



ORIGINAL ARTICLE

Floriculture Industry: Multifunction Leaves Stem Cutting Machine for Small Medium-sized Enterprises

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Abstract

The floriculture industry plays a crucial role in the global economy by providing not only aesthetic value but also contributing significantly to agricultural employment and the export market. However, the efficiency and sustainability of SMEs in floriculture are often hindered by labour-intensive practices, especially in the propagation of plants through stem cutting. This novel multifunction leaves stem cutting machine designed specifically to cater to the needs of SMEs in the floriculture sector. This machine serves the function to separate the flowers and leaves for selling purposes. It has gained lots of interest specifically in the flower-related field, florist businesses, and leaves extraction processes due to its convenient applications in separating the leaves from the flowers. However, readily available machines such as rose cutting machine are lack in it functions where it only operates only one function. The deficiency of the current product may cause serious injury to employees because the existing machine does not have good safety features that can avoid the workers being injured while carrying out the work. The objective of this study is to design, fabricate and test the functionality of the new system and ergonomic multifunction leaves stem cutting machine. The design was created by using Fusion 360 with the main part separating leaves, cutting the stem, washing part, and system part. All the processes will be carried out on the machine that have safety features that will not harm the user. The machine demonstrated exceptional performance including consistency of the machine that will benefits the SMEs with high productivity and lower production cost.

Keywords: Ergonomic, Floriculture Industry, Multifunction Leaves Stem Cutting Machine, Small and Medium-sized Enterprises

Introduction

Floriculture is a thriving industry that involves the cultivation, marketing, and sale of ornamental and flowering plants. Nowadays, many agricultural sectors especially related to floriculture industry at certain area has grown rapidly where the flower were used to generate income that positively impact the Malaysian economy. Small and medium-sized enterprises (SMEs) form the backbone of this industry, contributing significantly to global production and employment. However, SMEs often face challenges related to labour-intensive processes, including stem cutting for plant propagation. Traditional methods for stem cutting are time-consuming, require a skilled workforce, and can lead to inconsistencies in plant quality and yield. This research focuses on addressing these challenges by introducing a Multifunction Leaves Stem Cutting Machine (MLSCM) tailored for SMEs in the floriculture sector (Bhagat et al., 2019).

The impact on an unorganized workspace will result in a reduced perception of employee health and productivity (Candido et al., 2016). To conduct the procedure of separating the leaf from the stem, there needs to be a conducive space and comfortable area to do the work. Safety workplace like the cleanliness of the workplace or the machines should work well to protect workers from adverse health effects of workplace hazards (Kumie et al., 2016).

If the workplace is uncomfortable, it will affect the daily performance of workers for example if the workplace is dirty, littered with piles of leaves and stems that are not collected in a strategic place, processing machines cannot work properly and poor manufacturing process place layout will be causing employee emotions to be disturbed and causing the production process to produce poor quality a comfortable place should be provided by those responsible in the flower industry sector in Malaysia to maintain the quality of flowers for export to the other countries.

There are various types of leave stem cutting machine models in the market manufactured by different manufacturers. In the market, there are also models intended for use in isolating vegetables. In addition, the leaves stem cutting machines in the market cannot meet the demand of the flower industry and small businesses that do flower business because the machines available in the market have a size that does not fit the function of the machine and does not have good safety features and cost for each such machine is also expensive. The main tools that while be used to produce this multifunction leave stem cutting machine are leave brushes, ac motor, power supply, Arduino, ultrasonic sensor, linear actuator, and garden micro drip irrigation system plant flower watering. Leave brushes work to remove the leaves from the stem by using special tools to separate the leaves from the flower stem. The alternating current motor (AC motor) rotates in the presence of magnetic force generated by the alternating current that will flow through the motor coil.

AC motor is a device that can convert electrical power to a voltage type and then to mechanical energy (Hitchins, 2022). There are various types of AC motors that are on the market either synchronous or asynchronous motors. AC motors move in single phase or polyphase, while synchronous motors include Reluctance Motors and Hysteresis Motors. The speed rated moves at a quicker pace when the cycle of the pole decreases. The motor's alternating current speed is computed as $RPM = 120 \cdot F / P$, where F is the frequency, (Hz) is the supply voltage, and P is the number of poles. (Matsuse & Matsuhashi, 2017). AC maintenance will check the dirt and corrosion found on the motor. The dirt can clog and can reduce the inflow of air properly. Due to that, the failure of the motor can have a bad impact on the motor AC. For example, when the airflow is not good such as unstable or slow air flowing AC the motor should be checked in depth again on the air duct (Bradley, 2021). power supply is powered to convert voltage power to direct current power and it also controls voltage current for smoother output. Power supply can also supply good electrical requirements for the operation to be carried out.

Arduino is an open-source platform that easy to be programmed and erase the reprogrammed at any time (Louis, 2016). Used for building electrics projects, Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on the computer, used to write, and upload computer code to the physical board (SparkFun Electronics, 2011). The board design is an open source, where it allows to make Arduino-compatible boards. This competition has led to low costs for the boards and all sorts of variations on the "standard"

boards. The basic boards are supplemented by accessory shield boards that can be plugged on top of the Arduino board (Monk, S., 2016).

The ultrasonic sensor can detect the distance of things like the distance between the object to a predetermined place with the required distance. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1" to 13 feet. The time taken is used together with the normal speed of sound in air (340ms⁻¹) to determine the distance between the sensor and the obstacle (Mutinda Mutava Gabriel., 2020). This ultrasonic sensor had been placed in the machine to detect the stem for starting the cutting function purpose. Linear actuators (LAs) are used for applications that require repetitive linear motion, such as linear pumps and compressors, servo drives in industrial automation, and pick-and-place robots in the pharmaceutical and semiconductor industry (Mirić et al., 2022). Linear actuators are utilized in a variety of applications, ranging between commercial products like short-stroke motors. Linear actuators for active suspension to wave-energy conversion and combustion the piston energy conversion. Linear actuators are also employed in high-purity and/or high-precision applications in the semiconductor production industries. In this machine, the sharp knife is placed at the linear actuators for the repetitive linear cutting motion to cut and separate the flower stem.

Garden micro drip irrigation may be a feasible option for smallholder farmers, who frequently lack the water and energy resources to permit irrigation with more traditional irrigation technology (Chigerwe et al., 2004). The system that was used for this machine water system is the garden micro drip irrigation system for plant flower watering that involves a small devices water irrigation system. Such micro-irrigation will send water directly to the leaves' surface. The system refers to a low-pressure irrigation system by spray, drip, sprinkle, and mist. The design of the irrigation device has different patterns that have been specially designed for the needs of the user.

In the floriculture industry, the body postures that related to the ergonomic aspect involved during work activities are very important. Non-neutral body posture will give the effect of major injuries and accidents at work whereas awkward posture will put a person at risk for the musculoskeletal system, especially for construction and manufacturing occupations. Factors such as back pain, and lower limb joints are the result of the use of incorrect posture in such activities (Conforti et al., 2020). Based on this statement, the manufacturing process of this multifunction leaves stem cutting machine has considered the height that required according to the height of the user. The appropriate standard height to operate the machine while standing is around 112 cm. This height is suitable for the users with height 165 cm.

The aim for this project is to produce a flower separate machine that can separate the flower leaves from the stems and cut the stem. This process is to ease the fresh flower packing and storage preparation after harvest from the plantation. The removed stem part from the flower can be replanted again to make a new plant. Other than flowers such as roses, helianthus, sunflower, hibiscus and others, this machine can also be used with other non-flower plants for collecting the leaves. The leaves that have been separated will be washed and collected to be used for the extraction process. The leaves also can be sold to wholesalers that want to purchase extracts from the leaves. These multifunction leaves stem cutting machines also have a storage to put the flower while doing the work. This machine can save more time for small industry workers to do the next process because all the processes that need to be done are already on the machine. This leaves stem cutting machine is very useful to the Malaysian flower industry like Malaysian Agricultural Research and Development Institute (MARDI), SME Corporation Malaysia (SME Corp. Malaysia), flower factory that exports flowers, florist businesspeople, and more. Based on this issue, a new idea had been generated to create multifunction leaves stem cutting machine that can separate the leaves from the stem, cut the flower stem and washed the separated leaves.

Materials and Methods

Figure 1 depicts framework research to design the multifunction leaves stem cutting machine. The purpose of this research is to identify the issues that consumers have when using the

existing leaves stem cutting machine. The goal of this research project is to improve the existing machine. This study will enhance the system in the leaf isolation part as well as the washing section. Based on the ideas, sketches, and technical drawings, optimization and analysis of design, material selection, fabrication and finishing can be made according to the required characteristics and ergonomic features. 3D models are used in addition to the creation of concepts as generated from the technical drawings. Later, the research flow will go through the selected design model in depth using design fabrication.

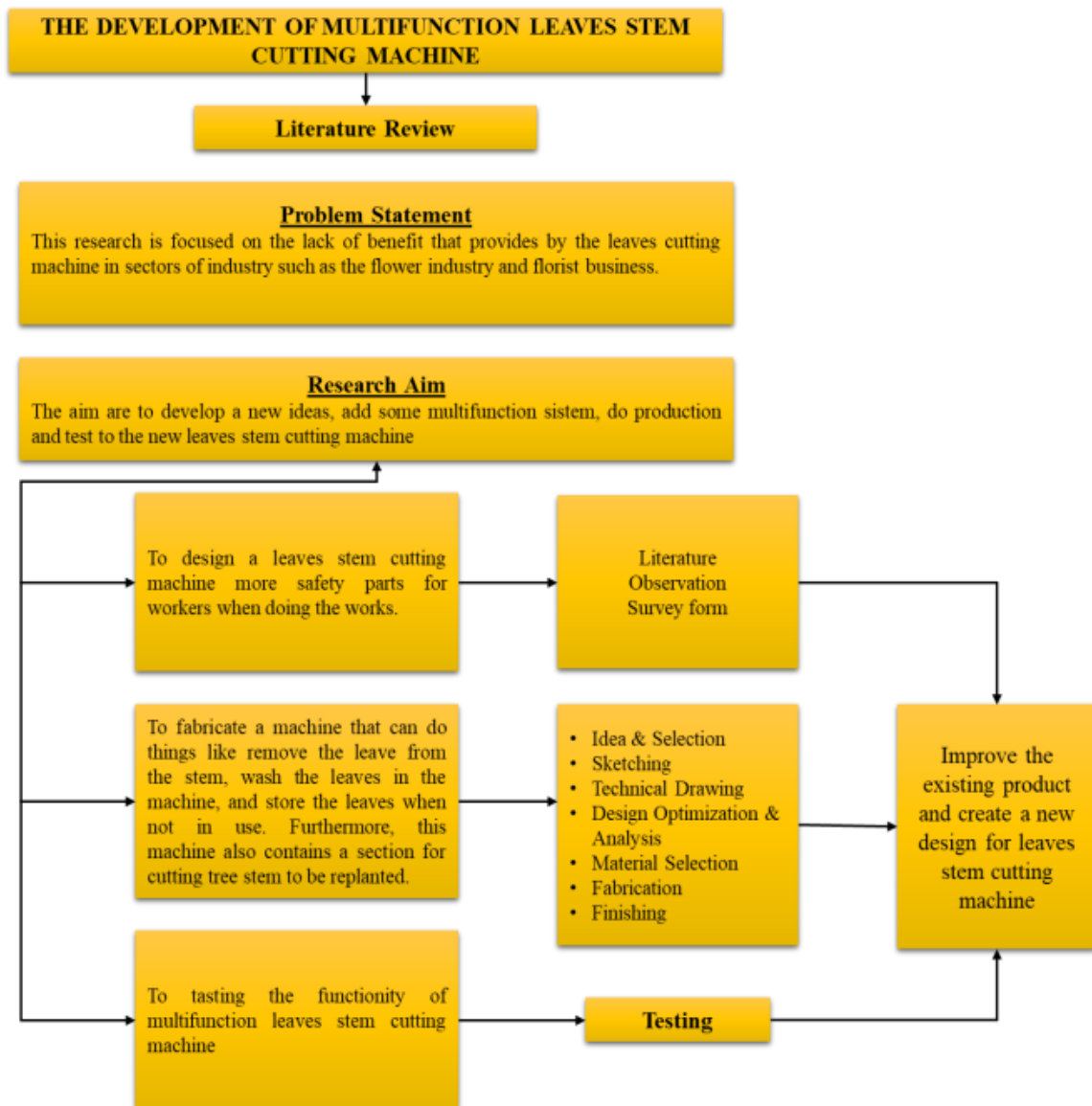


Figure 1. Framework of the research project

Based on the five sketches only one design has been selected based on customer's need criteria in the survey section. The best design was selected using screening and scoring method. The design that has been selected needs to follow all the functions from customer's needs. Figure 2 shows the final selected sketching of multifunction leaves stem cutting machine from the five-design sketched. This multifunction leaves stem cutting machine involves 21 parts and all the parts were assembled and combined to form one functional machine. Then the 3D modelling design from the technical drawing was done by using software Fusion 360 (Figure 3).

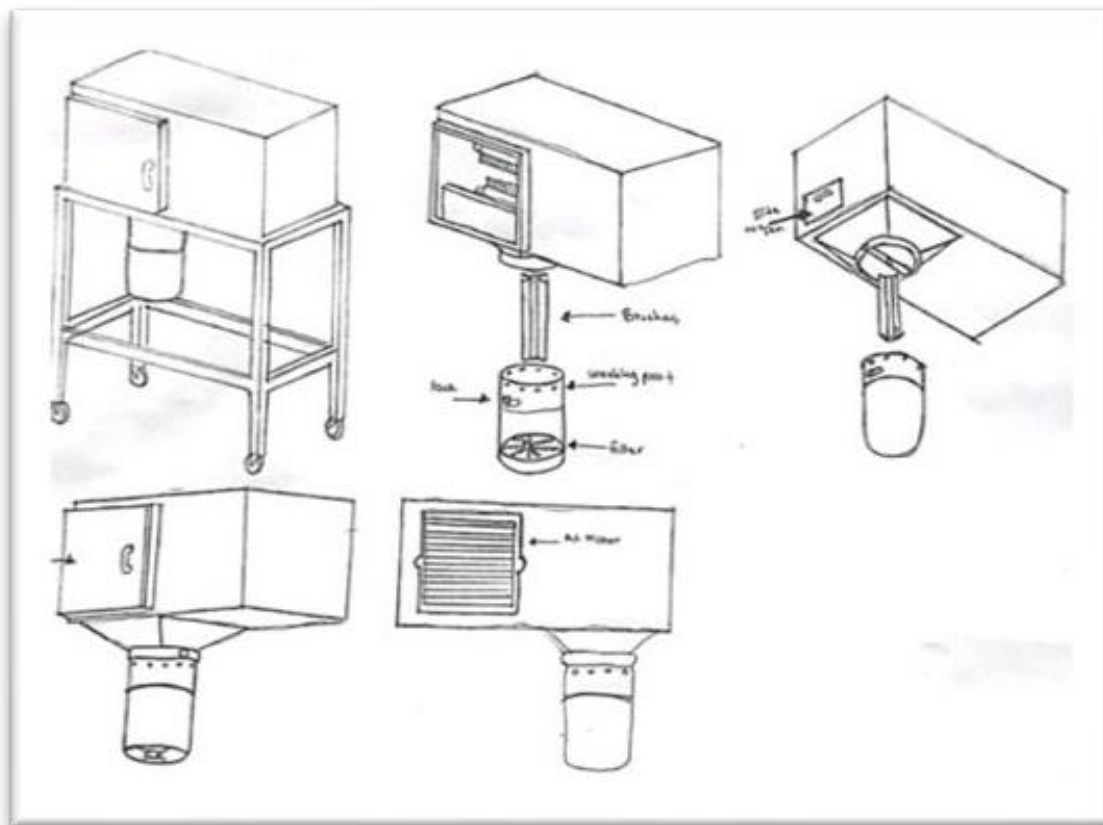
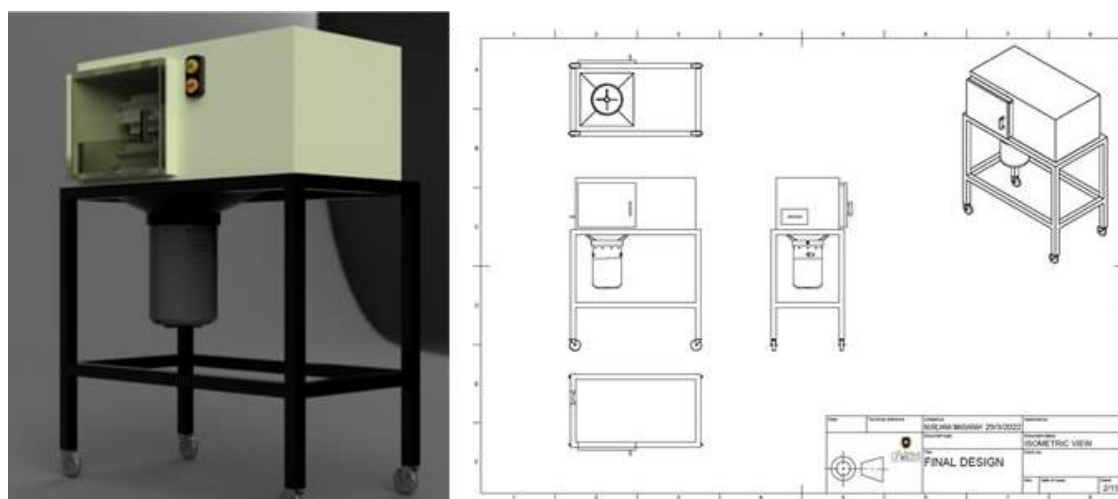


Figure 2. Final sketching multifunction leaves stem cutting machine.



a

b

Figure 3. (a) 3D modelling (b) Technical drawing of the multifunction leaves stem cutting machine

Material selection is a step in selecting object or material to be used during the design process. The goal is to select the items that needed to minimize the cost required by the product. A good selection of items can meet the goals that have been set. Among of the most important characteristics when selecting is there must be good durability, good strength, good flexibility, resistance of a material to heat and corrosion, resistance to electricity, and more.

Table 1. Material Selection

| No | Name of part | Components | Description |
|-----|--------------------------------------|---------------------------------|--|
| 1. | Body | Flat mild steel plate & Acrylic | Has a lower price and high of durability |
| 2. | Door & Top | Acrylic | More durable and easy material to care and cleaning |
| 3. | Body support | Angle steel | Has a low price and high of durability |
| 4. | Leaves remove brushes | Rubber filament 3D printing | Affordable price and easy to clean |
| 5. | Flower cutter | Hardener steel | The cutter will be sharper when cutting the flower stem |
| 6. | Leaves washing brushes | Silicon brushes | Easy to use and can prevent damage to the leaves when doing the washing process because the sponge has a soft surface |
| 7. | Rotation hollow | Aluminum | Has an affordable price and high of quality |
| 8. | Connector screw | Stainless steel | Has an affordable price and high of quality |
| 9. | Wheels | Rubber | More durable and has a low price |
| 10. | Flower stem dustbin | Aluminum | Material water resistant and easy to clean |
| 11. | Button on/off | Plastic | Has strong durability, good insulation quality as well as has a reasonable price |
| 12. | AC motor | 240v | Has more even power and it is able to maintain power consistently throughout the work process. Motor ac can reduce the risk of flammability when doing too much work |
| 13. | AC motor cover part | Aluminum | The function is to protector the AC motor so that no objects will enter the AC motor |
| 14. | Door handle | Stainless steel 4 inch | Low price and affordable to used |
| 15. | Drawer handle | Stainless steel 4 inch | Low price and affordable to used |
| 16. | Hose water drain | PVC | Durable and easy to use |
| 17. | Linear bearing shaft rod hard chrome | Hard rod chrome | Has strong durability |
| 18. | Support linear actuator | Steels | Has strong durability |
| 19. | Shaft support holder linear actuator | Steels | Has strong durability |
| 20. | Dc motor wheel coupling | Steels | Has an affordable price and high of quality |
| 21. | Shaft rod mounting connector | Steels | Has strong durability |
| 22. | DC to DC step down voltage regulator | 24 volts | Has an affordable price and high of quality |

| | module | | |
|-----|--|------------------------------------|---|
| 23. | AC to DC switching power supply | 12 volts | Has an affordable price and high of quality |
| 24. | Linear actuator | 12 volts 100mm 10mmps (700N) | Expensive and have a high quality |
| 25. | Linear actuator bracket | Steels | Has a strong durability |
| 26. | Ultrasonic sensor | Sensor | Durable and easy to use |
| 27. | Ultrasonic bracket sensor | plastic | Has an affordable price and high of quality |
| 28. | Mind plug top | Abs plastic | Durable and easy to use |
| 29. | Primer flexible cable | Cable | Affordable price and easy used |
| 30. | Pipe hole | Plastic | Durable and easy to use |
| 31. | Outlet hose | Pipe 1.5m grey | Easy to apply |
| 32. | Terminal block 6A | Polyamide | Has an affordable price and high of quality |
| 33. | 5V-4ways channels relay module with optocoupler. | Relay 4 ways for Arduino | Has an affordable price and high of quality |
| 34. | 2000w 220v ac voltage regulator | Motor speed controller | Has an affordable price and high of quality |
| 35. | KCD 21x15mm rocker switch | Rocket switch 3 pin | Has an affordable price and high of quality |

| | | | |
|-----|----------------------------------|---|--|
| 36. | Meter cable 40,76,3core | Wire | Has an affordable price and high of quality |
| 37. | Square hollow | Steel | Affordable price |
| 38. | Microtube 4mm (10mm) | Hose | Easy to apply |
| 39. | Hose clip with thumb screw | Hose clip | Easy to apply |
| 40. | 360-degree adjustable dripper | 360-degree adjustable water sprinkler garden watering | Has an affordable price and high of quality |
| 41. | Aluminum Zinc | Aluminum | High quality |

Fabrication process is the process that produces a structure from raw materials by using several techniques such as measuring, marking, cutting, welding, and drilling. Before starting the process of developing multifunction leaves stem cutting machine the material needs to measure following the same as the dimension in the technical drawing. This part will start from measuring angle steel, aluminum, hollow square steel, and acrylic. After done the measuring and marking, then proceed with the cutting process. In the cutting part, the materials were cut according to the marking process. In the welding process, angle steel was joined to make the body frame and the hollow square steel was attached to the frame body to make the support of the system part as shown in Figure 4. Some parts of the machine need drilling process to make hole for attaching the screw with the aluminum and acrylic for the body cover machine.



Figure 4. Fabrication Process

Assembly process is the step to assemble all the system components such as AC motor, power supply, Arduino, ultrasonic sensor, linear actuator, and garden micro drip irrigation. This part is very important to see the result of functionality of this multifunction leaves stem cutting machine. A fritzing diagram is a circuit in the form of a diagram. The user uses the wire symbol as a circuit component. The fritzing circuit is an easy -to -understand circuit (Agilo Research, 2018). Each given component has a realistic look. Fritzing also has popular suppliers such as Sparkfun,

Adafruit and Snootlabs. The advantage of using fritzing is suitable for Arduino, Raspberry Pi (Monk, 2015). Figure 5(a) shows the fritzing diagram for multifunction leaves stem cutting machine system while Figure 5(b) shows the process assembly of the component part system.

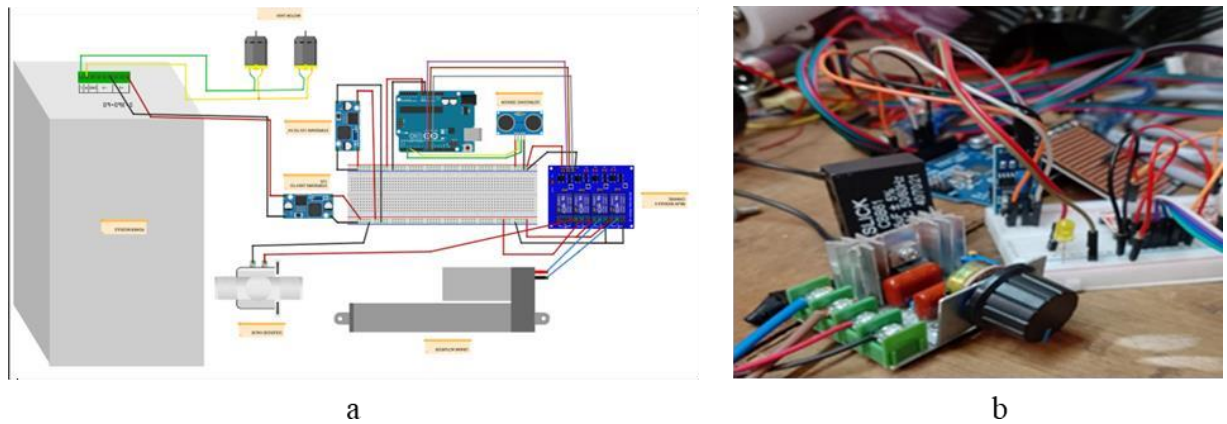


Figure 5. (a) System assembly part (b) circuit diagram

Results and Discussion

Design improvements are made due to some parts that cannot be implemented properly, and it will cause the high risks while implementing the manufacturing process of the product. The improvement that has been made by changing the design and mechanical part such as flower stem cutting part, leaves washing part and mechanical part to move the system at that machine. For the cutting part it will be carried out using Arduino, ultrasonic sensor, and linear actuator system. This system component will move when the ultrasonic sensor give the signals to the linear actuator move forward to start the cutting process. For the leaves washing part, the water will be sprayed using micro drip water irrigation. Micro drip irrigation will perform a spraying process that aims to wash the leaves. This process aims to remove traces of dirt found on the leaves of the flower. The technical drawing in Figure 6 illustrated the improvement detailed 3D drawing model that was created together with the component for each part and the bill of material.

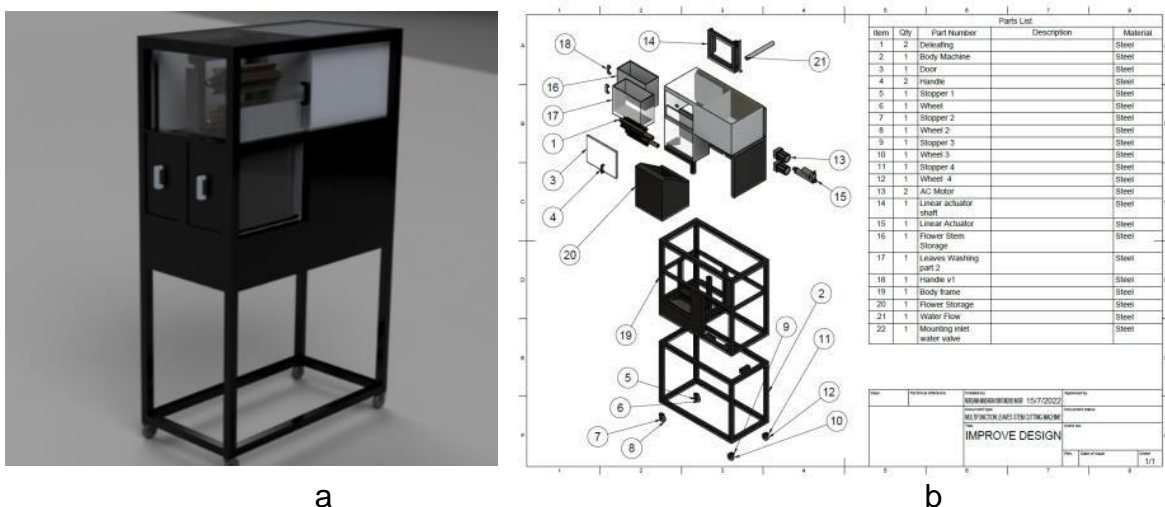


Figure 6 (a) Improved 3D modelling (b) Technical drawing and bill of material for the multifunction leaves stem cutting machine detailed drawing.

The improvements design was in making part such as flower cutting stems, flower leaves washing part, and adding a place for flower storage. Figure 7 shows the final product result of the developed multifunction leaves stem cutting machine.



Figure 7. Final product of the developed multifunction leaves stem cutting machine

The multifunction leaves stem cutting machine presents a groundbreaking solution to the challenges faced by SMEs in the floriculture industry. By offering precision, efficiency, and consistency in stem cutting, the machine not only reduces labour costs but also enhances the overall quality and market competitiveness of the plants produced. By reducing the labour costs and increasing efficiency, SMEs can significantly lower production costs. Moreover the machine can be customized for various plant species and cutting requirements, making it versatile and adaptable for the diverse needs of SMEs.

The function of the multifunction leaves cutting machine had been tested with the rose flower. A few roses at a maximum of twelve rose bunches can be inserted together in this machine and the process went smoothly. As observed, all the systems involved in the machine such as separating leaves from the stem, cutting the stem and washing the leaves had functioned and were running well. The machine demonstrated exceptional performance across all tested parameters including cutting precision, efficiency, and consistency of the machine. The machine consistently produced clean and precise stem cuts and reducing the risk of damage to the plant material. In addition, the machine consistently delivered uniform stem cuttings in terms of length and quality, which is crucial for propagation and replantation purpose. The machine ensures that the stem cuttings are of improved quality and uniform, enhancing the market value of the plants.

Time taken to complete the whole cycle that including the three main process was around 15 minutes with approximately 5 minutes for each process respectively. In one hour, the machine can work and produce around 48-50 cleaned roses. The machine works efficiently where it significantly reduced the time required for stem cutting and making the process up to five times faster compared to manual methods. This indicate that the machine allows for a higher volume of stem cutting within several hours and absolutely increasing overall productivity. Furthermore, the reduction in manual labour contributes to a more sustainable and environmentally friendly operation with energy saving consequence. This leaves stem cutting machine had successfully function as a multifunctional machine and is suitable to be apply in floriculture industry and small medium enterprise.

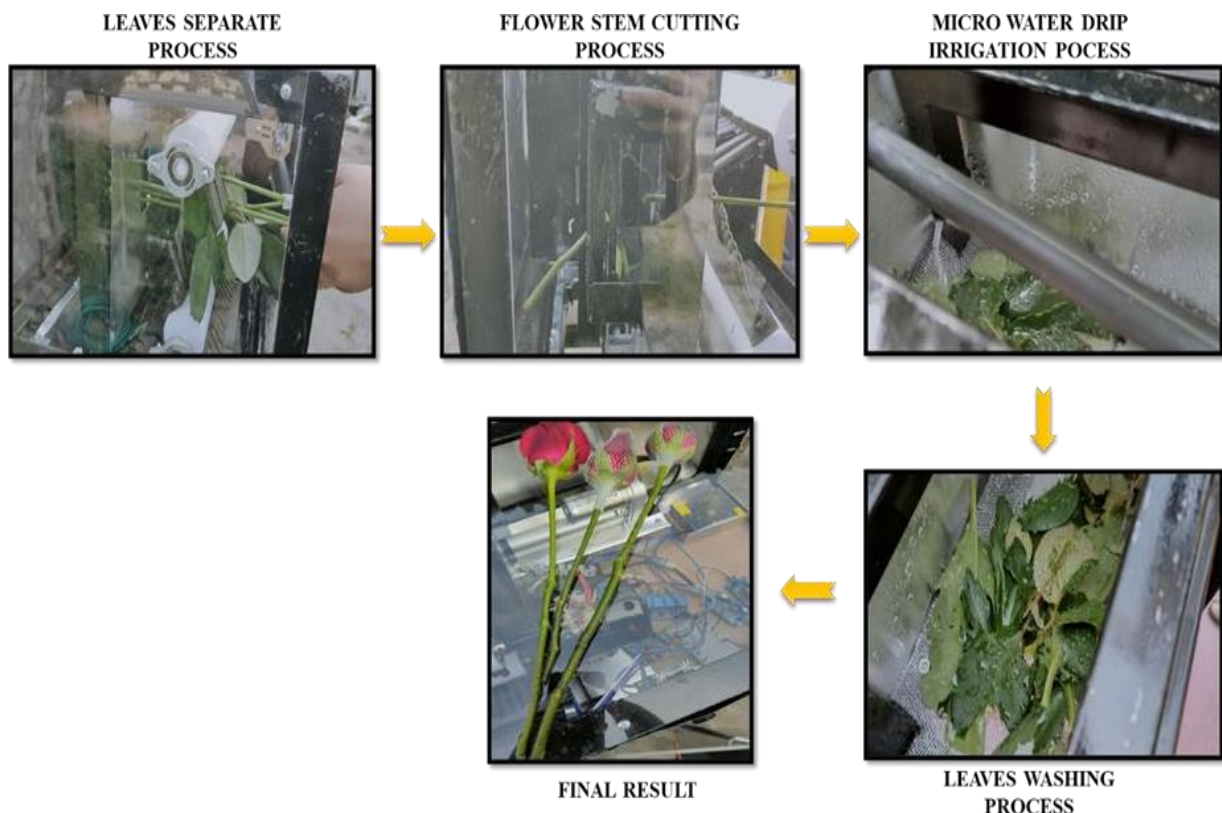


Figure 8. Multifunction leaves stem cutting machine product testing.

Further research is needed to explore the adaptability of the machine to different plant species and growing conditions. Additionally, efforts should be made to make the machine more accessible to SMEs, possibly through government incentives or cooperative initiatives. Monitoring the long-term effects of the machine adoption on the floriculture industry's sustainability and economic contribution is also a promising avenue for future investigation.

Conclusion

The floriculture industry is a vital component of the global agricultural landscape, with SMEs playing a pivotal role. The multifunction leaves stem cutting machine developed in this research has the potential to revolutionize the way SMEs in this industry propagate plants, enhancing efficiency, reducing costs, and improving overall quality. The adoption of this machine can empower SMEs to thrive and compete in the ever-evolving floriculture market, contributing to the industry's sustainable growth.

This research aims to design, fabricate, and test the functionality of multifunction leaves stem cutting machine. Based on the analysis through to the research method the final design can solve the problem of flower industry, florist business and others. This multifunction leaves

stem cutting machine will help the worker doing the separate leaves, cutting the flower stem, and washing the leaves easily. Perfect and easy work equipment may relieve employees' burdens in executing everyday activities and lessen workplace stress.

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