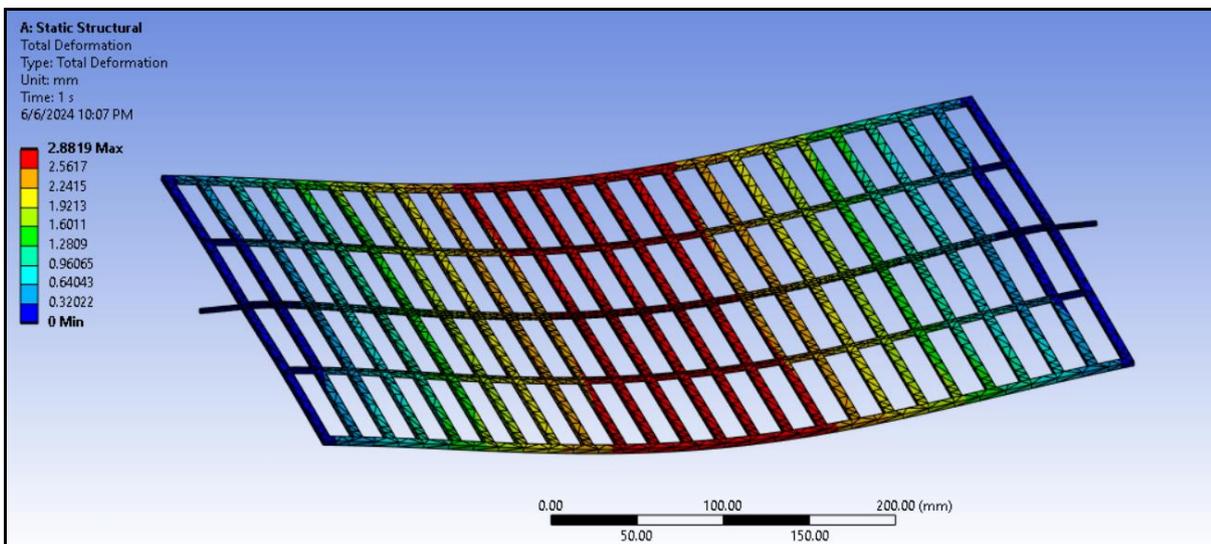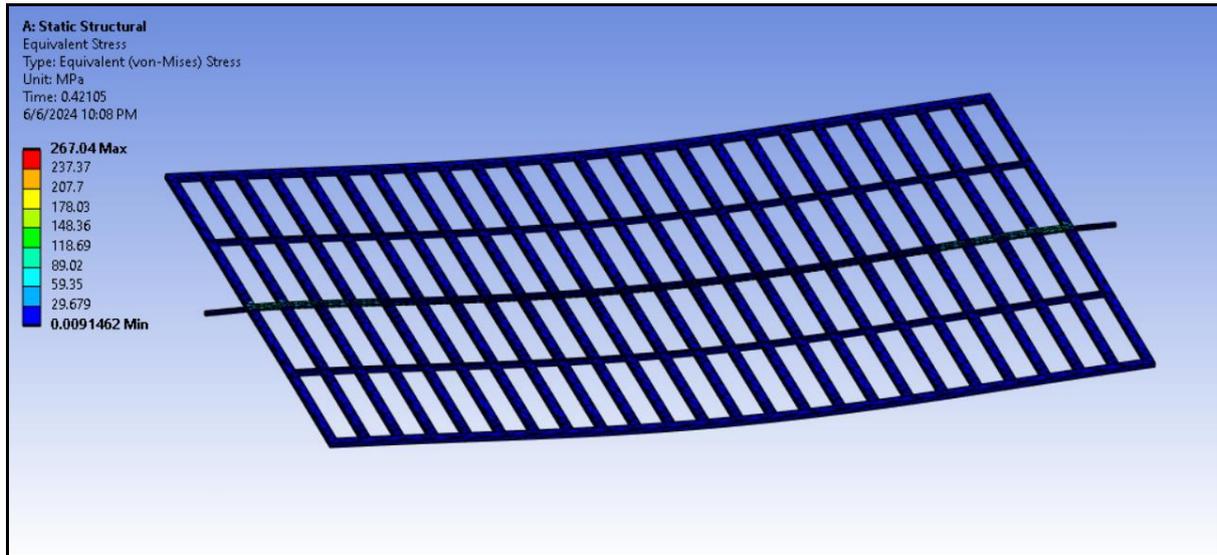
Appendix A: Machine Part Drawings

a)

b)

Fig. 6 *a) Machine Frame Drawing b) Grill Net Drawing*

Appendix B: Grill Net Stimulations

a)

b)
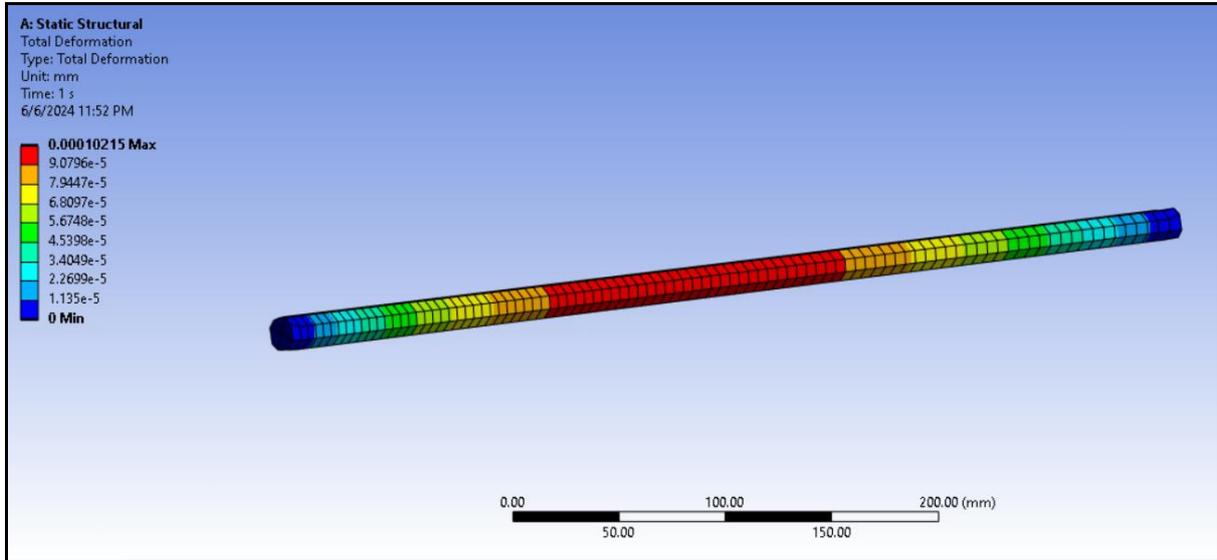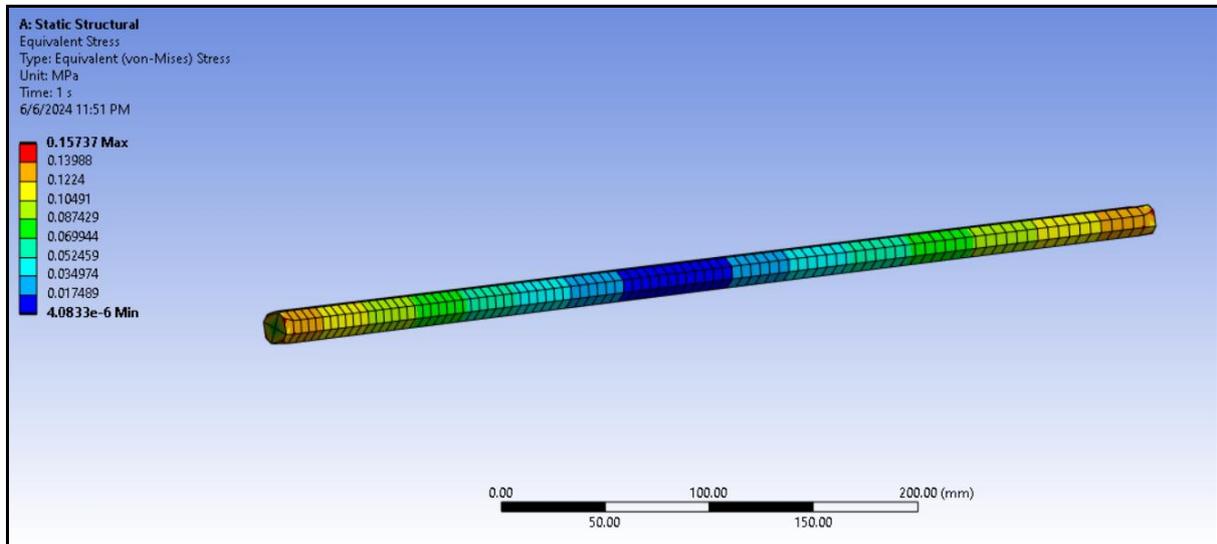

c)
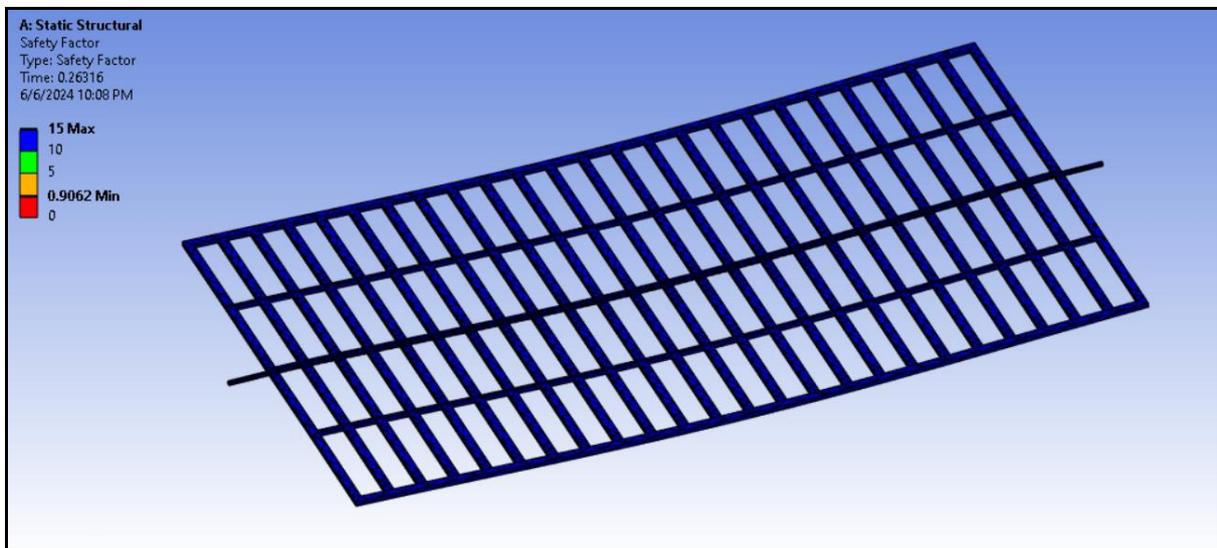
Fig. 7 a) Total Deformation b) Equivalent Stress c) Safety Factor

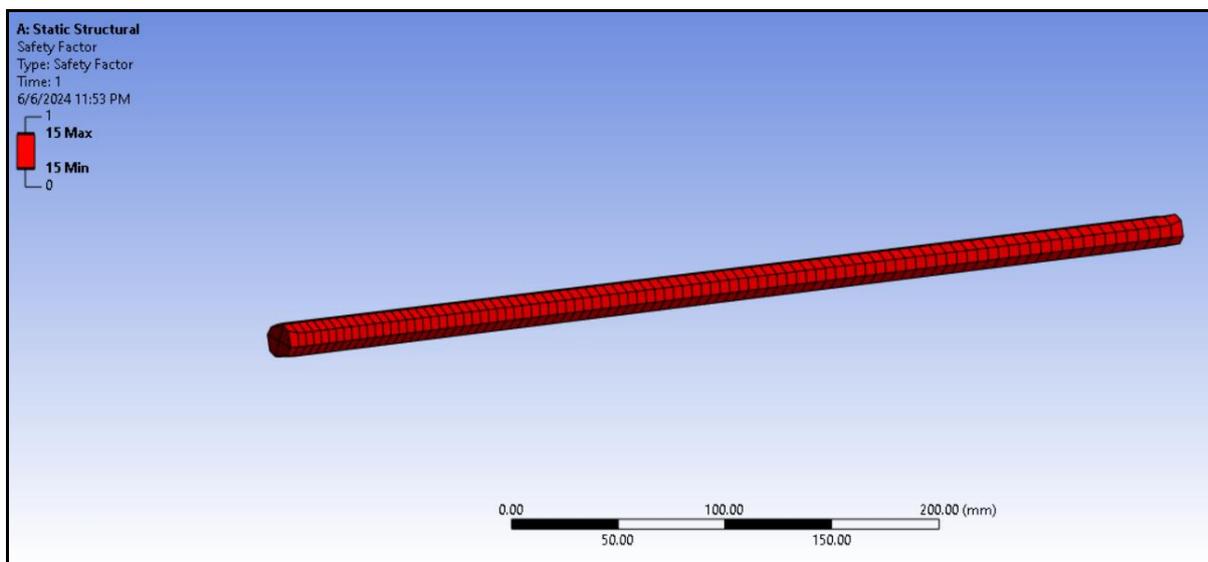## Appendix C: Shaft Stimulations

a)

b)

c)

Fig. 8 a) Total Deformation b) Equivalent Stress c) Safety Factor

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