



A Machine for Bubble Wrapping Glass Perfume Bottle

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Abstract: The perfumes industry in Malaysia is forecasted to grow in 2023 and the cylindrical glass perfume bottle is overlapped with other items during delivery process due to high demand which makes the bottle fragile, crack and broken. So, the main objective of this study is to design a bubble wrapping machine for packaging cylindrical glass perfume bottle that limited to a cylindrical bottle with maximum 14 cm height and bubble wrap as the wrapper. The machine has been designed and simulated in SolidWorks software and then, the machine and manual worker has been compared in term of time of wrapping and process of wrapping. The machine has been designed with six sub-assemblies. As a result, the machine is faster in time of wrapping and have simple process in wrapping process.

Keywords: Perfume, Glass, Cylindrical, Bubble Wrap, Design, Wrapping Machine

1. Introduction

Perfume is a combination of fragrant essential oils or aroma compounds, fixatives, and solvents that are used to provide a pleasant scent to the human body [1]. According to Malaysian Meteorological Department, the average temperature ranges from 24°C to 33°C [2]. Sweat combined with bacteria on the skin, causes unnecessary body odour in humans in such hot weather conditions [3]. Making public appearances becomes a source of discomfort and embarrassment in this scenario. As a result, the perfume industry is experiencing a surge in demand to address the problem.

Based on the Euromonitor International (2020), the perfumes industry in Malaysia reached MYR 622 million in 2018, and is forecasted to grow to MYR 863 million in 2023 with a compound annual growth rate (CAGR) of 7 per cent [4]. Most people preferred the perfume to be in cylindrical shape and small in size because it is easy to carry. The perfume is sometimes overlapped with other items due to many items that must be delivered. So, the products received in bad condition such as fragile, cracked and broken because most perfumes use the glass as the material of the perfume bottle. To prevent this scenario from happening, the bubble wrap can be used as an insulator against impacts [5]. Although some of the traders use bubble wrap to protect the glass perfume bottle, the wrap is untidy where the bubble wrap is not cut in a straight line. To get a neat wrap, the worker must carefully cut the wrapping and use a ruler to get a straight line.

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1.1 Problem Statement

Because of the high demand for perfume, it is sometimes overlapping with other items due to the large number of items that must be delivered. As a result, the perfumes that customers receive are fragile, cracked, and broken. Bubble wrap can be used as an impact insulator to avoid this scenario from occurring [5]. Some traders use bubble wrap to wrap the perfume bottles. However, the way the bottle is rolled is untidy and time consuming due to the use of manpower. Aside from that, the packaging time increases when the worker tries to have proper wrap and aligned cut bubble wrap. So, a wrapping machine with bubble wrap as the wrappers is required to wrap the glass perfume bottle. Based on the study, there is a machine that use bubble wrap as the wrapper. However, this machine is using bubble wrap to replace the need for a corrugated carton and then use heat shrinkable film to tight wrap around the product [6]. This means that the machine only wraps the product into the group, not individually. There are also machines that pack cylindrical bottles not in individual form, but in large quantities [7]. The machine also only packs large items such as water bottles and tissue rolls.

1.2 Purpose of Study

The main purpose of the study is to design a bubble wrapping machine for packaging cylindrical glass perfume bottle. This wrapping machine will use the bubble wrap as the wrapper and the wrapping method will be simple rolling. Tape will be applied to the top and bottom of the glass perfume bottle to complete the wrapping process. Next, the purpose of the study is to compare the time of wrapping and process between machine and manual worker.

2. Software and Methods

2.1 Software

Software that has been used for this study is SolidWorks 2020 software. This software has been used to design, analyse and simulate the wrapping machine. This software use Finite Element Analysis (FEA) to predict a product's real-world physical behaviour by virtually testing CAD models, for example, static and fatigue analysis. SolidWorks software has the motion studies. Motion studies are graphical simulations of motion for assembly models. This software can simulate and animate the motion that has been prescribed for a model.

2.2 Methods

The methods that have been used in this study are analysis and selection of motor, material selection, analysis of the machine, simulation of the machine and comparison between the machine and manual worker in terms of time of wrapping and process wrapping.

This machine will use a motor that needs to be calculated. The motor specification such as power, speed, voltage and current must be obtained from the motor in the market. The selection of the motor will be based on the suitable size for the machine. To design the durable features of the wrapping machine, the material was selected to increase the durability of the mechanism. The selection will be made based on tensile and yield strength.

In this study, analysis will be done to observe the wrapping machine main structure performance such as static and fatigue. Next, an assembly drawing is needed for all products or inventions that have more than one part. After that, the simulation is mainly to show the movement of bubble wrap, cutting process and wrapping process. Lastly, the time of wrapping and process to wrap the glass perfume bottle will be compared between machine and manual worker.

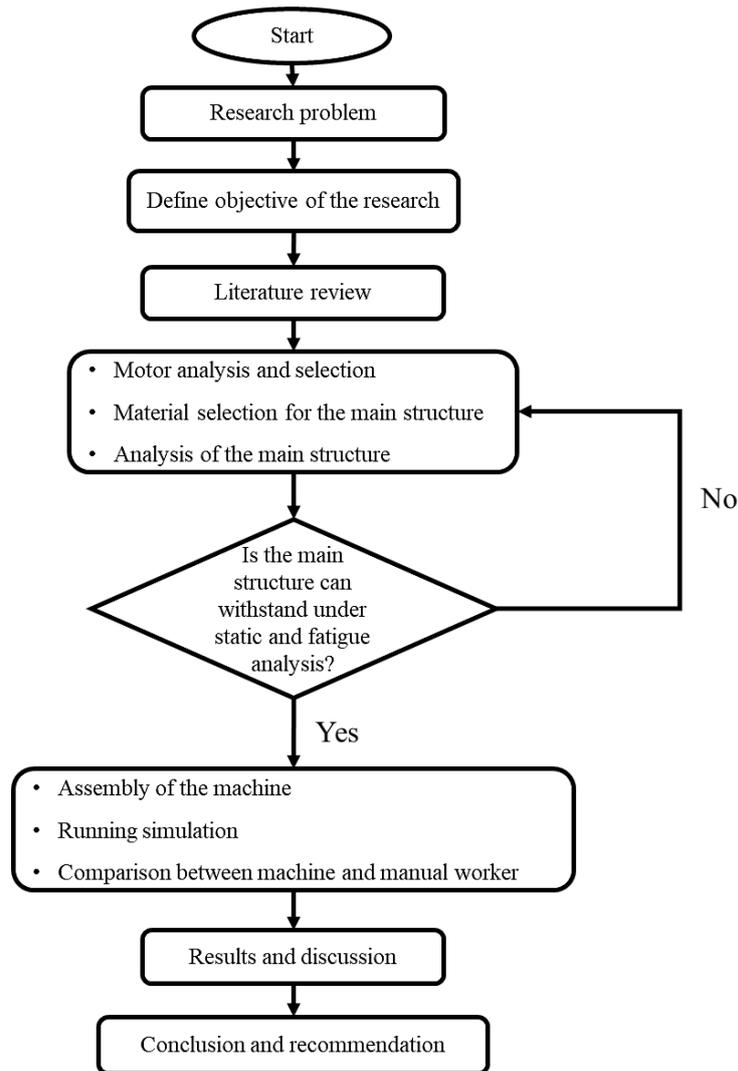


Figure 1: Methodology flowchart

2.3 Equations

Equations that has been used for this study are as follows:

i) For DC motor, the equation are

$$Torque, \tau = \frac{9.5493 \times Power, P}{Speed, N}$$

$$Torque, \tau = \frac{(Voltage, V)(Current, I)}{\left(\frac{2\pi(Speed, N)}{60}\right)}$$

ii) For stepper motor, the equation are

$$Max\ speed = \frac{Voltage, V}{2(Inductance, L)(Current, I)\left(\frac{steps}{rev}, spr\right)}$$

$$Power, P = (Current, I)(Voltage, V)$$

3. Results and Discussion

Firstly, the motor has been analysed and three motors were used for this machine which are MY6812 motor for feed roller, Nema 17 Stepper Motor for cutter and DC Gear Motor 12 V for wrapping roller. The power of the MY6812 Motor is 150W, Nema 17 Stepper Motor is 4.8 W and 14 W for DC Gear Motor 12 V. Then, the material for the main structure of the machine has been selected. Aluminium Alloy 6061 has been chosen with yield strength of 124 MPa and tensile strength of 55 MPa for the housing structure and wrap holder shaft. Plain Carbon Steel that has yield strength of 221 MPa and tensile strength of 400 MPa has been chosen as the material for the feed roller.

Next, the main structure of the wrapping machine has been through the static and fatigue analysis. Housing structure has been through static decompression, static compression and fatigue analysis. For the feed roller, the static tensile, static compression and fatigue analysis have been done. Lastly, the wrap holder shaft has been through static bending and fatigue analysis.

Housing structure have been through the analysis with load 30 kg or 294.3 N. The minimum stress of the housing structure under static decompression analysis is $1.268 \times 10^{-2} Nm^2$ and the maximum stress is $3.23 \times 10^6 Nm^2$. Next, the minimum stress of the housing structure under static compression analysis is $4.509 \times 10^{-2} Nm^2$ and the maximum stress is $3.245 \times 10^6 Nm^2$. The minimum life cycle of the housing structure is 1.000×10^8 and maximum is 1.001×10^{-3} .

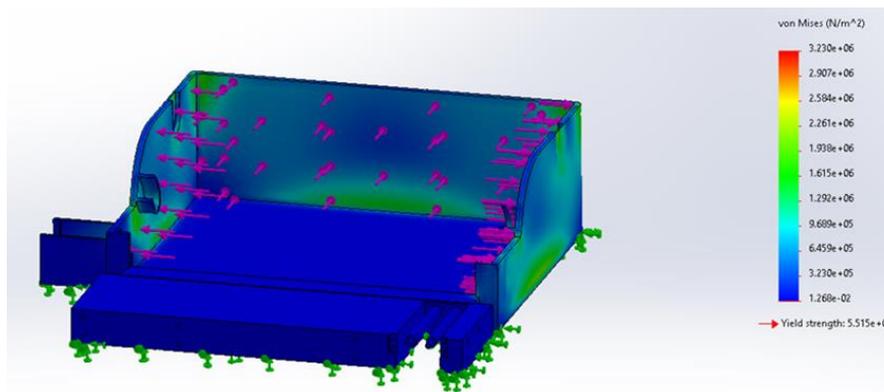


Figure 2: Von Mises stress results for housing structure (Static decompression analysis)

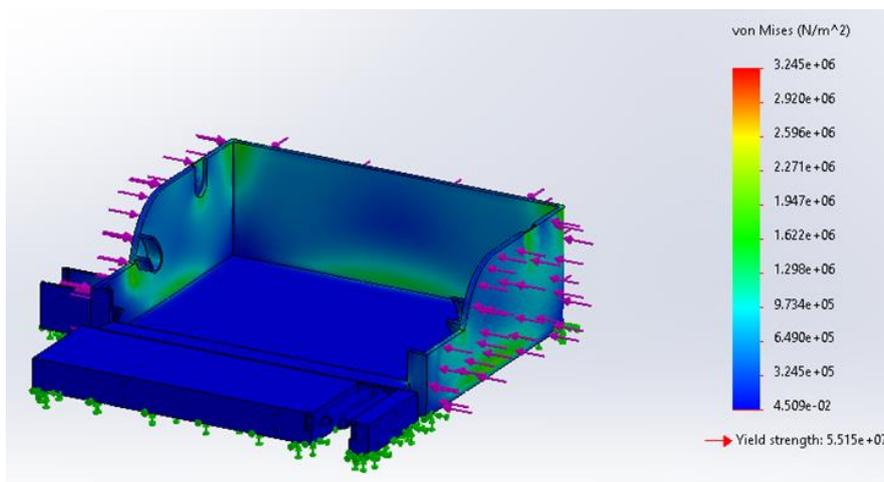


Figure 3: Von Mises stress results for housing structure (Static compression analysis)

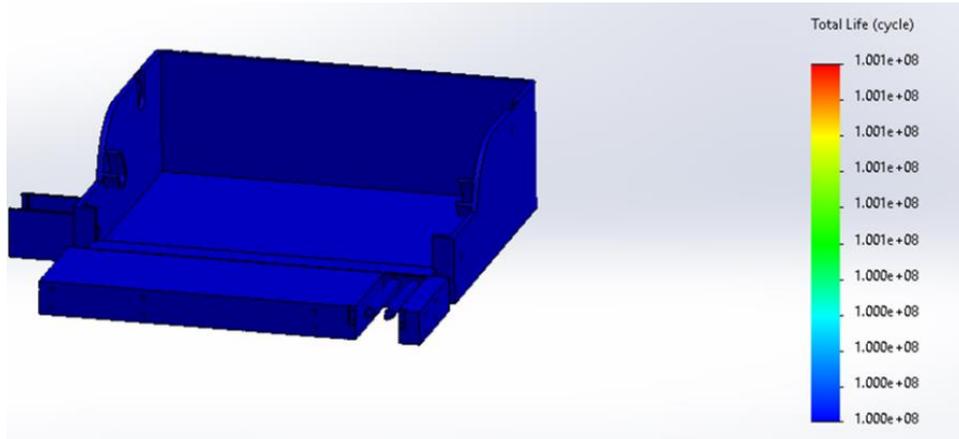


Figure 4: Life cycle parameters for housing structure

Driver feed roller have been analysed with load 20 kg or 196.2 N. The analysis shows that the minimum stress of the driver feed roller under static tensile analysis is $1.178 \times 10^5 \text{ Nm}^2$ and the maximum stress is 3.844 Nm^2 . For static compression analysis, the minimum value is $1.652 \times 10^{-2} \text{ Nm}^2$ and the maximum stress is $4.395 \times 10^3 \text{ Nm}^2$. The minimum life cycle of the driver feed roller is 1.400×10^7 and maximum is 1.401×10^7 .

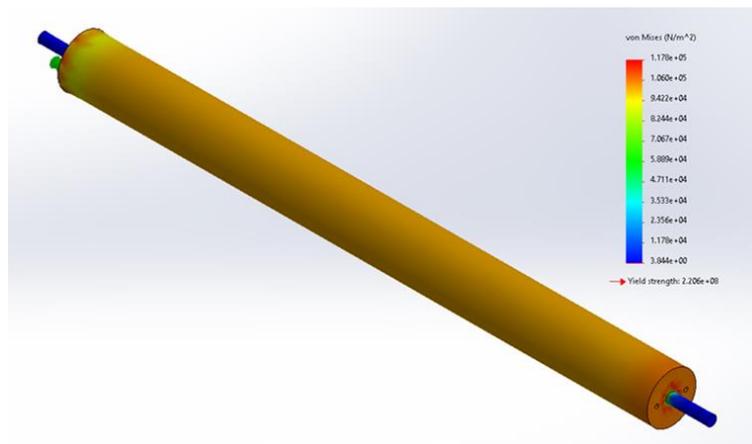


Figure 5: Von Mises stress results for driver feed roller (Static tensile analysis)

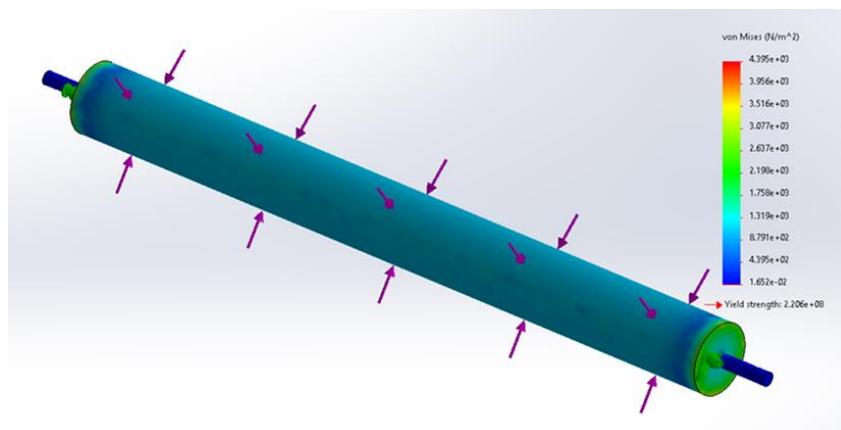


Figure 6: Von Mises stress results for driver feed roller (Static compression analysis)

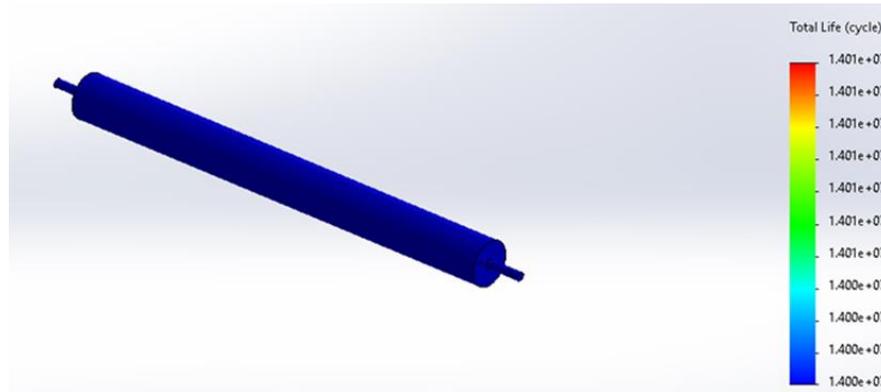


Figure 7: Life cycle parameters for driver feed roller

The load for analysis of wrap holder shaft is same as the driver feed roller which is 20 kg or 196.2 N. The analysis shows that the minimum stress of the wrap shaft holder under static bending analysis is $2.709 \times 10^2 \text{ Nm}^2$ and the maximum stress is $2.0609 \times 10^6 \text{ Nm}^2$. The minimum life cycle of the wrap holder shaft is 5.000×10^5 and maximum is 5.005×10^5 .

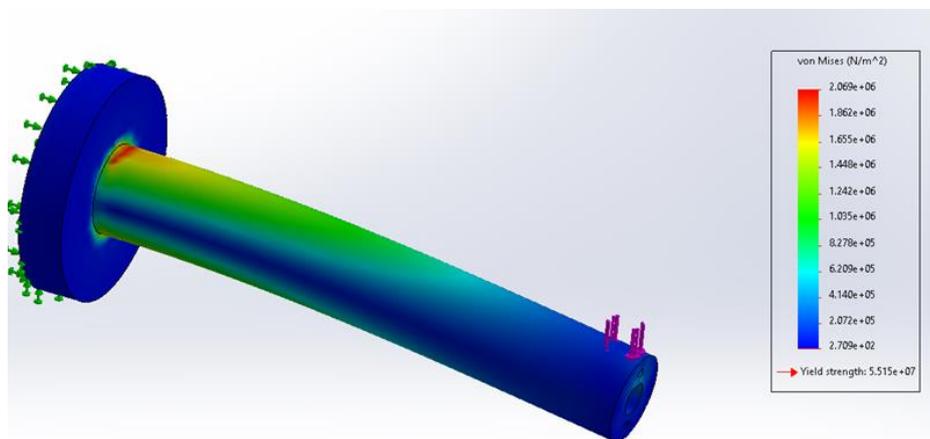


Figure 8: Von Mises stress results for wrap holder shaft (Static bending analysis)

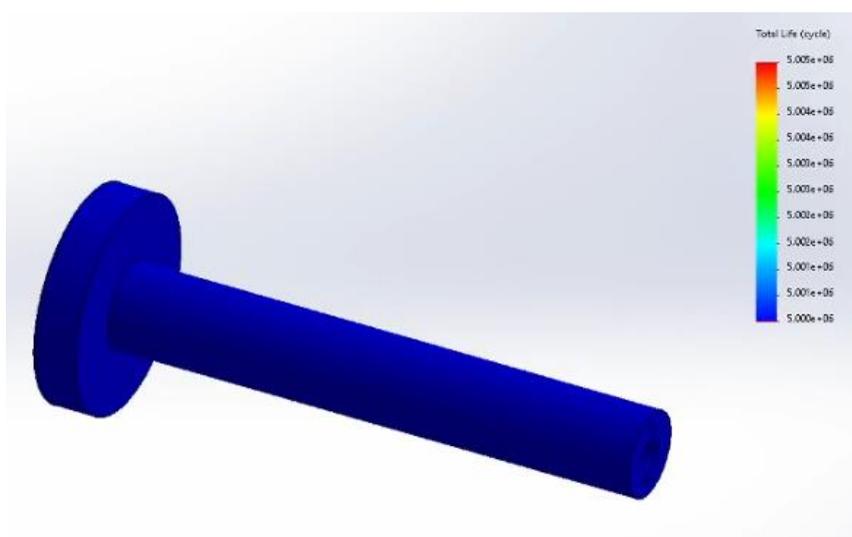


Figure 9: Life cycle parameters for wrap holder shaft

After that, the wrapping machine was assembled with six sub-assemblies that are feeder structure, cutter mechanism, cutter head, electronics, wrapping mechanism and automatic tape dispenser. The wrapping machine has been simulated in SolidWorks software to show the process of the wrapping glass perfume bottle.

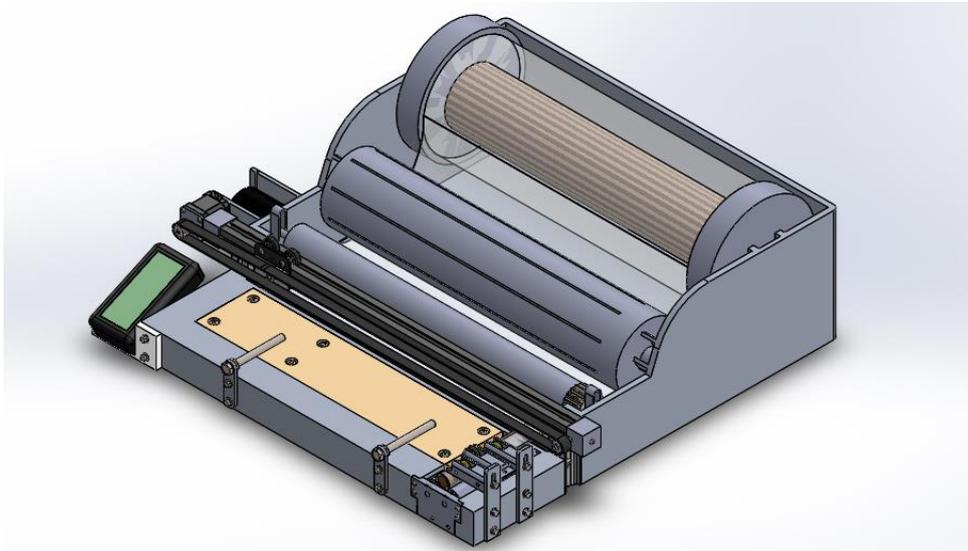


Figure 10: Assembly of the machine

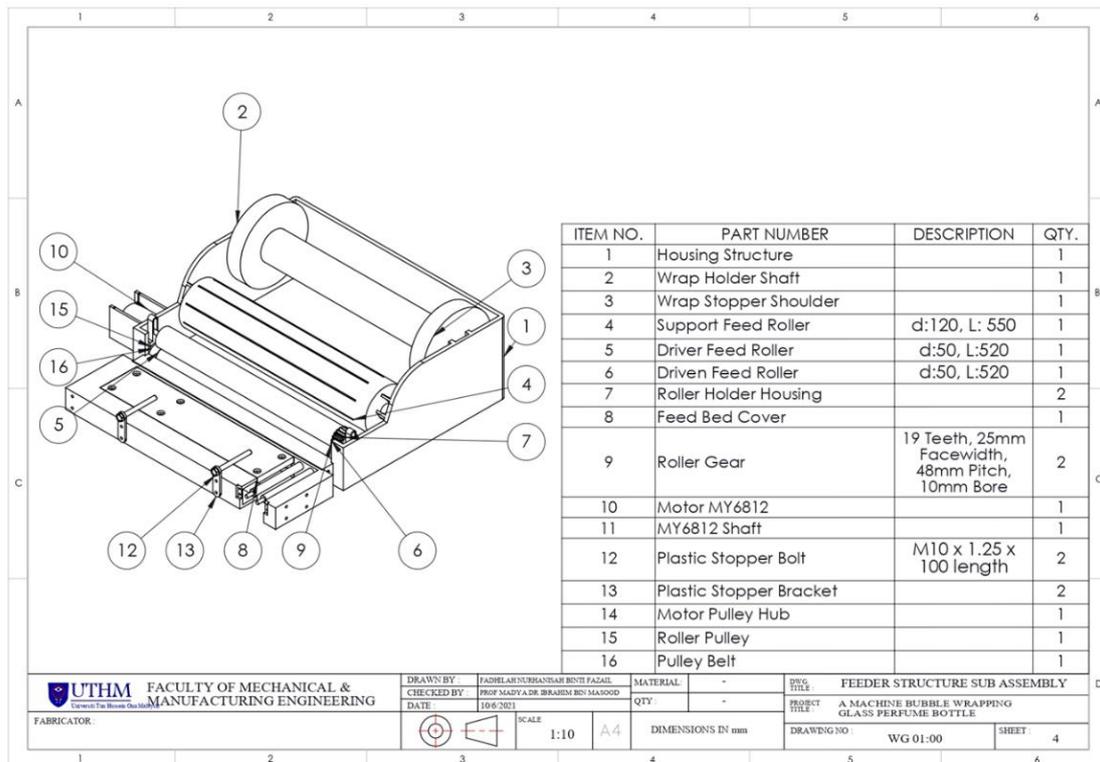


Figure 11: Feeder structure sub assembly

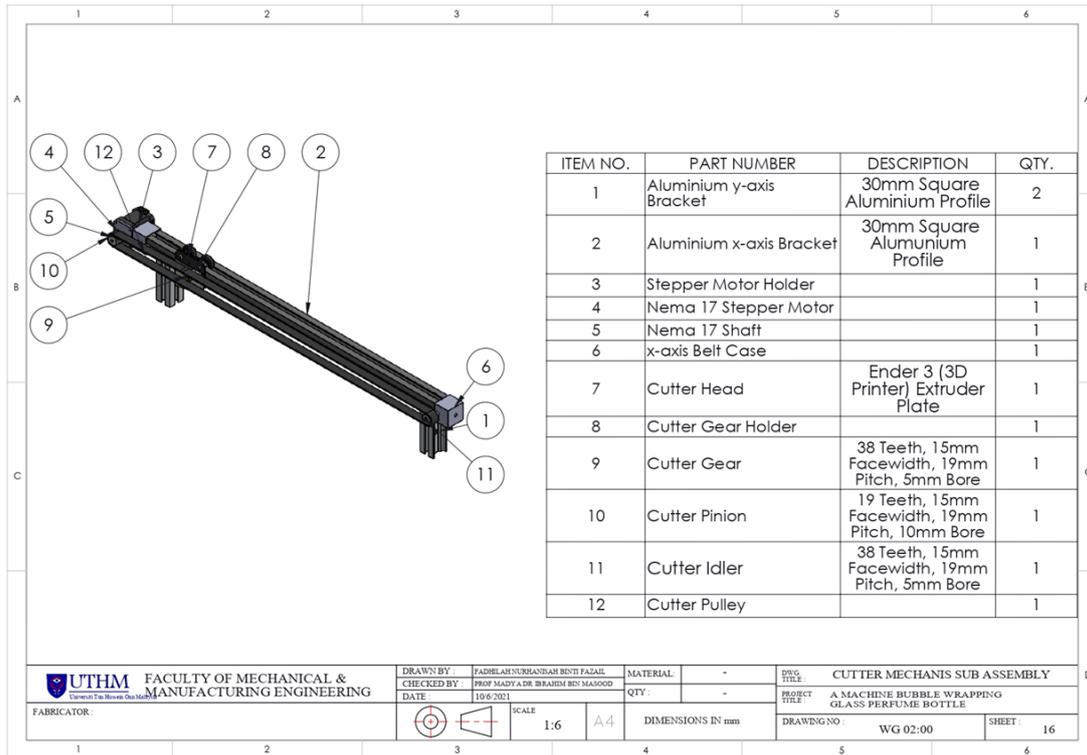


Figure 12: Cutter mechanism sub assembly

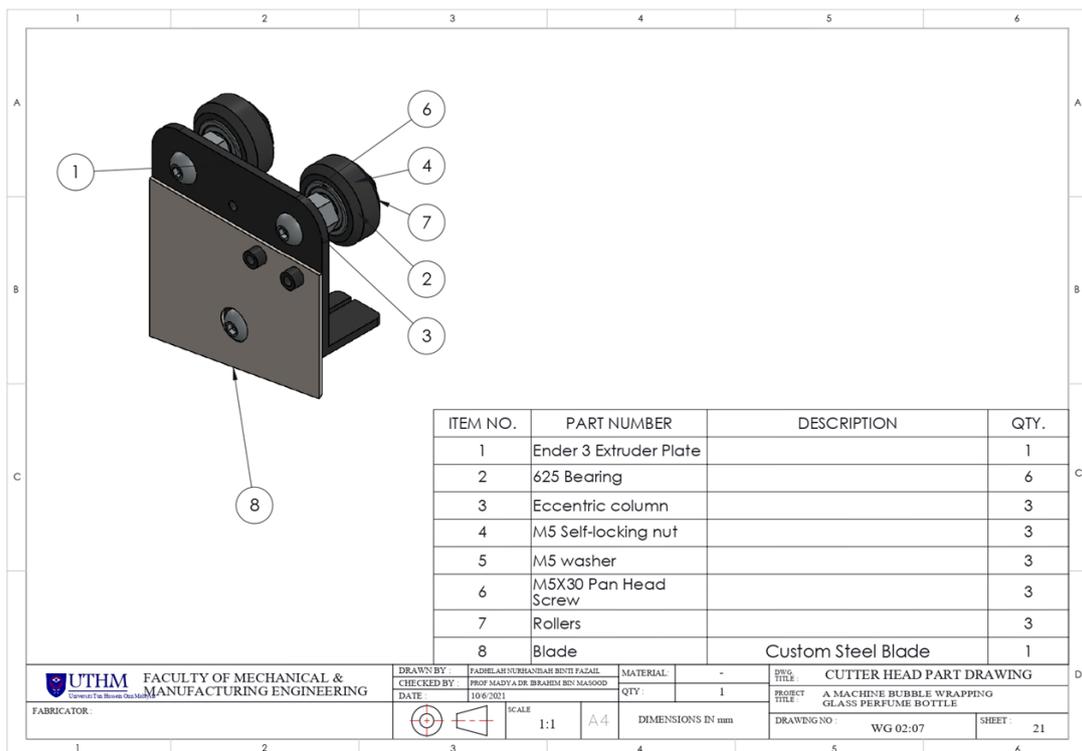


Figure 13: Cutter head sub assembly

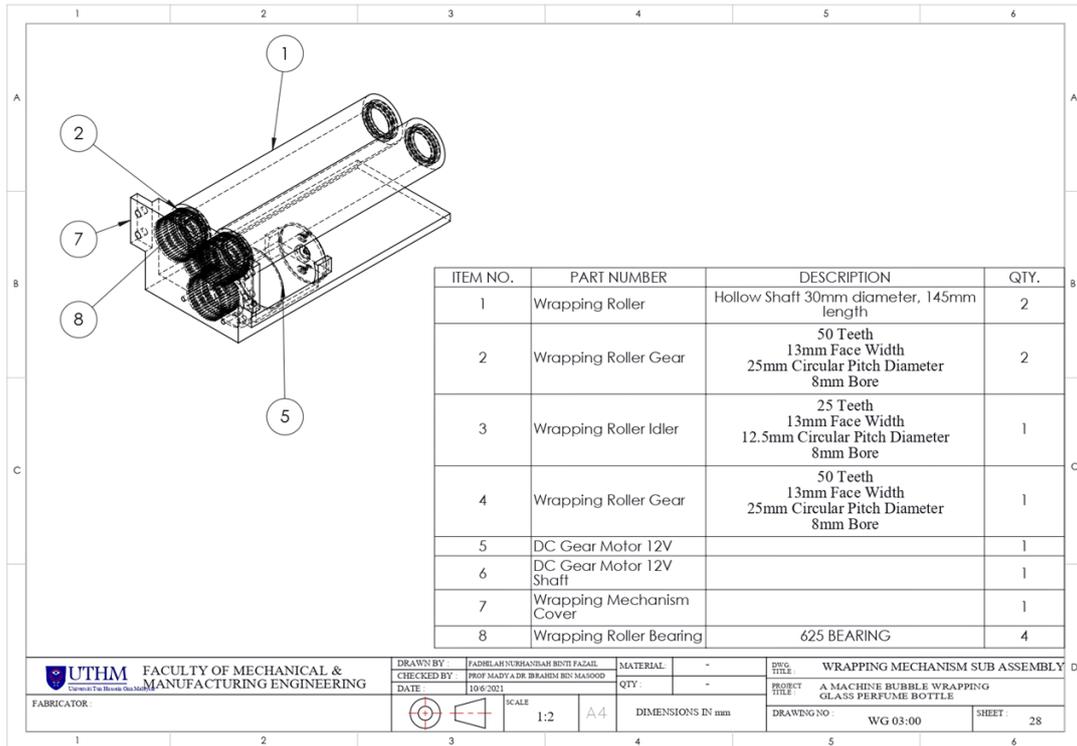


Figure 14: Wrapping mechanism sub assembly

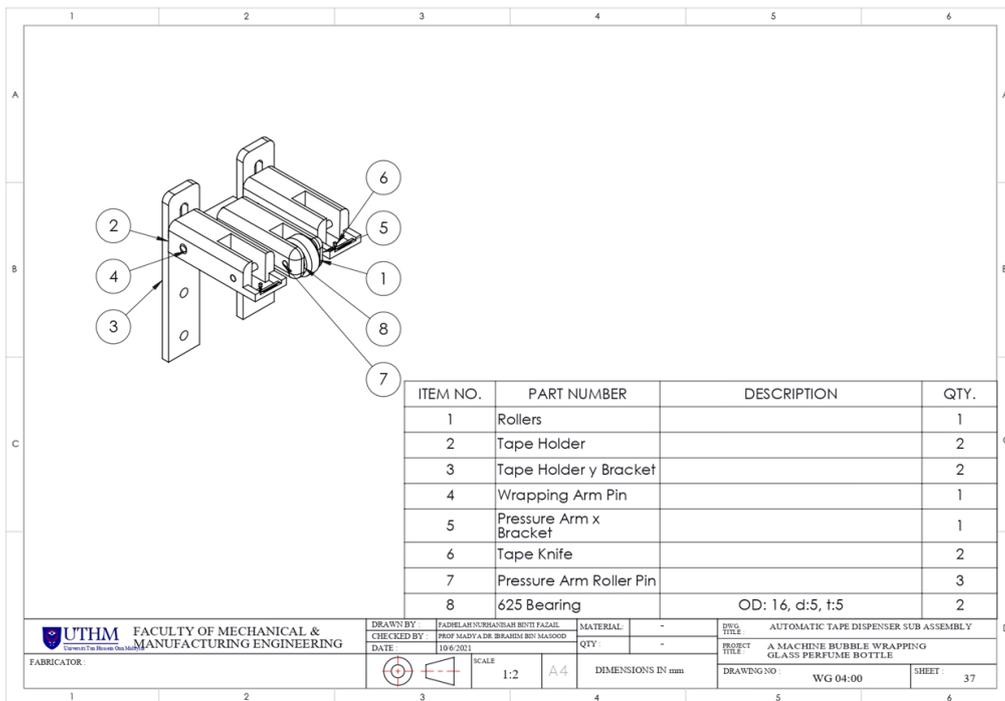


Figure 15: Automatic tape dispenser sub assembly

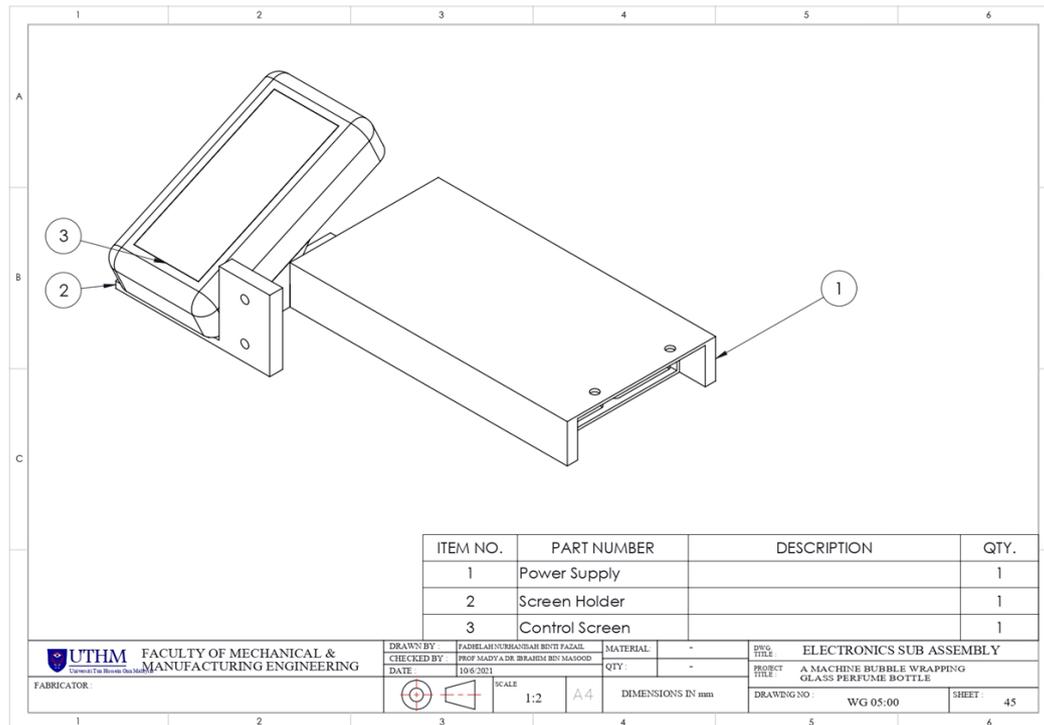


Figure 16: Electronics sub assembly

Lastly, the comparison of the time of wrapping and process between the machine and manual worker has been made. The time of wrapping for the machine is around 1 to 1.5 minutes while manual worker around 3 to 6 minutes. The time of wrapping process for machine is lower than manual worker which means that the time of wrapping process for machine is fast. To get an aligned cut, the machine only needs a cutter while manual worker need a ruler and cutter. Other than that, manual worker need a ruler and marker to mark and measure the desired length. For the machine, only use the control panel or control screen to get the desired length. This shows that the process of wrapping for the machine is simple compared to the manual worker.

4. Conclusion

In conclusion, the two objectives have been achieved which the machine has been designed and the comparison has been made. The wrapping machine has been designed to have three motors. Next, Aluminium Alloy 6061 was chosen as the material for housing structure and wrap holder shaft while Plain Carbon Steel for the feed roller. Six sub-assemblies have been assembled to get the full assembly of the machine. For the comparison, the time of wrapping for the machine is lower than the manual worker and the process of wrapping for the machine is simple compared to the manual worker. There are some suggestions for the machine to be improved that can be made in the future where the machine can be designed to be fully automatic. The worker only needs to control the system at the beginning of the process. Next, the amount of the bottle that can be wrap in one time needs to be improved where at least 5 bottles can be wrap at one time. This can decrease the time of the wrapping process. Since the wrapping machine design is limited to cylindrical shape, more variation of shape can be applied to the machine in future.

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