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# Design of Cockles Cleaning and Grading Machine Using Cost Based Method

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**Abstract**

This study focuses on the development of a cockles cleaning and grading machine to enhance shellfish processing and agricultural productivity. The machine is designed to maximize resource utilization and support medium-sized businesses. The user-friendly and cost-effective machine incorporates a washing and grading system, resulting in flawless shell output. The machine's capabilities include processing 3,834 clams per hour, providing entrepreneurs with increased efficiency in mussel output.

## 1. Introduction

In the 1980s, Malaysia implemented an economic diversification strategy, shifting focus from commodity sectors to aggressively develop the manufacturing sector. The Rangka Rancangan Jangka Panjang Ketiga (RPJP3) facilitated the growth of other industries, including education, tourism, agriculture, electronics, and medicine. Supported by government policies and incentives, these National Key Economic Areas (NKEAs) aimed to make Malaysia a developed nation by 2020. Malaysia's GDP, measured as Gross Domestic Product (GDP) or Kadar Dalam Negara Kasar (KDNK), reflects the overall market value of goods and services produced. The country's economy continued to expand, driven by services, manufacturing, mining, agriculture, and construction. Manufacturing accounts for 24.1% of production value, while agriculture contributes 6.1%. Small and medium-sized enterprises (SMEs) play a vital role in driving economic growth, and the Industrial Classification System (IKS) categorizes businesses based on revenue and employee count.

The fisheries sector in Malaysia faces challenges from climate change, limited production factors, and trade liberalization. Overexploitation of marine catches has led to a decline in production, with biomass decreasing by over 80% since the 1960s. To meet the rising demand for food fish due to population growth, aquaculture is being promoted as an alternative. The government aims to increase fish output through aquaculture, which has the potential to contribute up to 50% of the nation's fish supply by 2020. However, the sector must overcome challenges such as input price growth and competition for resources. An Action Plan formulated by the Department of Fisheries in 2013 supports the growth of the aquaculture industry as a backup for marine fish supply and to meet domestic demand.

Cockles are a significant marine catch in Malaysia's aquaculture industry. The blood clam (*Anadara granosa*) is commonly farmed in the mangrove swamp regions on the west coast of Peninsular Malaysia. Cockle cultivation began in 1984 and has since grown in popularity, with a potential farming area of 28,540 hectares. Cockles have a healthy market in Malaysia and neighbouring countries like Thailand and Singapore. The farming technique is straightforward, and cockles offer favourable pricing and returns. However, ensuring good quality and a large yield requires careful site selection, seed collection, proper seed sowing, predator control, and efficient handling. Inconsistent cleanliness levels of manually harvested clams can be a challenge. To address these issues, strategies and activities must be developed to support the cockle farming business and ensure sustainable aquaculture. This diversification can benefit coastal fishermen, small and medium-sized enterprises (SMEs), and seafood restaurants by providing additional revenue streams during adverse fishing seasons.

Before the invention of modern equipment, cockles cleaning and grading was done manually, requiring significant time and effort. Cleaned cockles were packed into 70 kg bags and sold to wholesalers. However, modern technology has introduced automatic washing and grading machines for cockles. These machines efficiently clean large quantities of cockles, reducing time and effort. They utilize mechanisms such as strong water pressure to remove debris like slime, ensuring cleanliness and quality. The automated devices play a crucial role in the cleaning process.

The fishing sector, including small and medium-sized enterprises (SMEs), has the potential to contribute significantly to the national economy. However, cockle farmers face challenges in maintaining sanitary standards during the cleaning process. Manual cleaning techniques are time-consuming and require a large workforce due to the rough and hard shells of the cockles. To support SMEs in the shellfish farming sector, cost-effective and user-friendly technologies are needed. Therefore, a Cockles cleaning machine is being developed in three stages: design idea, design explanation, and detailed design. Issues related to grading size for cockles include inconsistencies in determining sizes, lack of standardization among producers, and outdated grading techniques. This can lead to confusion, disputes, and inefficiencies in the market. Standardized grading guidelines, modern grading equipment, and industry-wide standards can help address these challenges. The goal of this project is to produce a simple clam cleaning and grading machine design using a cost-based design method.

The funding of this study will contribute to Malaysia's small business owners in designing a Cockles cleaning and grading machine, addressing cost and other challenges. This research serves as a benchmark for individuals and organizations involved in developing cockles processing equipment. It offers an effective and affordable solution for small business owners and can be used as a reference for further research.

One of the patent analyses is the cleaning machine for fragile-shelled cultured cockles should have two removable phases. The first phase includes a water-filled container with a loading chute, outlet, fluid inlet, and drain. Metal chain filaments rotate inside the container to break up clumped mussels without damaging their fragile shells. Downstream, compliant abrasive brushing elements brush and roll the Cockles to clean their exteriors.

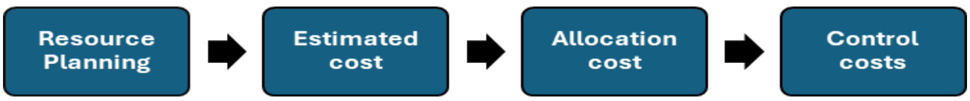
## 2. Methodology

### 2.1 Design Methodology

Design methodology refers to the systematic and structured approach used to guide the process of designing a product, system, or solution. It involves a series of steps and techniques aimed at understanding the problem, generating ideas, evaluating options, and creating a final design that meets the desired objectives.

### 2.2 Cost Based Design

Cost-based design entails controlling manufacturing costs and is the basis for choices made during the product development process. To maximise cost-efficiency, it considers material selection, development costs, and manufacturing time. To balance low cost and good quality, this strategy calls for innovative thinking and deft execution:




### 2.3 SolidWorks

SolidWorks by Dassault Systems is a versatile CAD and CAE software used for solid modelling. It operates on various platforms like Windows, Linux, and macOS. This parametric feature-based tool is widely employed by companies to design product models and conduct prototype simulations to analyse functionality and mechanisms.

## 3. Data analysis and Result

### 3.1 Customer Requirement

A research investigation was done in which an entrepreneur was questioned, and four criteria were prioritized, namely the function of the processing machine, Ergonomics, Safety, and Cost, which were graded by the respondents on a percentage scale. The total of the four factors is 100%.

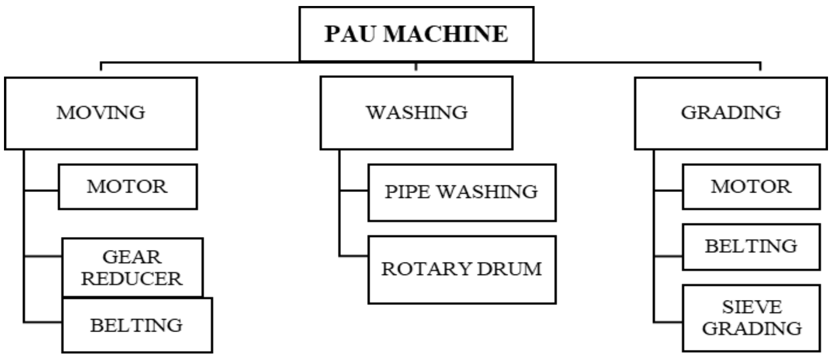
| No | Priority Requirement | Rating % | Weighting |
|---|---|---|---|
| 1 | Function | 28 | 0.28 |
| 2 | Safety | 25 | 0.25 |
| 3 | Cost | 25 | 0.25 |
| 4 | Ergonomic | 22 | 0.22 |
| Total | | 100 | 1.00 |

## 3.2 Product Design Specifications (PDS)

Product design specifications are necessary for the establishment and control of the product base. This method is frequently utilised in product design across the world. This specification list may be used as a design process reference to maintain ideas on track.

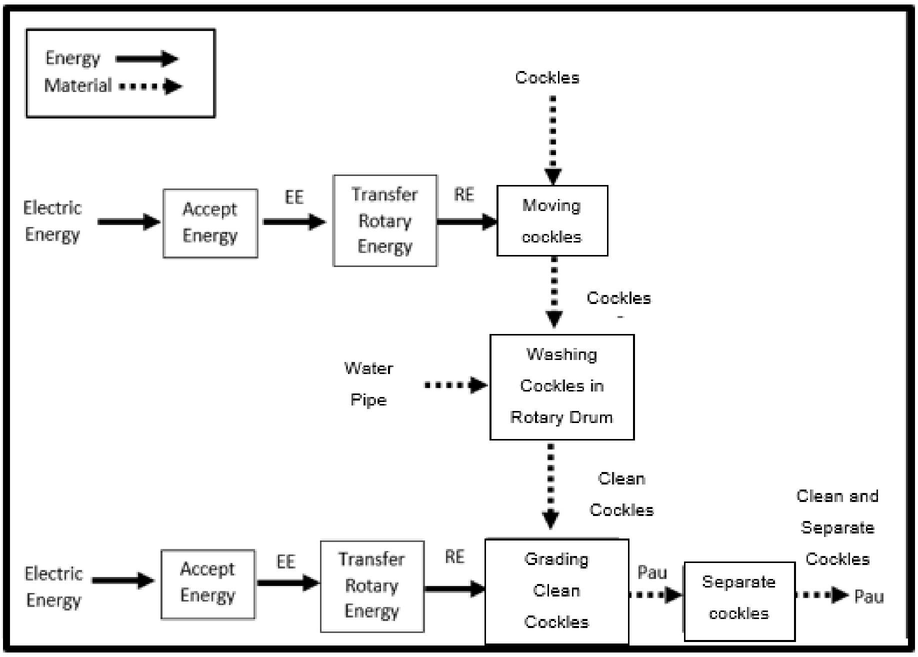
## 3.3 Component Decomposition Analysis

Function Decomposition Analysis simplifies complex problems by breaking them down into component elements. It helps clarify the relationship between components and their contribution to the main goal.



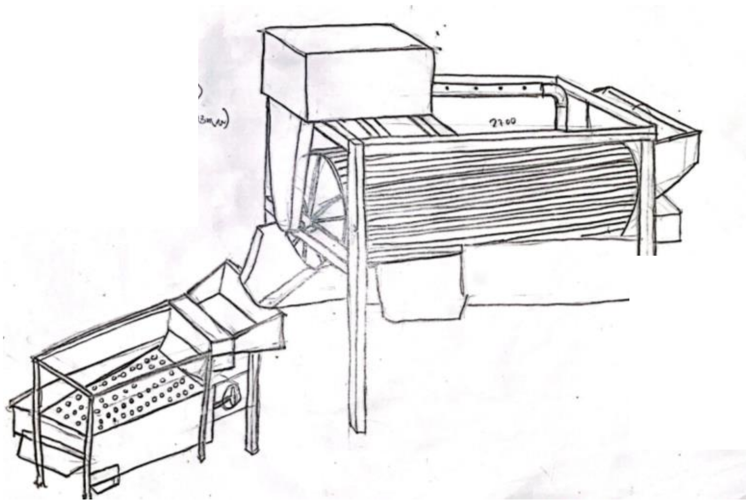

## 3.4 Functional Structure

In order to build the functional structure of the Cockles Washer and Grader, the overall function of the designed product needs to be determined first. The overall function is based on the statement of the research problem




## 3.5 Product Sketching

Product sketching is a form of sketching that is used in product design. It is the process of producing hand-drawn or digitally produced drawings to illustrate and express design thoughts and ideas for tangible products.



## 3.6 Calculation of Washing Machine

This is only an assumed value and not the actual value for the forming part of the Cockles cleaning and grading machine, as the actual value will be shown later. So, the result for the speed value is as shown below:

Speed = 70 rpm

Mass properties of Large Tube washing drum
Configuration: Default
Coordinate system: -- default --

Density = 0.01 grams per cubic millimeter

Mass = 49380.01 grams

Volume = 6172501.75 cubic millimeters

Surface area = 24689705.16 square millimeters

Center of mass: ( millimeters )
X = 0.00
Y = 0.00
Z = -0.27

Principal axes of inertia and principal moments of inertia: ( grams * square millim
Taken at the center of mass.
Ix = ( 0.00, 0.00, 1.00) Px = 10460861307.02
Iy = ( 0.00, -1.00, 0.00) Py = 22010412225.26
Iz = ( 1.00, 0.00, 0.00) Pz = 22010412225.26

The weight of the forming part, M = 49380 g = 49.380 Kg
Drum Rotary Radius, R = 300 mm = 0.30 m
Moment of inertia, I

$$I = \frac{1}{2}MR^2$$

$$I = \frac{1}{2}(49.380)(0.30)^2 = 2.2221\ Kgm^2$$

Acceleration angle, a
Assumption to get 70 rpm in 12 degrees:

$$\alpha = \frac{\omega_f{}^2 - \omega_t{}^2}{2\theta}$$

$\omega_f{}^2$ = $(\mathrm{rad}/s)^2$ = 70 x $(\frac{2\pi}{70})$ = $3.142^2$

$\omega_t{}^2 = (\mathrm{rad}/s)^2 = 0$

$\theta = rad$ = 12 x $2\pi$ rad = 24 $\pi$ rad

$$\alpha = \frac{3.142^2 - 0}{2 \text{ x } 24\ \pi \text{ rad}} = 0.1309\ rad^2$$

Torque, T

$$T = I\alpha$$

$I =$ kg.$m^2$ = $2.2221\ Kgm^2$

$\alpha = 0.1309\ rad^2$

$$T = 2.2221\ (0.1309) = 0.2908\ Nm$$

Power is required, P:

$$P = \frac{2\pi NT}{60}$$

$$P = \frac{2\pi(70)(0.2908)}{70} = 1.82\ kW$$

Motor gearbox selection:

$P_{required} = 1.82\ kW$

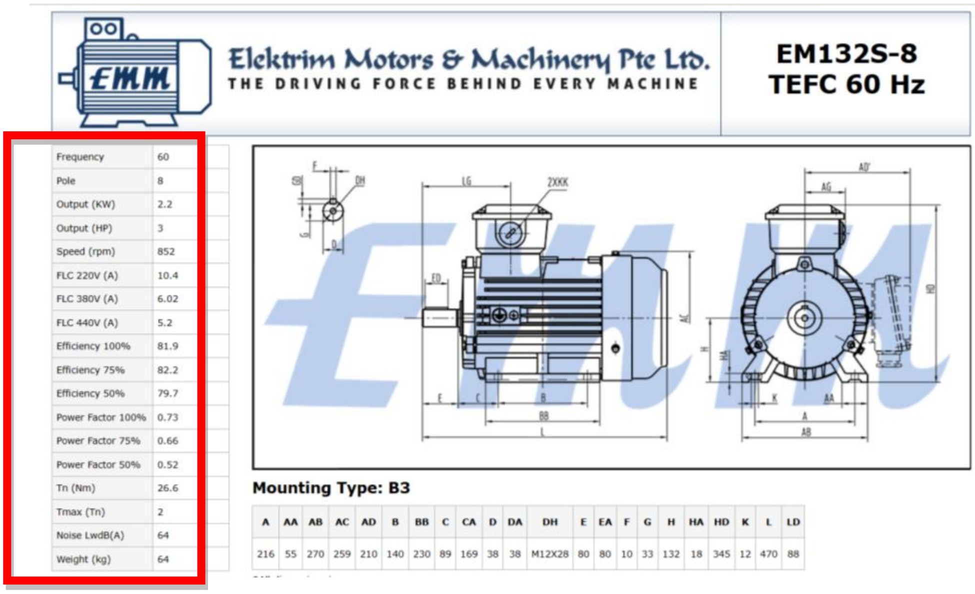
Efficiency, $\eta_m = 0.85\ \%$

Motor power:

$$(P_m)needed = \frac{P_{required}}{\eta_m}$$

$$(P_m)needed = \frac{1.82\ kW}{0.85} = 2.15\ kW$$

Therefore, the motor power, $P_m$ is higher than 2.15 kW. $(P_m)$>$(P_m)$needed to avoid the load limit. In this study, gearbox analysis was carried out to analyze the transfer of power from the gearbox motor to the forming part can be identified. Figure 4.15 below shows the motor selected for this analysis.




Power motor for 8 pole-852 rpm with mounting type B3:

$$Kuasa, (P_{motor}) = 2.2\ kW$$

$$2.2\ kW > 2.15\ kW$$

Therefore, the motor that has been chosen is reasonable. Therefore, the B3 mounting type motor is selected as the motor for the cockles cleaning part.

Analysis gear summary:

| Gear | $P_1$ | $G_1$ | $P_2$ | $G_2$ |
|---|---|---|---|---|
| Ratio, $M_G$ | 3 | | 4 | |
| No. of teeth, N | 15 | 45 | 16 | 64 |
| Speed, n (rpm) | 852 | 275 | 275 | 68.7 |
| Torque, T (Nm) | 26.6 | 79.8 | 79.8 | 319.2 |
| Diameter pitch, $D_P$ (mm) | 45 | 135 | 48 | 192 |
| Module, m | 3 | | 3 | |
| Contact ratio | 1.61 | | 1.64 | |
| Force, F (N) $F^t$ | 1182.2 | 1182.2 | 3325 | 3325 |
| $F^r$ | 430.28 | 430.28 | 1210.2 | 1210.2 |
| $\lvert F \rvert$ | 1258.06 | 1258.06 | 3538.32 | 3538.32 |

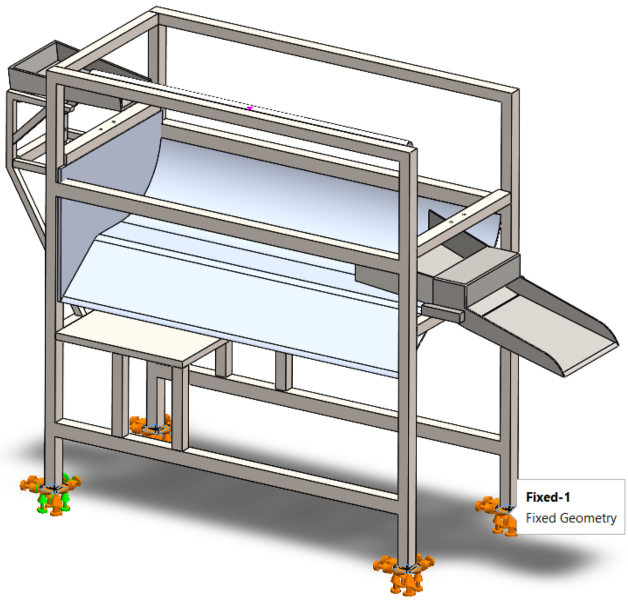
## 3.7 Cost Estimate Analysis

In this section, the estimated cost is evaluated to identify whether the machine is affordable and suitable for small industries. The cost of the materials used is estimated according to the reference from the sources obtained. The quantity of each ingredient is also included to identify the total cost for the entire product used.

| No | Material | Cost (RM) | Quantity | Total cost (RM) |
|---|---|---|---|---|
| 1 | Gear (80 teeth) | 100.00 | 1 | 100.00 |
| 2 | Gear (64 teeth) | 86.00 | 1 | 86.00 |
| 3 | Gear (45 teeth) | 72.00 | 1 | 72.00 |
| 4 | Gear (16 teeth) | 54.00 | 6 | 324.00 |
| 5 | Gear (15 teeth) | 54.00 | 1 | 54.00 |
| 6 | Stainless steel metal sheet (500 mm X 500 mm) | 625.00 | 8 | 5000.00 |
| 7 | Pipe Burst Water PVC | 27.11 (3 Inci) | 2 | 54.22 |
| 8 | Stainless Steel Rod 25mm Diameter (per meter) | 604.00 | 1 | 604.00 |
| 9 | Alloy Steel Bar 75mm Diameter (per 0.25 meter) | 130 | 4 | 280.00 |
| 10 | Gear motor | 262.00 | 1 | 262.00 |
| 11 | Motor | 2,875.00 | 2 | 5500.00 |
| 12 | Bearing | 34.00 | 4 | 136.00 |
| 13 | Bolt & Nut set | 10.00 | 1 | 10.00 |
| Total | | | | 12,392.22 |

## 3.8 Analysis Structure

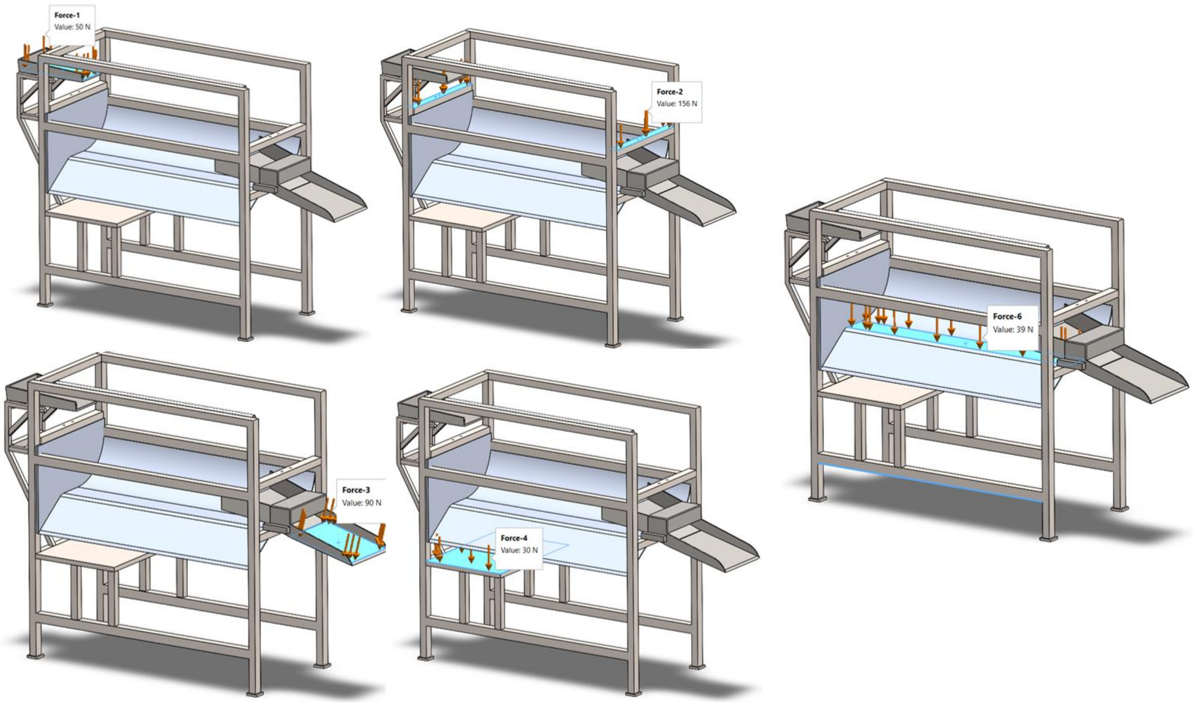
The focus of structural analysis is on the components' structural elements. This study was done using Solidworks, and the results of the stress, displacement, strain, and component safety factor tests were obtained. The figures below illustrate the fixed geometry that has been applied to the washing frame structure, respectively. The washing and grading machine's frame structure has been subjected to all of the force generated by the top portion, including the washing, grading, motor, and gear.



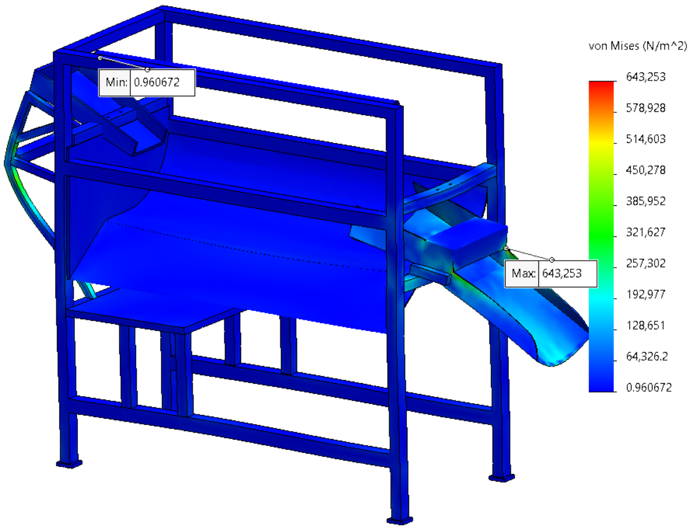

The use of fixed geometry indicates that the structure is fixed on a flat surface. A force was applied to the frame structure of the cockles cleaning machine. There are 6 different amounts of force that have been applied in this analysis to identify the strength and structural stability of the shellfish cleaning machine frame.

Penerbit UTHM

Force 1 with a total force of 50 N is the force from the clam input that is inserted into the upper hopper. Force 2 also with a total force of 156 N is from the rotary drum of the washer that resists the force of the shells. Force 3 with a total of 90 N is from the hopper for transferring the shells to the grading machine. Force 4 is 30 N which is the total force from the motor and reducer components and is the main mechanism. Force 6 with a total force of 39 N is the force from the dirty water for cleaning the shells while the rotary drum rotates for the transmission system.




## 3.9 Stress Analysis




Based on figure above shows the results for stress analysis after force is applied. The highest value acting on the frame structure of the washing cockles machine is 6.4325×$10^6$ N/$m^2$.

## 3.10 Displacement analysis

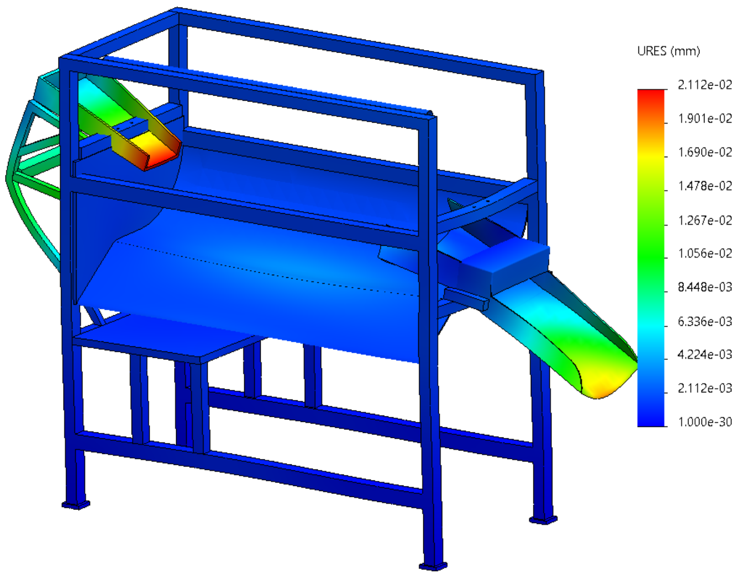



Figure above the results of the displacement analysis, the maximum displacement value is 2.112 x$10^{-2}$ mm located at the top of the washing cockles machine frame structure. The value is small and will not cause problems to the product.

## 3.11 Strain Analysis

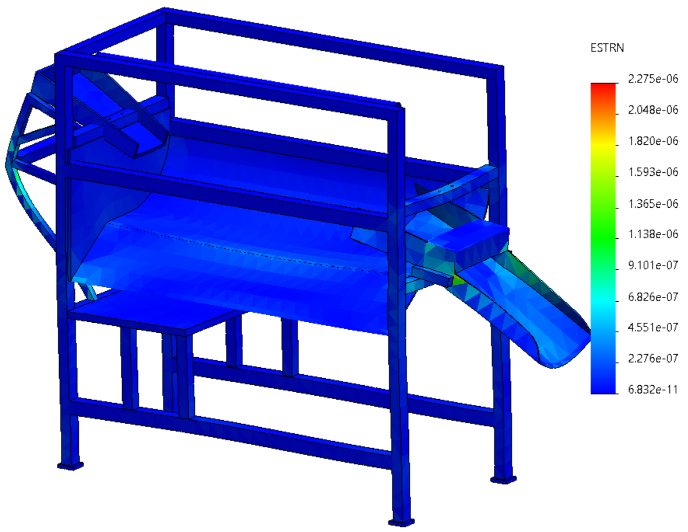
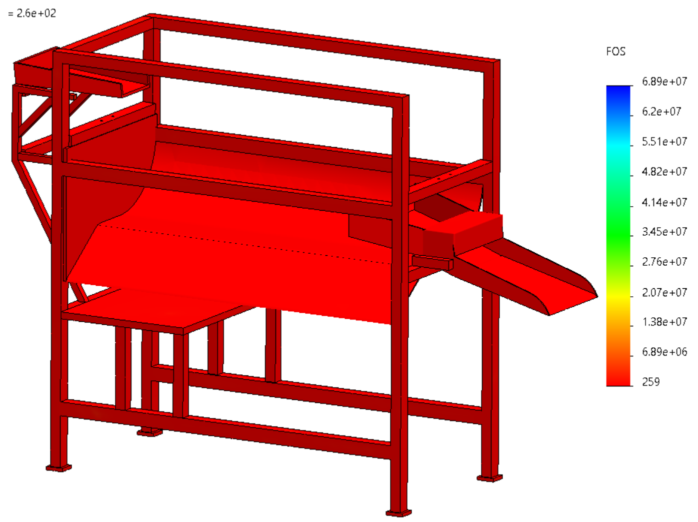



Figure above shows the results of the Strain analysis, the maximum value for this analysis is 2.275 x$10^{-6}$which is located at the top of the frame structure of the clam cleaning machine.

## 3.12 Safety Factor Analysis




## 3.13 Product Specification

Product Specifications is the simple structural that are focusing on the all the information that are related to the machine. The specifications cannot be too technical to ensure that the customer can understand their needs and why they should buy the product.

| Product **Specifications** | Description |
|---|---|
| Motor Power | 2.2 kW, 1.5 kW, |
| Material | Stainless steel, Alloy steel, PVC |
| Load | 400 kg |
| Dimensions | 730 mm x 726 mm x 1430 mm |
| Price | RM 20,000 |
| Capacity | 3834 Unit per Hour |

## 4. Conclusions

In conclusion, the cockles cleaning and grading machine was developed to improve shellfish processing and enhance agricultural productivity. It aims to maximize resource utilization and support medium-sized businesses. The user-friendly machine operates efficiently and is cost-effective for medium-sized companies. The study successfully designed a washing and grading system for flawless shell output. The machine costs RM 20,000 and can process 3,834 units of clams per hour, benefiting entrepreneurs by increasing efficient mussel output.

## Acknowledgement

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