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Creative Product Prototype of Natural Fiber Craft Tray in Rural Vocational Communities

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ABSTRACT

In the digital era, the creative economy is increasingly developing through creative products that have become leading products in every country. one of them is the water hyacinth tray which is one of the superior products of the Kulon Progo community, Special Region of Yogyakarta. The purpose of the study is to apply mechanical engineering science, the frame of this tray will be tested for its feasibility and durability and students can participate in implementing creative product applications that are beneficial to the general public. The research method uses action research with sample data including materials, material density values and material volume lifted by the tray. Testing of the tray frame using Finite Element Analysis (FEA/FEM) to determine the maximum load that can be carried by the tray. The tray frame is loaded to obtain stress propagation, deformation, tensile safety factor and cycle life. The working loads given include 2.9 kg, 3.4 kg and 4 kg while the maximum load in the experiment is 5 kg and 10 kg. The results of the research on the concept of creativity become a basic concept in the development of science and skills. In tray design, steel is the best material for making trays when tested with software.

Keywords: Creative, Product Testing, Finite Element Analysis

INTRODUCTION

The industrial revolution 4.0 is characterized by competitive competition and rapid technological and information progress in all sectors, including human resources [1]. Industrial growth and technological development require competent human resources in every business organization [2]. The current industrial development certainly encourages the business world to become an industry supported by the development of science and technology [3]. In this era, the progress of civilization will grow in line with the rate of economic growth in the area. The new rural collective economy is an important external mechanism for improving welfare [4]. Economic figures show that the rural economy is very different from the urban one. In rural economies, it is less advanced because the level of productivity is low compared to urban areas. One of the obstacles in the development process is the large number of unemployed in an area [5].

Rural productivity depends on food crops such as rice, corn, beans, and so on. This is what makes the rural economy tend to be lower. Economic data shows that poverty and unemployment rates are highest in remote rural areas. One of the problems that often occurs in villages is the problem of unemployment and urbanization. [6]. On the other hand, the existence of entrepreneurship in rural areas provides its own color for unemployment [7]. This is what inspires researchers to develop economic potential in rural areas which can later be utilized by the wider community, academics, and other businesses. Through a global survey, UNCTAD revealed various economic contributions from the creative economy in various countries, ranging from 0.5% to 7.3% of GDP and employing between 0.5% and 12.5% of the workforce [8]. On the other hand, the growth of the digital economy in Indonesia in 2023 increased by 8 to 10 percent or worth 82 billion US dollars [9].

Employment development is very important for rural areas to develop economic progress. Rural areas with large creative economic potential and tourist villages have opportunities if they can be optimized with the support of various parties [10]. In addition, employment development can also advance civilization, skills, and enthusiasm of rural communities. MSMEs must be able to improve their quality through empowerment by increasing innovation in both products or services, supported by the development of human resource quality and technology [11]. Human resources are one of the important aspects in an organization because human resources manage various other aspects of an organization. [12]. Creative products are one of the solutions to develop the rural economy because they are in line with the village culture, abundant natural potential, increasing human resource potential, and reducing unemployment. Such as the potential for rural green tourism in Ukraine by determining the main directions of its

innovative development, through consideration of global, national, and regional trends [13].

Business actors in the creative economy are required to be able to create innovation or creative ideas to create creative output [14]. The creative industry should be able to create new products that are original, unique, and have high appeal or at least develop existing products [15]. For example, the use of water hyacinth is processed into various kinds of handicraft products which can provide economic benefits for the community [16]. Water hyacinth trays are one of the creative economic products that utilize water hyacinth as one of its basic ingredients. So far, water hyacinth has received a negative stigma as a plant that causes a lot of losses because it has a fast and uncontrolled reproduction rate, especially in tropical and subtropical areas, [17].

However, if processed into creative products, they have been circulating in the market for a long time. One of the areas producing water hyacinth crafts is the Kulon Progo area, Yogyakarta. This area is a center for water hyacinth crafts, most of the craftsmen have been producing various kinds of creative economic products made from water hyacinth which are exported to various countries. Most of the creative economy craftsmen who use water hyacinth as their material are residents in Kulon Progo, the majority are housewives who help to secure the family economy. The participation of housewives will increase household income and encourage the country's economic development [18]. The water hyacinth craft center provides extensive benefits for the water hyacinth craftsmen's areas, in addition to being able to advance the economy of a region, this craft can also help the community to be more creative and innovative in utilizing objects around them that can be made into valuable products.

In its development, this creative product has not been tested for feasibility in technical or vocational aspects. Vocational and engineering sciences are very useful for the development of creative economic products in terms of welding, bending, and structural science. In addition, in educational science, this research will be useful for Sarjanawiyata Tamansiswa University students to practice fabrication. The fabrication in question is the 3D design process, modeling, design testing, to product manufacturing using bending, cutting, and welding methods. This can increase students' insight and understand the usefulness of vocational science in society to advance the economy of a region. After that, the development of this creative product can increase new employment opportunities in the agro-industry sector, and village-based industries that have developed rapidly in the Kulon Progo area, Yogyakarta.

In the field of engineering, of course, we will see in terms of product quality such as product strength, manufacturing efficiency, safety in the production process, product life,

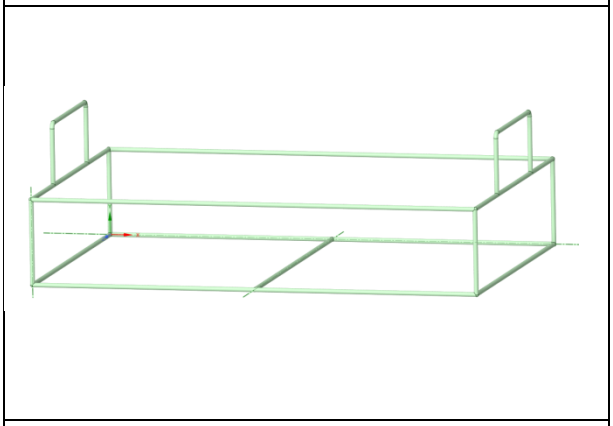
to the loading that occurs so that it can provide satisfaction for product buyers. Because the product quality is good, there will be interest in buying and consumers will feel satisfied [19]. This study will focus on knowing the durability and maximum loading limit on the water hyacinth tray structure. In addition, knowing the manufacturing process, development of water hyacinth trays which will eventually be marketed to the wider community.

RESEARCH METHOD

The research method uses action research. The basic objective of this research is more focused on improving conditions, through a cycle process, followed by systematic findings, as a reflective process, participatory with the topic of the problem determined by practitioners [20]. Through the test of the tray strength results with the finite element analysis method to review the strength of the material structure. Samples taken quantitative data using numbers in describing research data [20]. Obtained in the study include the strength of this structure is taken based on load data when the tray is used. The load value will be varied from what material is carried by the tray. Calculations are based on the value of the material density and the volume of material loaded by the tray. The hope is to get the maximum load value, maximum stress, total deformation, safety factor, to the life cycle of the tray.

The data results obtained are analyzed and presented through the Miles and Huberman analysis concept including data reduction, data display and conclusion drawing/verification [21]. Supported by FEA stages. FEA stages are used to model the tray, including 3D models, meshing, boundary condition settings, load settings, tensile method settings, fatigue method settings, until the results are obtained. The 3D model is modeled like the original tray. The tray uses 3.5 mm steel wire with material properties shown in table 1. The tray structure uses dimensions as shown in figure 1. The tray model is then discretized using ANSYS Student Version software with a mesh of 80606 tetrahedron nodes. Then setting the boundary condition as in Figure 1, the boundary condition is used to set the load and fix support on the tray. The analysis taken from FEA is the desired result. In fatigue analysis, the method used is Goodman and the kf value is 0.8.

a



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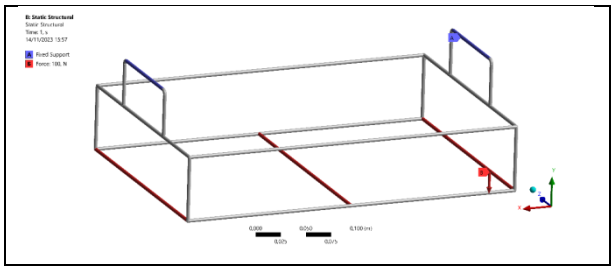


Figure 1. (a) Model; (b) Setting boundaries

Then converting material to mass can be seen in the following table:

Table 1. Mass conversion results

Load	Material	Volume	Total	Mass of material	Water Mass	Total Mass
12 Aqua	Plastic	240 mL	2880 mL	60 gr	2.88 kg	2.9 kg
12 Glasses	Glass	200 mL	2400 mL	1 kg	2.4 kg	3.4 kg
12 Bottle	Plastic	330 mL	3960 mL	72 grams	3.96 kg	4 kg

Table 1. Design testing

Variation	Weight or Load
1	28.45 N
2	33.35 N
3	39.24 N
4	50 N
5	100 N

In addition to the existing load, the modeling experiment also uses 2 materials, namely steel and galvanized. The material properties of each material are shown in table 3 below:

Table 2. Material properties

Material properties	Galvanized Material	Carbon Steel Material
Density (kg/ m^3)	2660	7850
Ultimate Tensile Strength (MPa)	275	360
Yield Strength (MPa)	125	250
Young's Modulus (MPa)	70300	210000
Poisson's Ratio	0.3	0.3
Maximum Allowable Stress (MPa)	93.75	176.25

The difference between the two types of materials will affect the stress that occurs and the effects of the deformation that occurs, both fatigue and tensile. This will be analyzed in the research results section.

Tray Production

After knowing the strength and durability of the tray with various existing materials, the tray will be produced using the appropriate material through the welding process. After the welding process, the tray will be processed post weld heat treatment (PWHT) to reduce residual stress to a temperature of 300-400 ^{o} C. This is done so that the tray structure does not have residual stress due to welding.

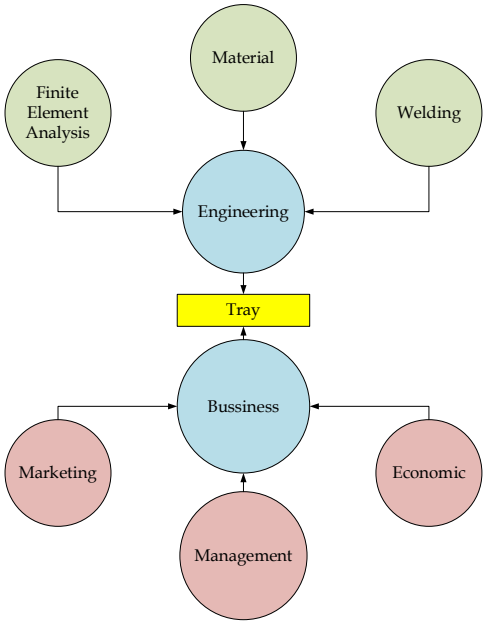
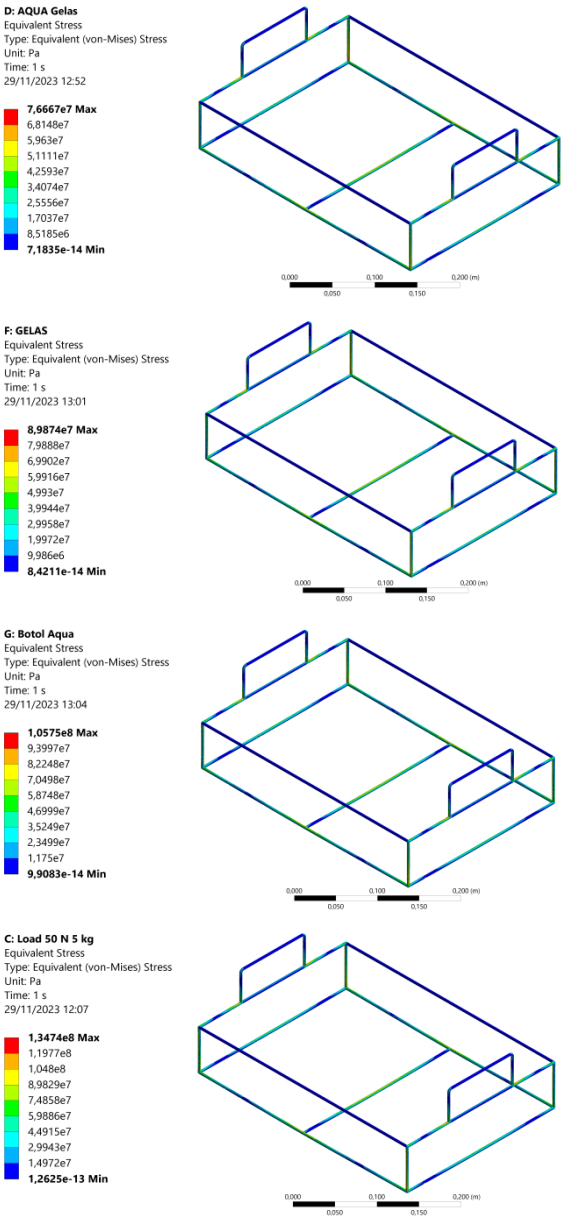


Figure 2. Production process

RESULT AND DISCUSSION

Based on the samples that have been taken to be able to determine the design and selection of good materials, careful calculations are needed. In the planning process of calculating the frame, a calculation process is needed to facilitate the manufacturing or planning process [22] . von mises stress results , the stress received by the tray structure is 76.67 MPa at a load of 2.9 kg (Aqua glass), 89.7 MPa at a load of 3.4 kg (Glass), 105 MPa at a load of 4 kg (Aqua bottle), 135 MPa at a load of 5 kg, and 269 MPa at a load of 10 kg. If referring to the yield strength figures on both materials. Galvanized material has a lower yield strength than medium carbon steel. This will affect the tensile strength of the material . However, the stress on each material will be the same because the stress is calculated based on the existing load per unit area. Figure 3 shows the von mises stress contour with each load.

The voltage is depicted through the colors blue to red, with the blue color detail indicating the minimum voltage, while the red color is the maximum voltage. The stress distribution that occurs in the middle parts of the tray, tray joints, and the bottom tray bars.



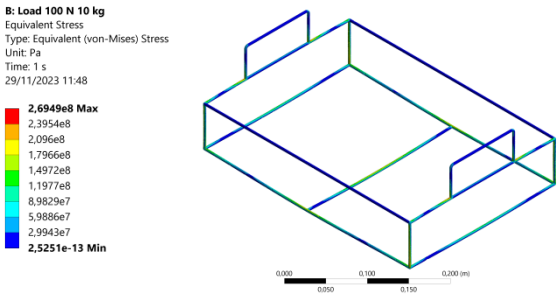
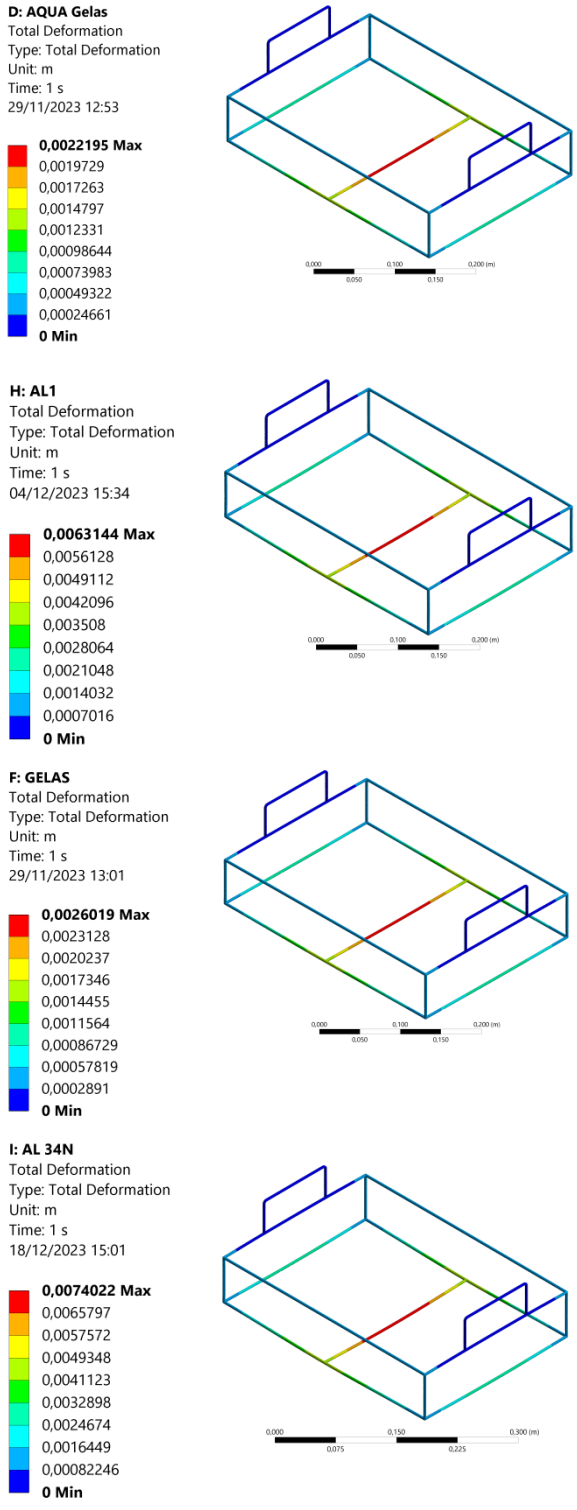


Figure 3. Contour von mises stress

Total Deformation

Based on the results of the total deformation contour, the use of aluminum and steel materials looks different . The difference between the two occurs in the magnitude of the deformation that occurs. Figure 4 shows a comparison of the contour of the total deformation results that occur in galvanized and carbon steel materials. The contour shows the color from blue (lowest) to red (highest) based on the total deformation value. This total deformation is a change in the shape, dimension and position of a material or object [23]. This stress is generated from von mises stress that occurs due to load. The difference in material use can be seen in the load 1 galvanized material 6.3 mm while steel 2.2 mm, load 2 galvanized material 7.4 mm while steel 2.6 mm, load 3 galvanized material 8.7 mm while steel 3 mm, load 4 galvanized material 11 mm while steel 3.9 mm, load 5 galvanized material 22 mm while steel 7.8 mm.



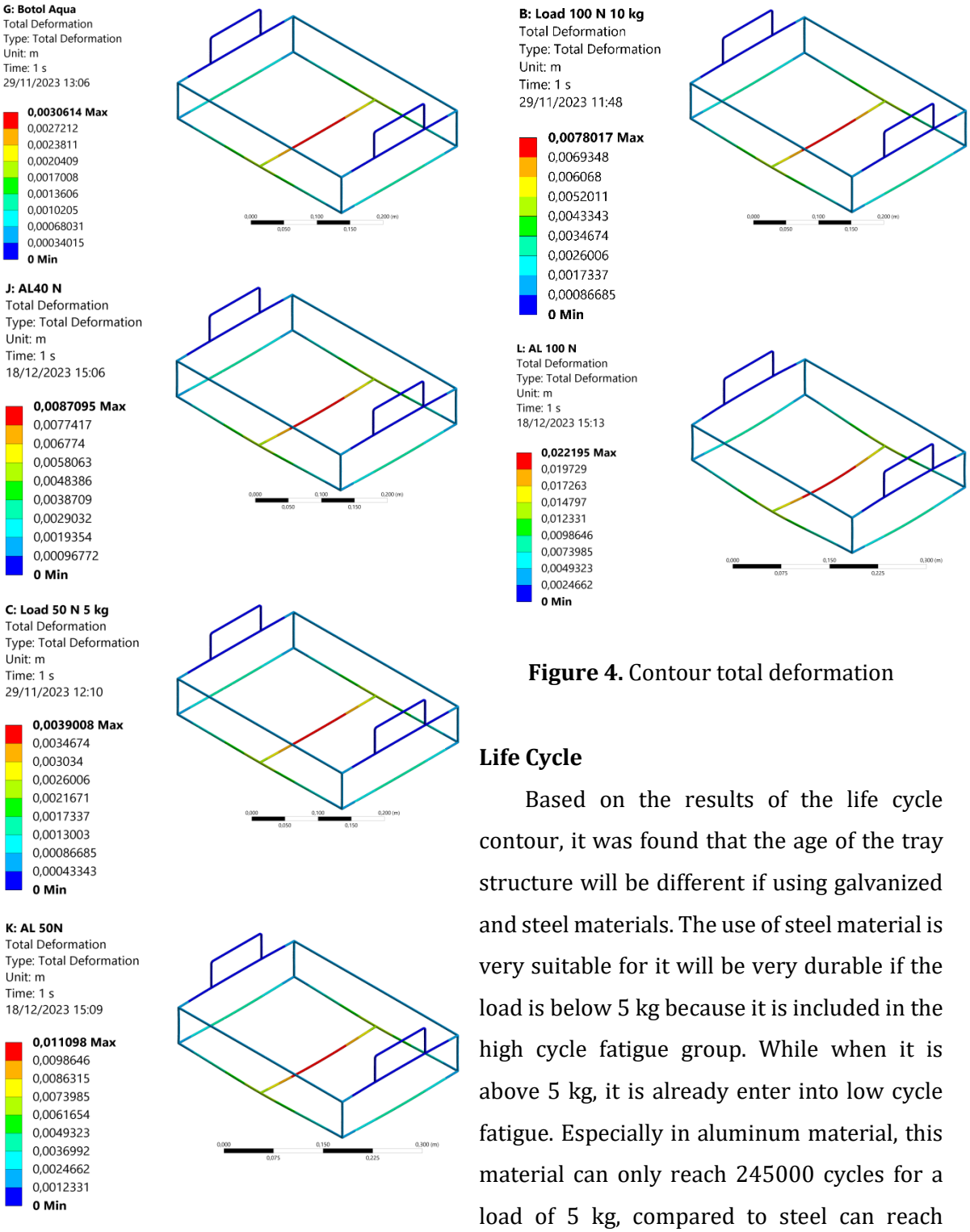


Figure 4. Contour total deformation

Life Cycle

Based on the results of the life cycle contour, it was found that the age of the tray structure will be different if using galvanized and steel materials. The use of steel material is very suitable for it will be very durable if the load is below 5 kg because it is included in the high cycle fatigue group. While when it is above 5 kg, it is already enter into low cycle fatigue. Especially in aluminum material, this material can only reach 245000 cycles for a load of 5 kg, compared to steel can reach 500000 cycles . This fatigue occurs due to the use of load and unload continuously and repeatedly so that the structure is susceptible to failure and damage.

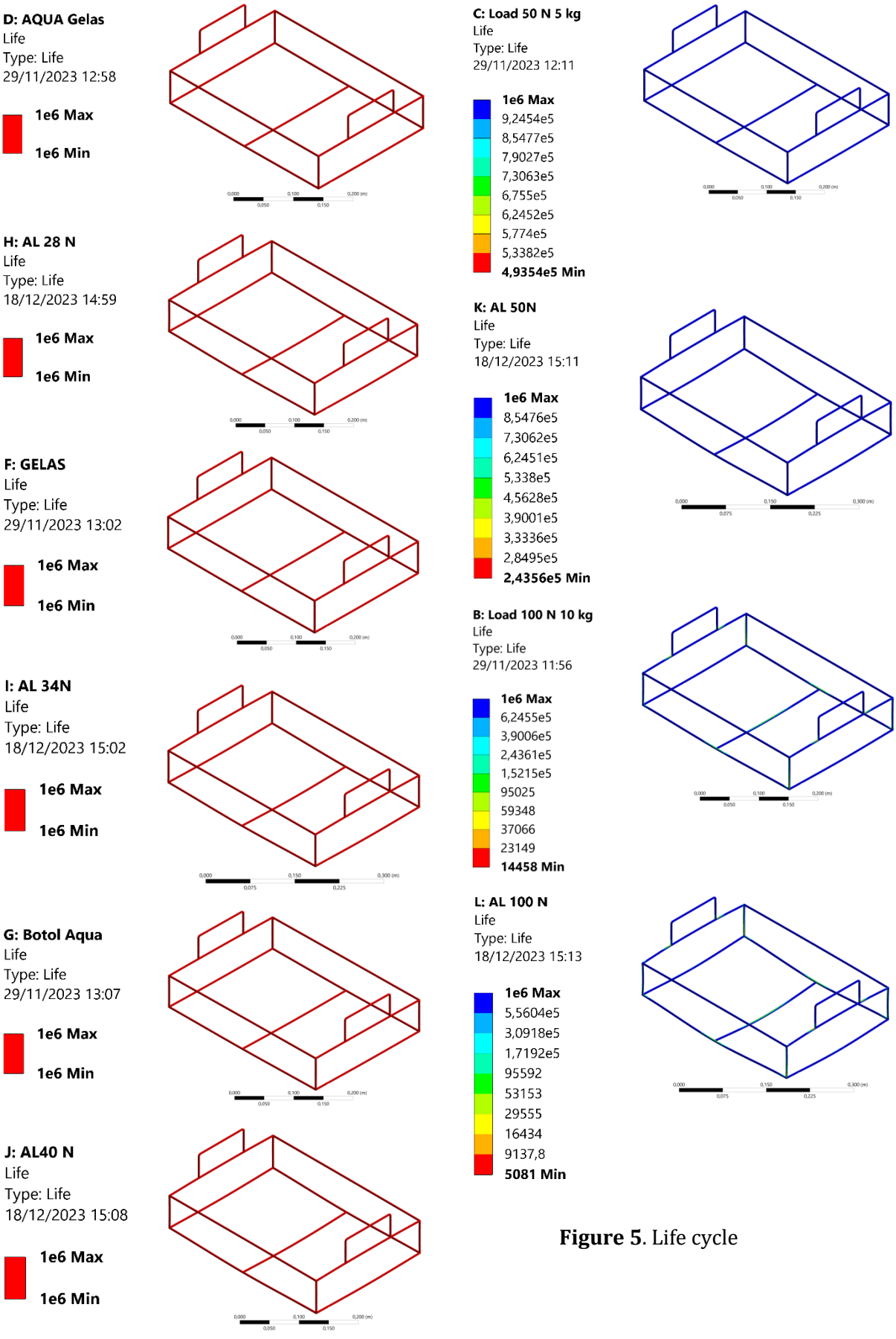
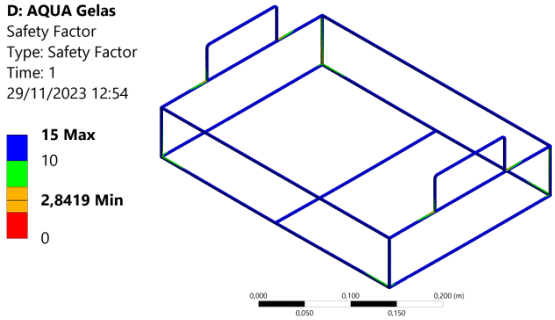
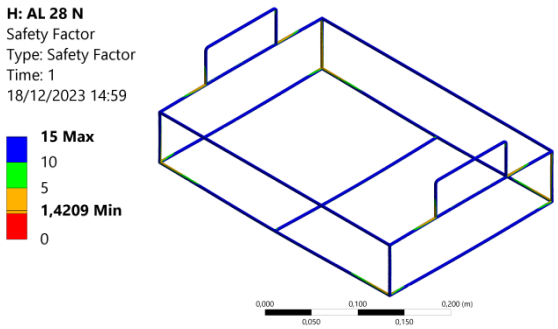


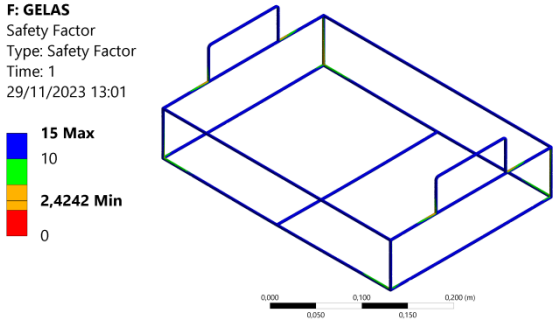
Figure 5. Life cycle

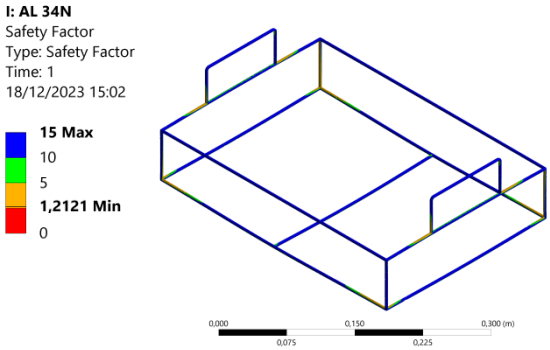
Safety Factor

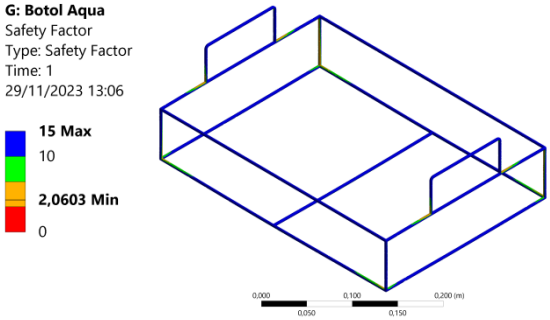
Based on the safety factor figures, this tray structure tends to be below the ASME standard. But still above the SNI standard. In a structure with steel material, it can withstand a load of up to 5 kg and still meets the SNI standard, while with Galvanized material it can only lift a load of 3.4 kg to meet the SNI standard. The SNI standard itself ranges above 1.4-2 sf. Safety factor is an important safety standard factor in product design, a factor used to evaluate so that construction planning is guaranteed to be safe [24].

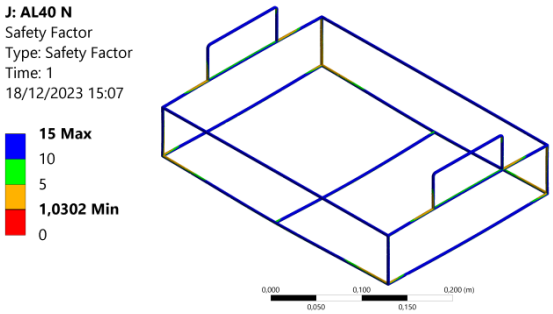


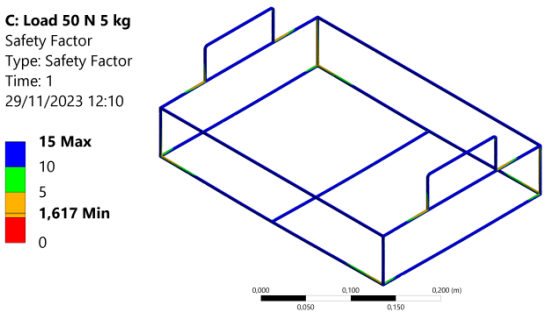


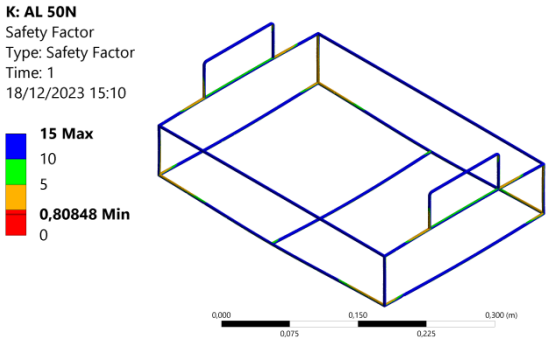












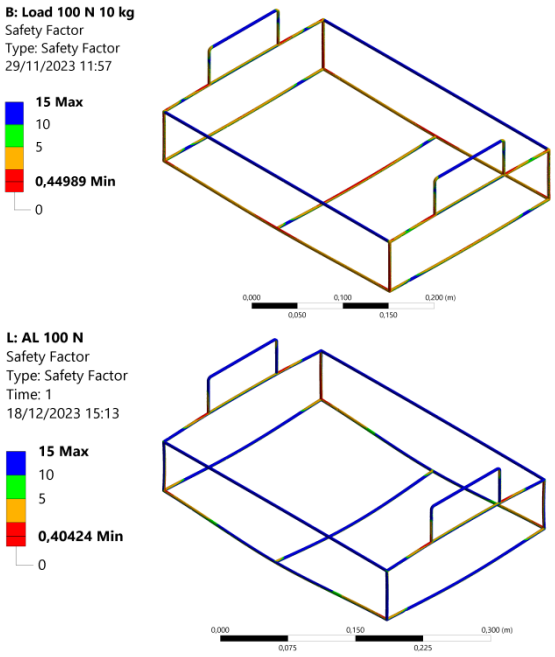


Figure 6. Safety factor tensile

Based on the discussion of the Engineering field, Steel structure is better than using galvanized. This is illustrated in the results of the total deformation image, life cycle, and safety factor on the galvanized tray model which is easier to deform. So that the use of steel will be more effective and stronger than the use of galvanized. Efforts to produce optimal products in product design certainly require a series of activities including product planning and development, starting from the stage of finding creative ideas, analysis, development, design, systems and details of making prototypes, production, evaluation or product testing, ending with the sales stage [25].

Tray Production

The production process is done manually with a welding process to combine one by one the steel bars to form a single tray frame unit. The welding process has indeed been widely used in connecting rods in construction steel [26]. The production process is certainly carried out according to the design that has been made previously to obtain good results in terms of shape and strength that can be optimal. Product quality is the main thing in the production process to provide satisfaction to buyers later. The quality of the company's products must be maintained properly, because the better the quality of the product in a product, the more customers will be interested in buying and even buying repeatedly [27].

Marketing

Marketing of tray products is done by ordering according to the amount that will be needed. This process is carried out to maintain product quality by optimizing the production process and also to encourage the development of businesses that are still medium to low. Innovation in products and good strategies have a positive and significant impact on the development of SME businesses [28]. marketing and natural resources (SDA) so that they can be utilized as efficiently as possible to provide positive value for their creative economic efforts [29].

Development of Knowledge and Skills

The tray design process through software as an illustration is the application of current technological advances. The development of science with the support of skills will create a product that certainly has a selling value. The advancement of Information and

Communication Technology in the era of the industrial revolution 4.0 encourages us to be able to keep up with the increase in human resources by increasing the level of self-competence, especially in the field of technology [30]. Humans who have the concept of lifelong learning and continue to process that implements innovation will have competitiveness towards sustainability. Lifelong learning in the 21st century is a very important skill for every human being in facing the era of disruption that is developing rapidly [31]. Because of the importance of increasing competence in facing the development of the times [32]. In addition, all work activities have the main goal of earning a living in improving the standard and quality of life of the family [33]. Through education for individuals that is fully carried out throughout life is an effort to develop self-potential in harmony with nature and essence through growing awareness of the process of growth of science and skills that are alive and dynamic to maintain and improve the quality of life [34]. One of them is through quality control carried out by assessing objects in the realm of knowledge, attitudes, and skills [35].

The development of trays involving knowledge, abilities and creativity from tray development is a concept that makes the latest breakthroughs. creative and innovative attitudes are able to survive and thrive in difficult economic conditions [36]. In addition, in running an MSME business, of course, accurate calculations and brilliant ideas are needed to get creative and innovative results as an effort to provide an attractive image or value to consumers [37]. So the most important thing is to grow innovation in the creative economy to strive for sustainability [38].

CONCLUSION

The concept of creativity is a basic concept in the development of knowledge and skills. Improving quality by testing tray durability using technology is an application of mechanical engineering in mature product manufacturing planning to produce quality products. In tray design, steel is the best material for making trays when tested using software. The application of tray design uses individual skills in combining several steels into one unit to form a product that is ready to be sold to consumers with the best quality.

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