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FABRICATION OF RAINWATER HARVESTING FILTER WITH FOG COLLECTOR FOR CLEAN WATER HARVESTING IN VILLAGES

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Abstract

Safe and clean water is essential for public health, whether it is used as drinking water, domestic usage, food production, irrigation, or for recreational purposes. Rainwater harvesting and fog collecting are integrated environment-friendly systems to produce renewable feedstock or water supply in the efforts to help reach the Sustainable Development Goals (SDG). Most of the villages in Kuching, Sarawak are supplied with water tanks to harvest the rainwater from the roof by collecting the rainwater in gutters. Therefore, the rainwater may be contaminated with residues such as dry leaves, rotting leaves, dead plants, twigs and others. Rainwater harvesting can be problematic, particularly within the dry season, although there might be a significant amount of fog in the mountainous areas of the country. Hence, this project aims to fabricate a rainwater filter integrated with a fog collector to obtain clean water. The system can channel up to 90% of rainwater into the storage tank. The system consists of a self-designed and 3D-printed body with a mesh filtration tube as the core to collect large residues before the rainwater drops into the storage tank. Meanwhile, the fog collector works to capture water from the ambient using the concept of a fog harp utilizing vertical parallel wires. In the post-testing, it is found that the system was able to channel up to 92.6% of water. Meanwhile, the fog collector was able to accumulate 485ml volume of water for 5 days period at Kampung Duyoh hilltop village. It is also noted that the system is relatively easy to operate, requires low maintenance, and has a reasonable cost. In the end, the objectives of fabricating a rainwater filter with a fog collector are successfully achieved and can be utilized by the villagers to obtain clean water and water supply.

Keywords: Clean Water, Rainwater, Fog Collector, Villages

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1.INTRODUCTION

Water is our most precious natural resource and essential for all life. It plays an important role in transforming the lives of people into better and healthier ones. Clean water and sanitation belong to one of the 17 sustainable development goals (SDG) under goal number 6. It aims to achieve universal and equitable access to safe and affordable drinking water for all, provide adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. These can be successfully achieved by substantially increasing water-use efficiency across all sectors and ensuring sustainable withdrawals and supply of freshwater to address water scarcity. Therefore, these measures will reduce the number of people suffering from water scarcity and improve the water quality through various methods such as reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and increasing recycling and safe reuse of water. Hence, these are very important for sustainable development as it helps in poverty reduction, economic progress, and environmental sustainability.

However, in recent decades, environmental destruction, pollution, and climate change happen drastically globally due to human activity. From United Nations facts and figures (Nations, n.d.), two billion people live without safely managed drinking water services in the year 2020, with 1.2 billion people lacking even a basic level of service. With the rapid increment of water demand from various sectors such as agriculture, industry, energy and etc., protection and restoration of water-related ecosystems are the imperative steps to ensure sustainable access of safe and clean water for all. Any innovation projects correlate to improve the water-use efficiency is one key to reducing the water stress. Hence, utilization of natural resources such as rainwater and fog can provides an alternative method to obtain clean and safe water for multiple usages.

Utilization of the rainwater harvesting system can reduce the demand for mains water supply. A simple and carefree method for harvesting rainwater is essential to make it more sustainable and the easiest method is rooftop rainwater harvesting. Rainwater harvesting for house systems comprises some basic components (Figure 1). The rooftop will be the catchment area to capture rainfall. Then, a conveyance system such as a gutter will move the captured rainwater from the roof to a storage tank and a storage tank is used to store the rainwater for future usage. Finally, a distribution system is installed to flow the rainwater for various purposes such as garden/lawn irrigation, toilet flushing, clothes washing, car washing, showering/bathing, and even for drinking (after water treatment methods). Treatment of rainwater is typically performed by the diversion of the first flush and the use of strainers to retain gross particles (e.g. leaves) (Ltd., n.d.).

Figure 1. Rainwater harvesting system for house (Ltd., n.d.)

The rainwater harvesting methods vary from traditional to modern solutions and it evolves rapidly. Traditional

rainwater harvesting is a process that requires the concentration, collection, and storage of rainwater such as

the Khadin system. Khadin is a water conservation system designed to store surface runoff water from sloping farmland to form a reservoir. This helps moisten the soil and helps in preventing the loss of topsoil. Additionally, spillways are provided to ensure that excess water is drained off to the shallow dug well. This system of water conservation is common in the areas of Jaisalmer and Barmer in Rajasthan (Teachoo, 2023). As time passes, the rainwater harvesting method develops into a more holistic and sustainable strategy. In the modern world, the rainwater harvesting practice has evolved using different types of techniques to collect and store rainwater from rooftops and land surfaces. Among the modern types of rainwater harvesting devices in the market is the Wisy Vortex filter. The product is a unique patented design that uses the principle of adhesion, where water 'sticks' to a smooth surface, in this case, the outer layer of a vertical cylinder. This process causes the water to 'pull' through the fine mesh inner layer, leaving behind any leaves, insects, and any other particles greater than 0.28mm. The vortex filter also oxygenates the water to keep quality at its peak and inhibit the growth of anaerobic bacteria, which can cause the water to develop a bad odor (Ag, n.d.). Then, there is the Superhead Leaf Screen, a conventional method of installing the downpipe in any building vertically from top to bottom. The rainwater catchment area is normally placed on the roof, and the collected rainwater will flow down in the pipe vertically at high speed. By utilizing the gravitational force with the speed of rainwater flow, the rainwater can pass through the filter screen right below the inlet easily due to the extra downward force. This design enhances the filtration efficiency as the particles are quickly removed without contaminating the filter screen (Solutions, 2021). There is also FSP first flush filter collector as shown in Figure 2 that has a dual function which is filter & first flush. The concept follows vertical filtration and provides effective separation of collected rainwater from sediment, leaves, moss & insects. It has fine filtration that prevents mosquitoes from breeding and maintains a full cross-section of downpipe which means no obstruction of rainwater flow. This device can be easily connected to round or other types of rainwater downpipes (Store, 2023).

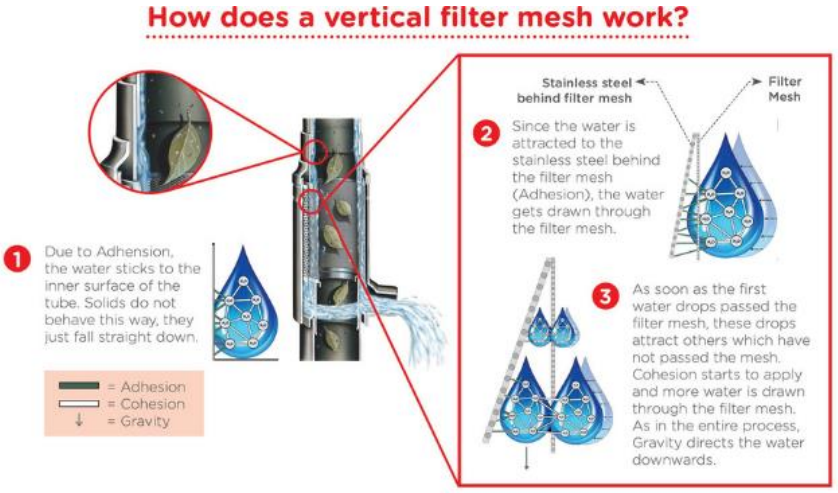


Figure 2. FSP First Flush Filter Collector (Store, 2023)

Meanwhile, fog harvesting provides an alternative source of freshwater through a technique used to capture water from wind-driven fog. Fog harvesting is a non-conventional method to produce freshwater. Fog is one of those water resources and it is important to maximize renewable resources such as water and elaborates the role of textiles to enhance the efficiency of fog water collectors. Fog is composed of micrometer-sized water droplets that form when the air becomes saturated with water vapor. Fog is a thick cloud that remains suspended in the atmosphere. Water condenses onto the array of parallel wires and collects at the bottom of the net. This requires no external energy and is facilitated naturally through temperature fluctuation, making it attractive for deployment in less developed areas. Fog harvesting systems are typically installed in areas where the presence of fog is naturally high, typically coastal and mountainous regions (Bhushan, 2020). Fog can be harvested using simple and low-cost collection systems and afterward, the captured water can then be used for agricultural irrigation and domestic use. The systems are usually consisting of a mesh net in between two posts that are spread out at an angle perpendicular to the prevailing wind carrying the fog. As the wind passes through the

mesh, drops of freshwater form and drip into an underlying gutter to lead the water into a storage tank (Network, 2016).

On the other hand, the fog harvesting technology also can consist of a double-layer mesh net supported by two posts rising from the ground. Mesh panels can be varied in size, design, and type of material used which contribute to the efficiency of fog harvesting. Among the high-efficiency fog collector is the heterogeneous rough conical wires. The artificial periodic roughness-gradient conical copper wire (PCCW) can harvest fog on periodic points of the conical surface from air and transports the drops for a long distance without external force. The effectiveness of the fog collector depends on the tilt angle (Xu et al., 2016). Then, there is the fog harp method inspired by linear needles of redwood trees where vertical wires were used compared to traditional mesh structures. Research findings illustrated the fog harp collected more water either in light or moderate fog conditions when compared to mesh harvesters. An optimal fog harp (Figure 3) should feature high-tension, uncoated wires within a large aspect ratio frame to avoid tangling and promote efficient and reliable fog harvesting(Shi et al., 2020). In addition, there is the cactus kirigami type where the simplified cactus-inspired fog collecting spines from a 3D cone to a 2D triangle. The wax-infused kirigami with an anisotropic shape can reproduce the efficient capture of fog droplets through rapid refreshing of the collecting interface. Research showed the harvesting rate improved significantly compared to harp-like and plate collectors with lower costs (Bai et al., 2020).

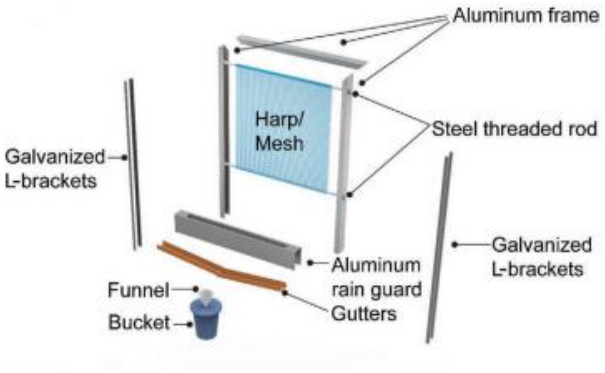


Figure 3. Fog Harp (Shi et al., 2020)

Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production, or recreational purposes. Improved water supply and sanitation, as well as improved management of water resources, may help countries develop economically and reduce poverty. Everyone has the right to sufficient, continuous, safe, acceptable, physically accessible, and affordable water for personal and domestic use. Contaminated water can lead to diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid, and polio. While inadequate management of urban, industrial, and agricultural wastewater means the water of hundreds of millions of people is dangerously contaminated or chemically polluted. The natural presence of chemicals, particularly in groundwater, can also be of health significance, including arsenic and fluoride, while other chemicals, such as lead, may be elevated in drinking water because of leaching from water supply components in contact with drinking water (Organization, 2023).

Despite several products available in the market that can produce or filter rainwater, most of the people in Kuching, Sarawak is still unaware of or do not use them. From the observation, many of the villagers in rural areas were given free water tanks as the water reservoir for rooftop rainwater harvesting. However, it is not equipped with any water filtering system for clean water. This contributes to the unclean water catchment and dirty water shortage with residues such as leaves, dirt, or dust, especially during the dry season. Therefore, the objectives of the project are to fabricate a rainwater water filter combination of fog collectors for water harvesting and conduct post-testing to evaluate the performance of the fog collector. Some of the scope and limitations of this project are a maximum of 5 days to collect water storage for the post-testing due to the hot season in Kuching, Malaysia which is in the month of May to August and only one outdoor field site was selected for fog harvesting.

2.METHODOLOGY

The development of the rainwater harvesting filter with a fog collector was based on the flow chart in Figure 4.

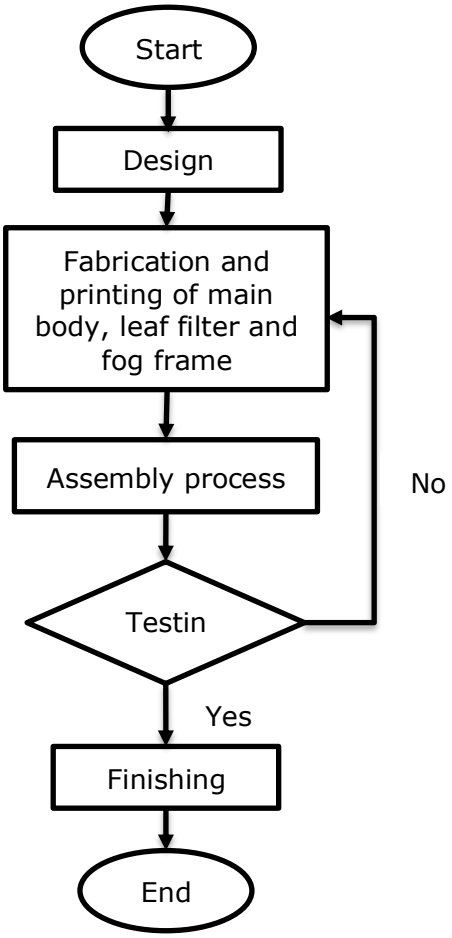


Figure 4. Flow chart of rainwater harvesting filter with fog collector

The first process is the design process using Autodesk Inventor. Figure 5 shows the final design of the project. During this process, various sketches were developed based on the literature review conducted and the final design was selected from a morphology chart with criteria such as filter type, size, effectiveness, cost and technical aspect taken into consideration.

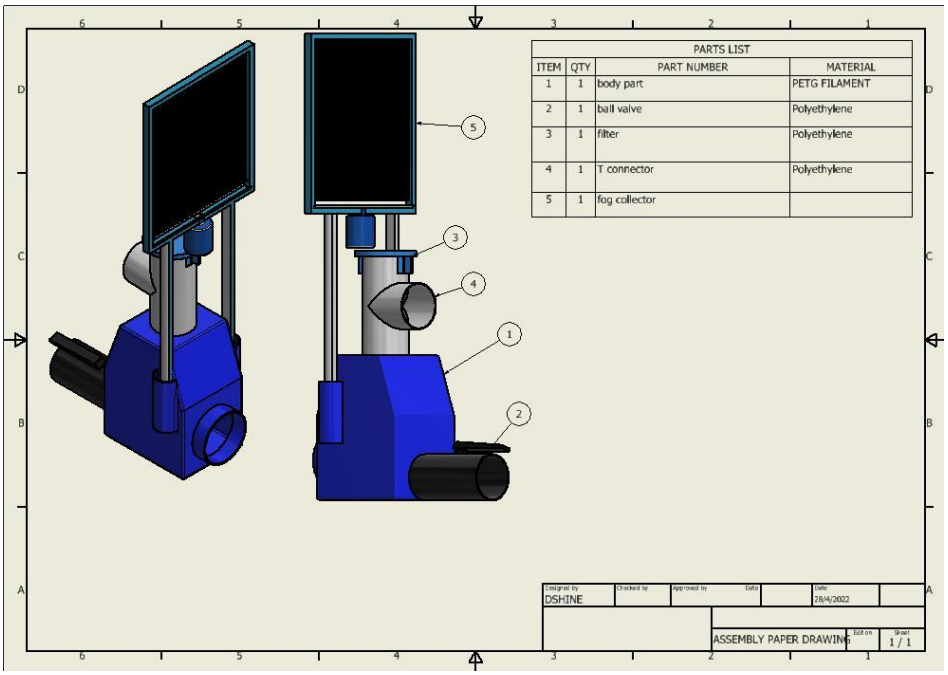
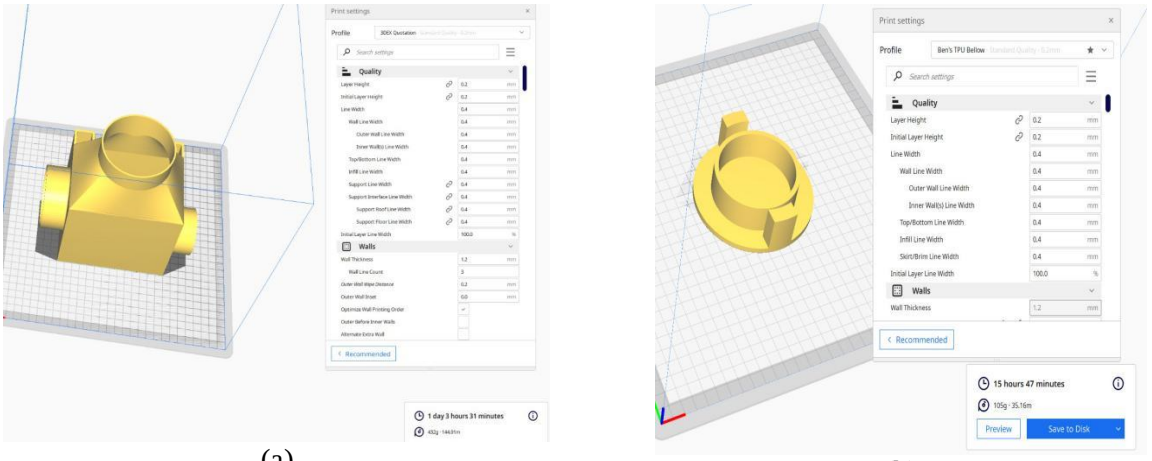


Figure 5. rainwater harvesting filter with fog collector using Autodesk Inventor

Once the final design was determined, the next step was the printing process of the main body. The body for the rainwater filter and 'cap' (Figure 6) were designed using Inventor software with the dimension of 20 x 12 x 21 cm while the diameter of the 'cap' of 11cm. Then, the designed parts were transferred to Ultimaker Cura software to slice the model. The software estimated and calculated the route and the amount of filament required to print the parts. Next, the software generated the G-Code files. The sliced files were uploaded into the 3D printer for the printing process. Eventually, the final touch was required to remove the unwanted filament on the printed parts.



(a) (b)

Figure 6. 3D printed parts; (a) Filter body, (b) Cap

As for the leaf filter, a length of 320mm with 78mm diameter PVC pipe was cut vertically using a hand grinder and divided into four equal parts from the bottom. Then, a rectangle with a length of 140mm was created on both sides of the pipe. After finishing the cutting process, to attach the PVC netting as the leaf filter (Figure 3.7 (a)), a hole was made to attach the netting to the pipe by thrusting it with a hot nail. Then, the pipe was aligned to the hole in the middle of the T-connector and marked. The marked part was then drilled (Figure 3.7(b)). Then the hole was polished and the printed cap was attached to the filter pipe using pipe-fitting tape (Figure 3.7 (c)). Subsequently, the T-connector was cut vertically with a length of 3cm on both sides using a hand grinder to slot in the cap for the leaf filter insertion.

(a) (b) (c)

Figure 7. Leaf filter-making process; (a) Attach PVC netting to pipe, (b) Drilling Pipe, (c) Leaf Filter

As for the fog collector, a PVC pipe with a diameter of 20mm was cut to form a 29cm x 33cm frame (Figure 8 (a)). To support the frame, the PVC pipe was cut to various lengths of 8cm, 10cm and 37cm for 2 pieces each (Figure 8 (b)). All the pipe was connected using the T and L connectors. Next, the bottom part of the frame was cut into half to form a gutter for the water to flow (Figure 8(c)). Finally, two 4.5mm stainless steel rods were inserted into the frame horizontally through the holes and fishing lines were attached around the rod vertically to form the fog collector.

(a) (b) (c)

Figure 8. Making fog collector, (a) Cutting Pipe, (b) Poles, (c) Gutter

Finally, all the components were assembled and a ball valve was attached to the main body too as the overflow valve and dirt trap. Post-testing was conducted by placing a rainwater harvesting filter with a fog collector on the ground level and hilltop level at Kampung Duyoh, Bau for 5 days. The volume of the water accumulated in 5 days was taken as the results to determine the best placement of the fog system. To evaluate the effectiveness of the filter, we also tried to pour 10 liters of water containing dry leaves into the filter system. A short post-testing survey was also conducted using questionnaire distribution to seven villagers in the same village to obtain their feedback on this innovation project.

3.RESULTS AND DISCUSSION

The completed rainwater harvesting filter with a fog collector is shown in Figure 9. The filter is simple via less maintenance at a relatively low cost as compared to modern and complex filters which are available in the market. Additionally, this will encourage the replication by the community and industry to achieve clean water to support the SDG activity.

(a)

(b)

(c)

(d)

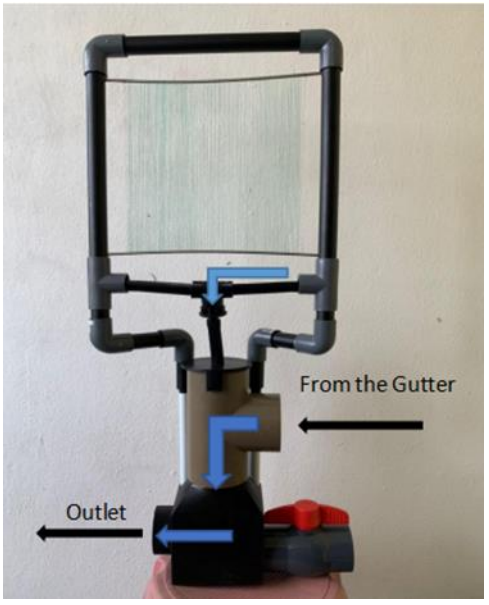
Figure 9. Completed rainwater harvesting filter with fog collector; (a) Plan (b) Isometric (c) Front (d) Side

The operation of the rainwater harvesting filter with a fog collector is straightforward. First, a single person is adequate to install the filter on the rooftop with the filter inserted into the rainwater filter body through the 80mm T connector pipe (Figure 10 (a)). Then the fog collector poles are inserted into the slot beside the body (Figure 10 (b)) and a hose is used as the funnel to channel the fog water to the filter through the cap. After the device is assembled, the other part of the T connector is connected to the roof pipe where the water flows from the roof gutter while the outlet for the water is at the opposite chamber for the ball valve. Figure 10 (c) shows the water flow and the initial point is when the water flows from the roof to the gutter during rain and turns into the water inlet from the roofing pipe to pass through the filter mesh. The blue arrows indicate water movement and any particles that are larger than the size of the mesh will be filtered. Next, the clean water will flow out from the filter compartment into the water tank as the outlet. The remaining water with heavy residues might be trapped at the bottom of the body compartment and can be removed by using the ball valve. Meanwhile, the

fog collector functions when abundant fog is trapped by the fog harp. The accumulated water will flow to the gutter and the body compartment through the hose connected as a funnel.

(a)

(b)



(c)

Figure 10. Installation of the rainwater harvesting filter with fog collector; (a) Leaf filter (b)Fog collector (c) Operation

Figure 11 shows the water quality and leaves filter for the post-testing. It is quite obvious that the leaf filter works well with a lot of trapped leaves (Figure 11 (d)) via cleaner water in Figure 11 (b). From the observation, only small residues and particles can pass through the mesh. Therefore, this filter is the best method to produce clean rainwater for houses built in estates or farms which surrounding areas covered with trees. During the post-testing also, it is found the efficiency of the rainwater filter is 92.6% with 740ml collected as blowdown water with some heavy residues such as sand through the ball valve.

(a)

(b)

(c)

(d)

Figure 11. Post-testing; (a) water with dry leaves (b) water after filtration (c) Empty leaf filter (d) After water filtration

Subsequently, the fog collector was installed at the ground level and hilltop in Kampung Duyoh, Bau, Sarawak and the results are shown in Figure 12. After being left for 5 days, the volume of water collected is tabulated in Table 1. During the post-testing, no rain occurred and therefore, the accumulated water was assumed from the fog itself only. From the figure and table, it is clear and visible the fog collector works fabulously with clean droplets collected and free from impurities after 5 days. The results also show the suitable location to install a fog collector is on the hilltop compared to ground level. This argument is coherent with the literature (Bhushan, 2020) stated geographical position will determine the amount of fog collected. Therefore, this can be suggested that the fog collector serves as the main alternative to obtain clean water, particularly for the hilltop residents.

Table 1. Fog collector performance

Area	Volume (mL)
Ground	360
Hilltop	485

(a) (b)

(c) (d)

Figure 12. Fog collector; (a) 1 day at ground level (b) 5 days at ground level (c) 1 day at hilltop (d) 5 days at hilltop

As for the quantitative post-testing survey, it is found that samples which consist of seven villages agreed on the filter with fog collector machine can provide a cleaner water supply to the existing rainwater rooftop system. The main advantages of the current filter system are it does not require any electricity to

operate, has minimal maintenance, has easy installation and can be fitted into existing piping systems.

Lastly, the cost of this machine is approximately RM 214.68 (Table 2) which is a relatively cheaper option when compared to the filters sold in the market. Hence, this filter is an attractive option and recommended for small and medium hilltop farms and estate villagers to obtain clean water.

This current innovation is an upgraded version as compared to the one's available in the market, mainly due to the novel of combination of rain water filtration with additional fog collector to increase the clean water intake.

Table 2. Cost of the Filter

No.	Material	Quantity	Price Per Unit (RM)	Total Cost (RM)
1	19mm pvc pipe (3 meter)	1	3.50	3.50
2	20mm pvc pipe (2meter)	1	10.50	10.50
3	75mm pvc pipe	1	17.50	17.50
4	PVC netting (1m x 1m)	1	5.50	5.50
5	Cable tie	1	1.00	1.00
6	45mm stainless steel rod	1	10.00	10.00
7	50mm ball valve	1	21.00	21.00
8	3D printed body + cap	1	122.08	122.08
9	80mm T connector pipe	1	12.50	12.50
10	20mm T connector pipe	2	1.95	3.90
11	20mm elbow	6	1.20	7.20
				214.68

4.CONCLUSION

The objective of this project is successfully achieved as the rainwater harvesting filter with fog collector is

produced. The post-testing results also produced positive outcomes when 92.6% of clean water passed through the filter with big residues such as leaves collected by the mesh and 485mL of water collected from the fog collector after 5 days at the hilltop of the test field site. A qualitative survey also obtained positive feedback from the villages. Lastly, the cost of this filter is RM214.68 and this makes it very affordable in the market when compared to complex filters. With the aforementioned features and benefits, this filter can be utilized in activities to obtain clean water for the sustainability of the earth in long-term prospects. As for the suggestion to improve the current design, more empirical work on the fog collector can be done as variables such as tilt-angle and mesh-gap might play crucial roles in fog harvesting. In order to collect more water volume, a bigger scale of fog collector can be considered which mountainous area is the most ideal placement.

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AUTOMATIC ELECTRIC WALL MOUNTED HANGER RACK

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Abstract

With the Automatic Electric Wall Mounted Hanger Rack, users will no longer face issues with limited space or reaching and pulling out the suspension manually. The inclusion of an automatic electric controller simplifies the operation of the hanger rack. Durability is a key consideration, and the project addresses this by utilizing high-quality stainless-steel materials. This choice of material minimizes the risk of corrosion, ensuring the longevity of the hanger rack. To provide uninterrupted functionality, each user will be supplied with a 12V battery. This backup power source ensures that the hanger rack can still be used during electrical trips or blackouts. The assembly process of the project involves three main parts: the frame part, body part, and mechanism part. Various processes such as cutting, grinding, welding, drilling, and painting are employed to fabricate the hanger rack. In conclusion, the Automatic Electric Wall Mounted Hanger Rack project presents an innovative solution for drying clothes in small spaces. It can support a maximum load of 20 kg and features a rivet nut joint mechanism for smooth movement. The retractable design maximizes space utilization, and the automatic electric controller enhances user convenience. With high-quality stainless-steel construction and battery backup, this project aims to provide a durable and reliable solution for drying clothes in Malaysia.

Keywords: Automatic Hanger Rack, Innovation Hanger Rack, Innovation

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1.INTRODUCTION

Technology has significantly transformed our daily lives, revolutionizing various aspects and providing us with tools and services that simplify and enhance our routines. From multi-functional devices like smartphones and smartwatches to advanced home appliances, technology has made our lives simpler, faster, safer, and more enjoyable. One such everyday household item that has seen remarkable advancements is the clothes rack.

Traditionally, when doing laundry, homeowners would hang clothes to dry on a rope with two fixed points. This manual method of drying clothes is time-consuming and often presents challenges for homeowners. However, with the introduction of clothes racks, the drying process has become more efficient and convenient.

A clothes rack provides a designated space for freshly washed clothes to dry. These racks are typically constructed with a combination of ropes and poles. A laundry line, whether set up outdoors or indoors, offers a convenient solution for suspending clothes above ground level. Clothes racks are available in various materials such as wood, steel, aluminium, and plastic, catering to different preferences and needs. They come in different sizes and configurations, including large stationary outdoor racks, folding portable racks, and wall-mounted clothes racks. However, the conventional manual wall-mounted hanger rack commonly used by homeowners has its limitations. Users often encounter issues, such as incompatible attachment components, causing difficulties when trying to pull in and out the suspension. Additionally, the attachments may rust over time due to metal-to-metal rubbing, further hampering the functionality of the hanger rack. Insufficient space on the clothes rack to hang clothes is another common challenge faced by homeowners. This lack of space poses an inconvenience when attempting to hang freshly washed clothes. Moreover, many homeowners struggle to reach the suspension due to height limitations, often requiring assistance from others. To address these limitations, this research study focuses on a study of the "Automatic Electric Wall-Mounted Hanger Rack." This innovative solution aims to revolutionize the clothes drying process by utilizing a Linear Actuator mechanism powered by electricity. The proposed hanger rack will be automated, providing users with enhanced convenience during the drying process. By exploring the implementation of an Automatic Electric Wall-Mounted Hanger Rack, this research aims to investigate the potential benefits, usability, and impact of such a solution in improving the clothes drying experience for homeowners. The study will assess factors such as efficiency, space optimization, ease of use, and the overall user experience. Through this study, we seek to shed light on the advantages and challenges associated with the adoption of an automated, electric-powered wall-mounted hanger rack. The findings will contribute to the development of more advanced and user-friendly solutions, paving the way for more streamlined and hassle-free clothes drying process in modern households. The presentation will reveal questionnaire results indicating product acceptance.
The objective for the study is as follows: -

i. To fabricate an automatic wall-mounted hanger that use linear actuator.
ii. To increase the maximum load of the hanger that can be accommodate up to 20 kg of weight.

2.METHODOLOGY

The research methodology for the study of the Automatic Electric Wall Mounted Hanger Rack encompasses several key components. Firstly, the fabrication technique involves the utilization of four distinct methods to construct the hanger rack. These techniques encompass the cutting process, where various tools are employed to eliminate excess material and shape the hanger rack according to the desired geometry. The drilling process follows, utilizing a rotating drill bit to create circular holes in solid materials, facilitating the assembly of the hanger rack. To enhance the hanger rack's properties such as hardness and anti-corrosion, the painting process involves the application of metal spray onto the prepared surface, ensuring a quality finish. Finally, the grinding process employs an abrasive wheel to remove material from the hanger rack, enabling precise forms and fine finishes. Together, these methodologies provide a comprehensive approach to constructing the Automatic Electric Wall Mounted Hanger Rack, showcasing the importance of fabrication techniques in its development. Following the assembly of the automatic electric wall mounted hanger rack, the study conducted an experiment to assess its sturdiness and ability to withstand maximum weight. The objective was to enhance the hanger's weight capacity to accommodate loads of up to 20 kg.

Table 1. Experiment Setup Parameter

Weight (Kg)	5Kg, 10Kg, 15Kg, 20Kg
Observe parameter	Rack Bend/Break

Product durability tests were conducted to assess its ability to withstand imposed loads. The study utilized a setup consisting of weights suspended on a rack. The experiment involved incrementally adding 5kg weights to the rack every 10 minutes, starting from 1 unit of 5kg weights, until reaching a total load of 20kg. The objective of testing the product's load-bearing capacity up to 20kg was successfully achieved, and further durability testing beyond this limit was not conducted.

3.RESULT AND DISCUSSION

Figure 1. Final Product Automatic Electric Wall Mounted Hanger Rack

Table 2. Test Result

Test	Load(Kg)	Sturdiness
1.	5	Pass
2.	10	Pass
3.	15	Pass
4.	20	Pass

Based on the additional information provided, a product durability test was conducted to assess the hanger rack's ability to withstand the applied load. The setup involves hanging a weight on a rack, and the experiment follows a specific procedure. The objective is to evaluate the load bearing capacity of the product up to 20 kg. The study used a systematic approach by incrementally adding 5 kg of weight to the rack every 10 minutes. It starts with 1 unit weighing 5 kg and continues to add weight until it reaches a total load of 20 kg. This step-by-step process allows evaluation of the performance and stiffness of hanger racks under increasing loads. The main objective of the test was successfully achieved, as the hanger rack demonstrated its ability to bear a specified load of 20 kg without failing or exhibiting significant issues. However, it is important to note that the durability test did not exceed this limit, meaning that the performance of the hanger rack under a load of more than 20 kg has not been evaluated. Considering these results, it can be concluded that the hanging rack has been tested and shown to have sufficient load-bearing capacity for weights up to 20 kg. Users can rely on hanging

racks to safely support items in this weight range, making them an ideal solution for hanging and storing a

variety of objects. However, it is important to consider other factors such as long-term durability, safety regulations and specific usage guidelines provided by the manufacturer when making a thorough assessment of the suitability of hanging racks for individual needs.

Figure 2. Testing with Wet Cloth (Weighed Accordingly)

Table 3. Material Costing

No	Component	Quantity	Retail Price	Overall Cost
1	Stainless Steel Rectange Hollow Galvanis	2 Pcs	RM40.00	RM80.00
2	Aluminium Round Hollow Tube	2 Pcs	RM6.00	RM12.00
3	Anchor Spray Paint (Black)	2 Pcs	RM8.00	RM16.00
4	Bolt And Nut	12 Sets	RM2.00	RM24.00
5	Self-Tapping Screw Philips Pan Round	4 Pcs	RM0.20	RM0.80
6	Linear Actuator Control Switch Relay	2 Unit	RM132.00	RM264.00
7	Wireless Remote Control Switch Relay	1 Unit	RM7.50	RM7.50
8	Receiver Module	1 Unit	RM13.20	RM13.20
9	Power Supply Adapter	1 Unit	RM13.00	RM13.00
Total				430.50

In research projects, various items have been acquired for experimental or research purposes. The cost schedule provides item details along with corresponding quantities and prices. This project requires the following materials; First, two pieces of Galvanized Rectange Hollow Galvanized Stainless Steel were purchased at a cost of RM40.00 a piece, resulting in a total cost of RM80.00 for the two pieces. These stainless steel pieces may be used for their specific properties and characteristics in research. In addition, two pieces of Aluminum Round Hollow Tube have been obtained, each costing RM6.00. The total cost for the aluminum tube amounts to RM12.00. Aluminum tubes may be chosen because of their light weight and other related properties.In order to provide research materials, two cans of Anchor Spray Paint in Black were purchased, with each can costing RM8.00. The total cost for a can of spray paint is RM16.00. Spray paint may be used for surface treatment or color coding purposes. In terms of fasteners, twelve Bolt And Nut sets have been obtained at a cost of RM2.00 per set. The total cost of the bolt and nut set is RM24.00. These fasteners may be used to secure or join components together in a research project. For installation purposes, four pieces of Self Tapping Screw Philips Pan Round have been obtained, each costing RM0.20. The total cost for this screw is RM0.80. Screws may be used to securely fasten or attach components during the assembly process. Furthermore, research projects require certain electronic components. A Linear Actuator Control Switch Relay was purchased, at a cost of RM264.00 for one unit. These components may be used for precise control or automation purposes in research setups. To enable the functionality of the remote control device, a Wireless Remote Control Switch Relay is obtained at a cost of RM7.50 for one unit. These devices are allowed for remote operation or control of certain aspects of research experiments. In addition, the Receiver Module was purchased at a cost of RM13.20 for one unit. This module may be used to receive and process signals or data in a research system. Finally, the Power Supply Adapter was obtained at a cost of RM13.00 for one unit. A power supply adapter may be used to provide the electrical power required for the research setup. Overall, the cost table provides a breakdown of materials and components used in the research project, along with quantities with a total cost of RM430.50.

These items have been carefully selected and obtained to support the objectives of the experiment and enable the successful implementation of the research.

4.CONCLUSION

In conclusion, the research project successfully achieved its objectives of fabricating an automatic wall-mounted hanger using a linear actuator as the driving mechanism. The implementation of the linear actuator

technology enables the hanger to operate automatically, providing users with convenience and usability, especially in emergency situations and unpredictable weather conditions.

Furthermore, the project successfully increased the hanger's maximum load capacity to 20 kg through careful design and engineering. This enhancement ensures that the hanger can securely support heavier items. The research also focused on developing an improved working joint mechanism for the hanger, resulting in enhanced stability and reliability during everyday use. Additionally, a retractable design was incorporated into the automatic electric wall-mounted hanger to optimize space utilization. Users can conveniently retract the hanger when not in use, creating more available space in their living areas.

Overall, this research project offers an affordable alternative for individuals seeking a reliable and cost-effective drying hanger solution. By utilizing readily available linear actuators, users can fabricate the hanger at a significantly lower cost compared to commercially available options. In summary, the research project successfully achieved its objectives of developing an automatic wall-mounted hanger with a linear actuator mechanism. The hanger's increased load capacity, improved joint mechanism, and retractable design make it a practical and space-efficient solution for affordable and reliable drying hanger needs.

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CASE STUDY OF INVERTER AIR CONDITIONING LOGIC DURING OVERCHARGE REFRIGERANT

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Abstract

Preventative maintenance is a vital process for all mechanical machines. Known as routine or scheduled maintenance, it can be derived as a servicing and inspection activity aimed to prevent equipment from malfunction. It is a critical process because it prevents any machines from facing a breakdown which will cause an operation interruption and disturbance. For residential air conditioning systems, routine maintenance must be performed based on the usage frequency where a higher usage means an increase in maintenance activity. There are several air conditioner system parameters that need to be monitored during the maintenance activity which include refrigerant charge pressure (psi), operation current (amp), voltage (V), indoor unit supply and return temperature (°C). However, for an inverter air conditioner, there are two additional parameters need to be considered which are temperature of the compressor (°C) and expansion valve opening frequency which is measured in pulse units (pls). However, these additional two parameters often been neglected which cause an overcharge of refrigerant level during an inverter air conditioner system maintenance activity. An overcharged refrigerant in an air conditioning system will cause a drop-in cooling capacity, increase energy consumption, and shorten the lifespan of the equipment. Main objective for this study is to observe parameter changes that occur on inverter air conditioners during an overcharge refrigerant state. The observed parameter includes compressor discharge temperature, expansion valve opening and compressor frequency. Finding a suitable air conditioner capacity done prior to the experiment starts by calculating the cooling load requirements for the experiment area. Once the cooling load is determined, the installation of an R32 inverter air conditioner takes place and observation for overcharge refrigerant data is recorded. During the experiment, the refrigerant is being pump into the system starting from 100% capacity until 140% capacity with 10% increment for each charge level. The average recorded data and the differences between each refrigerant charge level is calculated to determine the percentage change for all three parameters considered in this study. Based on this study, a 10% increase of refrigerant level in the system will cause a compressor discharge temperature to be reduce by 12%, a 32% reduced in refrigerant flow due to the closure of the expansion valve and the compressor frequency drops by 17%.

Keywords: Overcharge Refrigerant, Inverter Air Conditioning, Maintenance

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1.INTRODUCTION

Nowadays, air conditioning system is widely used in residential, commercial, and industrial buildings as a means of treating air and to maintain and establish the require temperature (hot or cold), humidity (wet or dry), cleanliness and air motion in the building (Edward G. Pita-3rd ed., 1998). There are various type of air conditioner and the most popular among it is a split type air conditioner unit which is commonly used in residential building due to its simplicity and flexibility (M. A. S. S. A. Nada, 2017). However, due to its popularity, air conditioner has become one of the major electrical consumption appliances where it accounts of more than 50% of energy usage for a common household (Y. H. Jiangyan Liu Juanxin Chen, 2016). Since air conditioner has a high energy consumption among the household equipment (Mohsen Farzad, 1990), inverter air conditioner system was invented and introduced to reduce the energy usage for up to 40% by regulating the compressor motor speed based on room load demand. Most inverter air conditioners in Malaysia have a 4 to 5-star rating, as mandated by Suruhanjaya Tenaga's guidelines. All air conditioners sold in Malaysia must meet a minimum 2-star rating for energy performance standards (MEPS), (Guide on Minimum Energy Performance Standard Requirements for Air Conditioner with Cooling Capacity ≤ 7.1kW, 2018). Residential inverter and non-inverter air conditioners share the same main components, but inverter units have an extra feature to conserve the energy consumption. An inverter air conditioner is equipped with a special equipment which gradually adjust the compressor speed when the system reaches the desired temperature. In contrast, a non-inverter unit force the compressor to turn off abruptly. As a result, a non-inverter air conditioner consuming more power to restart the compressor. Purchasing cost of inverter air conditioner system is slightly higher compared to non-inverter unit due to several additional components such as intelligent sensor, outdoor printed circuit board (PCB), electronic expansion valve and multispeed compressor. However, the return on investment (ROI) can still be achieved by reduced electric consumption done by the inverter unit. Besides, inverter air conditioner type is preferred by mass consumer is due to its capability of maintaining the room temperature effectively and has a lower compressor sound level.

In order to achieve the ROI for inverter air conditioner system a proper routine maintenance need to be conducted. There are various activities involved during an air conditioning system maintenance and one of it is to monitor the refrigerant charge level. This monitoring activity is importance because having an over-charge or under-charge level of refrigerant in air conditioning system will cause a reduction of 20% in efficiency compared to proper refrigerant level (Proctor,1996). Besides that, the efficiency of air conditioner system operate with improper charge will deteriorate from 10% to 20% (Downey and Proctor, 2002). Furthermore, according to research conduct by (Mohd Hazwan Yusof, 2018), overcharged of 20% refrigerant in air conditioning system will drop the cooling capacity up to 11.4% and coefficient of performance 16.4% respectively. According to Zhao Yuqing (2018), excess refrigerant will lead to an excessive of liquid inside the condenser. As a result, it will reduce the effectiveness of heat transfer area which lead to condensing temperature and pressure ratio to rise. Thus, the compressor will consume more power and the cooling efficiency and Coefficient of Performance (COP) will decrease. Even though monitoring the refrigerant charge level is an essential process during air conditioning system maintenance, this step is still being neglected. During the maintenance process, most of the air conditioner technician will usually pump in the refrigerant into the air conditioning system without emptying the trapped air and moisture inside the air conditioning component and piping route. As a result, the air conditioning system will produce an incorrect refrigerant pressure reading (psi), incorrect operation current reading (amp) and ultimately will shorten the lifespan of system. Furthermore, the operation of air conditioning system without going through the vacuuming process will reduce the cooling capacity, contaminate the compressor oil, and leads to corrosion of air conditioning components.

As a counter measure, Department of Environment under Malaysian Ministry of Natural Resources, Environment and Climate Change has developed a training manual and Standard Operating Procedure (SOP) for air conditioning technician to cater this issue. According to the training manual, the air and moisture must be pump out from the refrigerant line (500 microns for HCFC and 200 microns for HFC) by using a vacuum pump before inserting the refrigerant into the air conditioning system. In addition, air conditioner manufacturer also provides an installation guideline on refrigerant pre-charge level for newly installed air conditioner split unit type which cater a piping system with length up to 7.5 metres. For a piping system that exceed the pre-charge length, an additional refrigerant is required and must be measured using a weighting scale to avoid over filling. The air conditioning performance is linked directly with refrigerant charge level in the system (H. M.-

T. F. Poggi D. Leducq, 2008). Therefore, this study will observe the effect to the air conditioning system by observing the parameter of compressor discharge temperature, expansion valve opening and operation current for inverter air conditioning unit during over-charge refrigerant level from 100% to 140%. These parameters were selected because it is unique to inverter air conditioner where it is equipped with specialized equipment such as discharge temperature sensor and electronic expansion valve. A lack of these equipment in non-inverter air conditioner hinders it from be use for the study. Additionally, the aim of this study is to investigate the correlation between these three parameters with the energy consumption level. The result of air conditioning parameter observe will be tabulate in table and presented for references.

The objective for this study as below:

a. To study the logic for compressor discharge temperature, expansion valve opening and compressor frequency for residential inverter air conditioner system while operated in overcharge refrigerant level.

b. To tabulate new table of data that presented inverter data parameter during overcharge for troubleshooting guidance at site and also for teaching and learning references.

2.METHODOLOGY

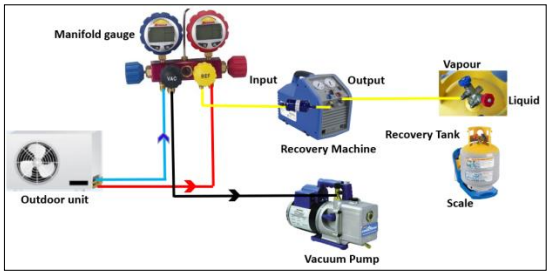

Figure 1. Recovery refrigerant setup

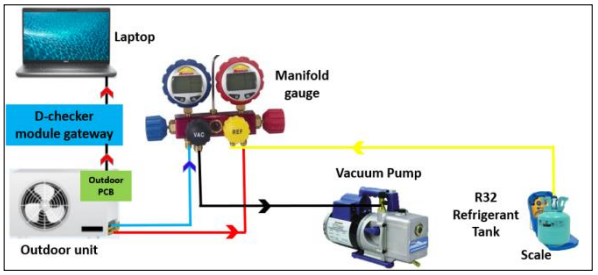

Figure 2. Refrigerant charging setup

The experiment was setup by using R32 inverter split unit air conditioner type, together with others relevant accessories and equipment as shown in figure 1 and figure 2. The study was performed by regulating the refrigerant charge level from 100% until 140% within 15 minutes. Air Conditioning & Refrigeration Institute (ARI) 210/240 standard is being applied during conducting this experiment (A.-C. & R. I. (ARI), Stand. 210/240, 2006). Prior to the experiment start, the cooling capacity requirement for the experiment's location (Metallurgy Laboratories, Politeknik Kuching Sarawak, Malaysia) was determined by using the following calculation:

Rule of thumb = Width (W) x Length (L) x Coefficient for laboratories
= 10ft x 12ft x 75btu/hr/ft2
= 9000Btu/hr @ 2.63kW

As a cooling load required for the laboratory is 9,000Btu/hr (2.63kW), the 9,100Btu/hr (2.67kW) inverter split unit air conditioner (model 2019) is selected and installed for this study. The air conditioner is using R32 refrigerant as the working refrigerant. D-checker module input wire is connected to outdoor printed circuit board (PCB) at outdoor unit of air conditioner and input wire was connected to the laptop for data collection. As shown in Figure 1, in order to get an accurate data, all the refrigerants, air and moisture inside the air conditioner system components and pipelines were pumped out using recovery machine and vacuum pump until it reaches 200 microns as R32 is an HFC refrigerant type. As shown in Figure 2, by referring to manufacturer standard, 0.55kg of new R32 refrigerant will be charged into the air conditioner system while being monitored by using weighting scale and manifold gauge. In this study, five different refrigerant charges level will be tested, and three fixed parameter setting is being used as shown in Table 1:

Table 1. Experiment setup parameter

Refrigerant charge (%)	100, 110, 120, 130, 140
Observe parameter	1. Compressor discharge temperature (°C) 2. Expansion valve opening (pls) 3. Compressor frequency (rps)
Temperature setting (°C)	24
Fan mode	High
Outdoor air temperature (°C)	30

3.RESULT AND DISCUSSION

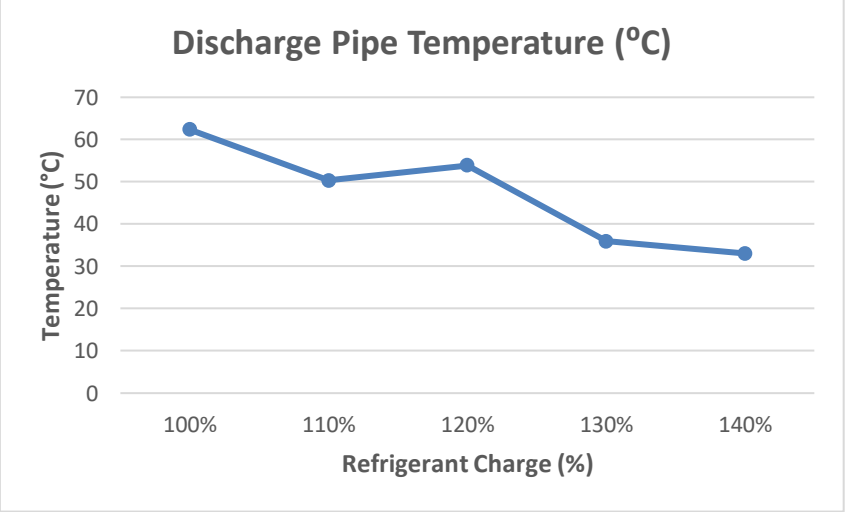

Figure 3. Compressor discharge temperature (°C) data

Figure 3 shows the average data of compressor discharge temperature (°C) in a duration of 15 minutes. The compressor discharge thermistor was located at the compressor outlet line approximately 5 cm from the compressor housing. Based on the observation, the initial temperature recorded is 62°C where it is on the optimum refrigerant charge level. The temperature keeps decreasing when the refrigerant charge level is increase by 10% until it reaches a value of 140%. At this level, the temperature is reduced by 46.77% with a temperature value of 33°C. Normal operating temperature for the compressor is between 60°C to 70°C. This descending temperature reading occur due to increase in refrigerant flow through the compressor. During the air conditioner system operation, the increase in refrigerant flow will result in excessive refrigerant. This excessive refrigerant will not be transformed into vapor phase during evaporation stage, thus it remains in liquid form. This liquid form will enter the compressor and consequently will affect the compressor suction valve function.

This negative affect from this experiment is expected as according to (Woohyun Kim, 2010), the overcharge refrigerant will reduce air conditioner lifespan, capacity for cooling or heating and overall efficiency. The increase in refrigerant volume will also reduce the superheating process in the evaporator (John Houcek, 1984). Next, based on study conducted by (John Houcek, 1984), the overcharge refrigerant will cause a slugging, motor overheating and liquid flood back which reduce oil dilution and lubrication of the components in compressor. In addition, the situation will become worse if the outdoor temperature is low and no routine maintenance is performed. Plus, liquid compression may also transpire if the capacity of air conditioner is larger than a required capacity

To counter this issue, modern residential air conditioner is equipped with accumulator at the compressor inlet that act as a temporary storage for refrigerant and to separate the liquid and vapour refrigerant. However, in

this experiment, it still unable to cater the excessive volume of refrigerant which indicate inserting excessive amount of refrigerant into the air conditioner is not recommended.

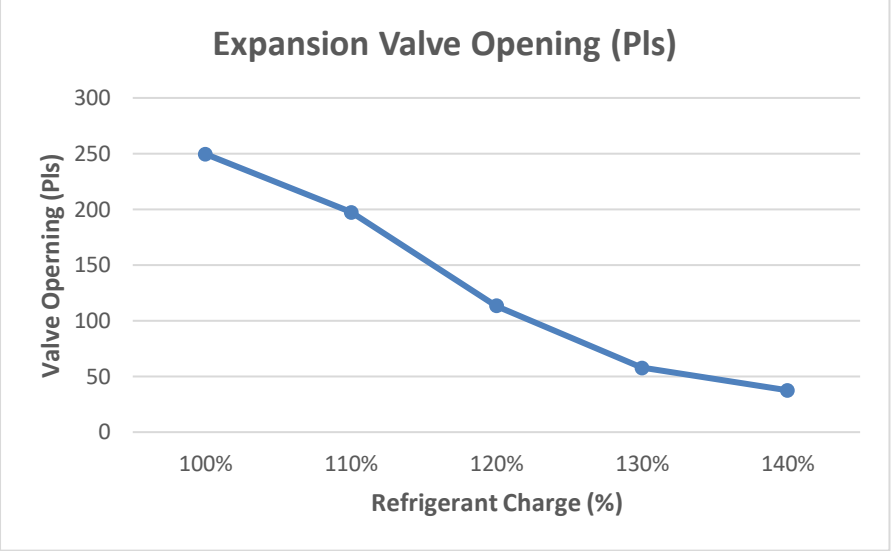

Figure 4. Expansion valve opening (Pls) data

Figure 4 shows the effect of overcharge refrigerant on the expansion valve opening pulse value (pls). As illustrated in figure above, the expansion valve pulse value (pls) shows a declining trend as the quantity of refrigerant increase. At the optimum refrigerant level (100%) setting, the expansion valve opening pulse value (pls) is at the peak with a value of 250 pls while during the highest refrigerant level (140%) setting, the pulse value drops significantly by 84.8% with just 38 pls. An increase of 10% of the refrigerant volume into a system will reduce the valve opening approximately by 50-60 pls. There are also a correlation between compressor discharge temperature with the expansion valve opening pulse value, where the value of compressor temperature is directly proportional with expansion valve value. At 100% charge setting, the compressor temperature was at 62ºC with a greater valve opening value (250 pls) and at 33ºC compressor discharge, the opening of the expansion valve is 38 pls. This phenomenon occurs because expansion valve is adjusting its opening to match the target temperature and the actual discharge temperature.

Beside over charging the refrigerant level, there are other factor that contribute in a reduce value of expansion valve opening. Improper maintenance on the interior air filter and evaporator, over-sizing capacity of the air conditioner and faulty procedure during the air conditioner installation also contribute to the decrease value of expansion valve opening. Furthermore, if this condition is still continuing to exist, it will reduce the superheat value in which will reduce the lifespan of the compressor due to liquid compression phenomenon.

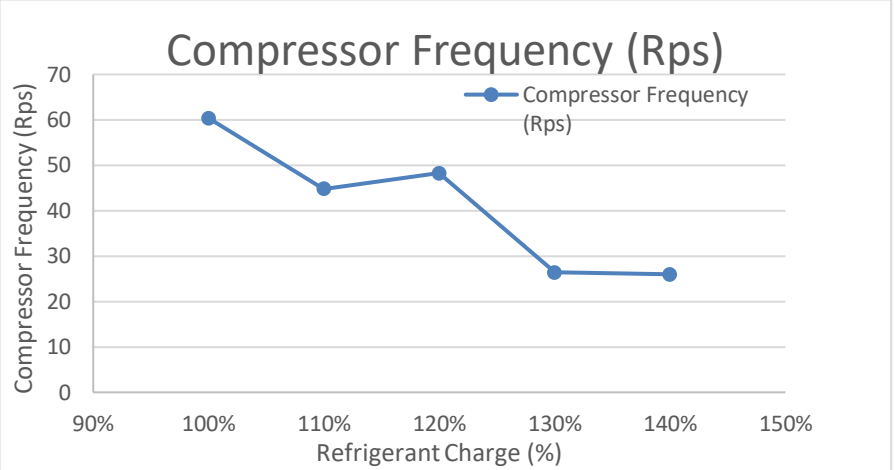

Figure 5. Compressor frequency (Rps) and temperature difference data

Figure 5 illustrate the value of compressor frequency (rps) recorded within 15 minutes for multiple refrigerant

charge level. The lowest frequency recorded is at 26rps where refrigerant charge level was at 140%. The compressor frequency value will drop due to increase in pressure in the air conditioning system. During refrigerant overcharge condition, the liquid refrigerant is not vaporized completely by the evaporator. Therefore, the air conditioner system is forced to operate in wet mode, where the liquid refrigerant flows through the compressor suction and damages the compressor valve.

During the experiment observation, the frequency of the compressor was automatically adjusted according to the temperature differences between ambient temperature and the temperature set by the user. In other word, bigger temperature gap between ambient temperature and the set temperature will result in higher compressor frequency value and it is applicable vice versa. In addition, the same phenomena as overload refrigerant conditions also occur when there is insufficient condensation occur in the condenser, a malfunction expansion valve and a reduction of the heat load inside a room.

4.CONCLUSION

The current research focuses on determining the value of three different parameters of the split unit inverter system. These data can provide some information to the air conditioner technician on air conditioner characteristic during overcharge refrigerant and could be act as a guidance for troubleshooting work on the inverter system. Increasing and decreasing of refrigerant charge will give impact on the reading for each component. The summary for this case study is tabulated in Table 2. As per the data in Table 2, an elevation in the refrigerant charge level results in a roughly 17% reduction in compressor frequency, primarily due to heightened workload. Additionally, the expansion valve exhibits a tendency to close by as much as 32% owing to the decrease in discharge pipe temperature. Furthermore, a 12% drop in compressor temperature leads to the closure of the expansion valve. Consequently, the air conditioner may not be able to deliver its intended cooling capacity and may struggle to reach the desired temperature setting. According to Farzad. M (1991), the air conditioner performance will decrease due to increase of compressor work.

Table 2. Case study summary

Refrigerant Charge (%)	Compressor discharge temperature (^{o}C)	Expansion Valve Opening (pls)	Compressor (rps)
100	62	250	60
110	50	198	45

120	54	113	48
130	36	58	26
140	33	38	26

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SELF RISING FLAG MACHINE

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Abstract

This paper presents a motorized flag-raising and lowering device that can be used in different settings such as public spaces, governmental buildings, and private residences. The device has a hollow flagpole with a storage compartment and a side exit port, a pulley at the top, and a drive wheel at the bottom. The flag is connected to the motorized assembly by a continuous halyard that runs through the pulley and the drive wheel. A reversible motor is housed in the assembly, which can be activated to lower the flag into the storage compartment and raise it for display. The device offers easy flag maintenance, adjustable speed rate, and reduced twisting of the flag strap. The research aims to solve the problems encountered during official flag assemblies in Malaysian schools, including the absence of students on duty, the flag not reaching the top of the flagpole, and twisting of the flag rope. To address this complex problem, a self-rising flag machine was created using a combination of simple machines such as polycarbonate, PVC, and remote-controlled car motors. The machine is portable, user-friendly, and can be easily controlled by a remote controller, reducing the time taken to prepare the flag during the assembly. Although the self-rising flag machine was initially designed for use in schools, it has the potential to be used in various settings, enhancing aesthetics, and providing convenience and safety features for flag maintenance. However, the machine has a limitation that it cannot be controlled at more than 20 meters from the machine, and the tension of the flag rope should be neither too tight nor too loose. Overall, this research offers a practical solution to the challenges faced during flag-raising ceremonies in different settings.

Keywords: Self-Rising, Motorized Flag-Raising, Machines

1.INTRODUCTION

The traditional method of raising and lowering flags on flagpoles is to do it manually. This requires someone to go under the flagpole, hold onto it, and then pull it down to raise or lower the flag. This can be a difficult and time-consuming task, especially if the flagpole is tall or located in a difficult-to-access area. In Malaysia, schools are required to hold a daily assembly for 30 minutes. During the assembly, students sing the state anthem, school anthem, and national anthem. An invigilator is responsible for raising the flag manually. Researchers have found that there are several problems with the current method of raising the flag. An automatic flag raising and lowering device. In this device, the flag moves inside a tube that is located outside the flagpole. The flag is attached to a sleeve-like part that is lowered into a space between the tube at the bottom of the pole and the pole. This equipment is also not suitable for use with old flagpoles. Another disadvantage of this construction is that the tube that is attached around the flagpole is only supported at its lower end. This type of support is not very durable. Sometimes, the student on duty is absent or sick. Other times, the flag does not reach the top of the flagpole before the song is finished. In addition, the flag can sometimes become twisted when it is raised. This requires the invigilator to tie the flag to the flagpole after the assembly is over. These problems can disrupt the assembly and make it difficult to show respect for the flag. To address these problems, researchers have developed a new flagpole that uses a combination of simple machines to raise and lower the flag automatically. A new method called the self-rising flag method makes it easier and faster to raise and lower flags. This method uses a motorized system that automatically raises and lowers the flag at a set time. This system is easy to use and can be operated by anyone, regardless of age or strength. The self-rising flag method

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has several advantages over the traditional method. It is faster, easier, and requires less manpower. It is also more weatherproof, as the flag is not exposed to the elements when it is being raised or lowered. This can help to prolong the life of the flag. The self-rising flag method is a great way to make raising and lowering flags easier and more efficient. It is a valuable tool for schools, businesses, and government organizations that want to show their patriotism and respect for their country.

Here are some additional benefits of using the self-rising flag method:

- It can help to improve safety by reducing the risk of falls from ladders or other elevated surfaces.
- It can help to protect the flag from damage by the elements.
- It can help to save time and money by eliminating the need to hire someone to raise and lower the flag manually.

This invention relates to flagpoles, and more specifically to a flagpole with a motorized, remote-controlled system for raising and lowering the flag. The system includes a motorized pulley at the bottom of the flagpole that is operated by a remote control. The pulley is connected to a cable that runs up the inside of the flagpole and exits through a closable hatch at the top. The flag is attached to the cable and is raised and lowered by the pulley. When the flag is lowered, the cycle is reversed, and the flag is pulled into the flagpole through the closable hatch. The flagpole can also be equipped with sensors that detect inclement weather. When the sensors detect inclement weather, the flag is automatically lowered. There are other flagpoles that can be raised and lowered automatically, but they are not as suitable for the purposes of this invention. Currently, there are a few inventions available in the market that allow for the automatic raising and lowering of flags on flagpoles. The inventive disclosures described herein provide an electrically operated apparatus that can be used to raise a flag on a flagpole for display and then lower it into a storage box for safekeeping (United State of America Patent No. US 2008/0121167 Al, 2008). The disclosed apparatus allows these steps to be performed using electrically operated mechanisms. The apparatus can be operated remotely, such as from inside a home or office, which makes raising and lowering the flag much easier.

Here are some of the benefits of using an electrically operated apparatus for raising and lowering flags:

- It can save time and effort, as you no longer must manually raise and lower the flag.
- It can help to protect the flag from damage, as it is not exposed to the elements when it is being raised or lowered.
- It can help to improve safety, as there is no risk of falling from a ladder or other elevated surface when raising or lowering the flag.
- It can help to improve visibility, as the flag can be raised and lowered at the touch of a button.

For example, other flagpoles may not be as reliable or as easy to use. Additionally, other flagpoles may not be

as safe for the flag. The flagpole of this invention is reliable, easy to use, and safe for the flag. It is a valuable tool for schools, businesses, and government organizations that want to show respect for their country's flag. The new flagpole uses a pulley system to lift the flag. The pulley system is powered by a small electric motor. The motor is controlled by a timer, which ensures that the flag is raised and lowered at the correct times. The new flagpole has several advantages over the old method of raising the flag. It is more reliable, as it does not rely on a student to be present. It is also more efficient, as it takes less time to raise and lower the flag. Finally, it is more respectful of the flag, as it does not require the flag to be tied to the flagpole after the assembly is over. The new flagpole is a valuable tool for schools that want to show respect for their country's flag. It is a reliable, efficient, and respectful way to raise and lower the flag. This study aims to design and fabricate a self-rising flag machine.

2.METHODOLOGY

The main goal of this study is to design and build a machine that can raise a flag using a remote control to minimize flag rope twisting while raising the flag. The twisting of the flag rope is a common problem that occurs when raising a flag manually. This can be caused by several factors, including the wind, the weight of the flag, and the way the flag is being raised. The twisting of the flag rope can damage the flag and make it difficult to lower the flag. The machine that will be designed and built in this study will use a remote control to raise the flag. This will allow the user to raise the flag slowly and carefully, which will help to prevent the flag rope from twisting. This will prevent the user from over-extending the flag rope, which can also cause it to

twist. The machine that will be designed and built in this study will help to reduce the twisting of the flag rope and protect the flag from damage. This will make it easier and safer to raise and lower the flag. The method of producing the machine is divided into designing of the machine, fabrication of the body and pulley, and the remote-control car was modified to create the motor for a self-rising flag.

2.1.Designing

The first step in creating a self-rising flag machine is to design the body and the look of the machine using Autodesk Inventor 2021 software. Several sketches are developed, and the final design is finalized as shown in the figure below. Once the 3D model is complete, it can be analysed to ensure that it is structurally sound. This can be done using the FEA (finite element analysis) tools in Autodesk Inventor 2021.

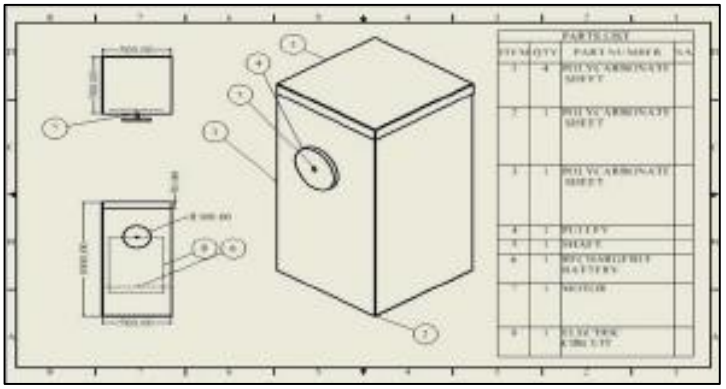

Figure 1. Design of the body using Autodesk Inventor 2021

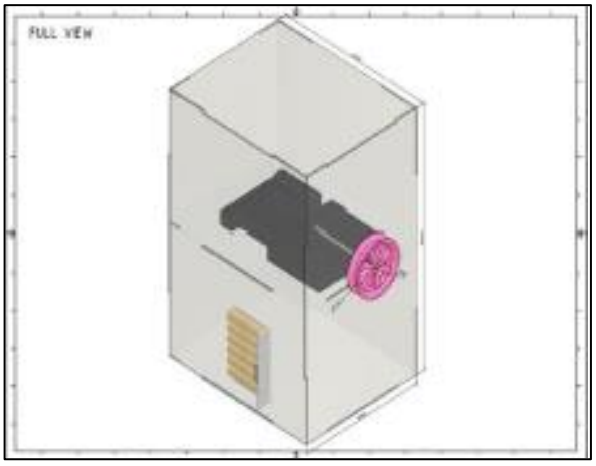

Figure 2. Assembly view of the final design

2.2.Fabrication

Acrylic sheets with a thickness of 2mm are measured before being cut to form a housing for the flag machine. The housing has four sides: two sides that are 200mm long and 300mm high, and two sides that are 160mm long and 300mm high. The following are the measurements for each side of the housing:

- Left side: 200mm x 300mm
- Right side: 200mm x 300mm
- Front side: 160mm x 300mm
- Back side: 160mm x 300mm

The acrylic sheets are placed on the laser cutting machine. The measurements for the housing are set using a computer and transferred to the laser cutting machine using a pen drive. The laser cutting machine then cuts the acrylic sheets to size. The laser cutting machine uses a high-powered laser to cut through the acrylic sheets.

The laser beam is guided by a computer, which ensures that the cuts are made accurately. Once the acrylic sheets are cut to size, they can be assembled to form the housing for the flag machine. The housing will protect the flag machine from the elements and keep it safe from damage.

Figure 3. Process of cutting acrylic sheet using laser.

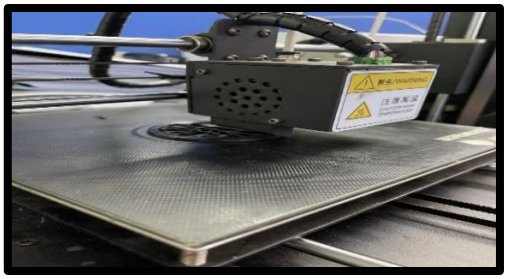

Figure 4. Process of printing the pulley using 3D printer

Figure 5. Pulley printed by 3D Printer.

The pulley is an important part of the flag machine. It is a simple machine that is used to raise and lower the flag. The pulley is made of PLA filament and is 3cm in size. The pulley will be combined with the body part and other components to create a fully functioning flag machine. Then, the remote-control car was modified to create the motor for a self-rising flag. The remote-control car was originally used to power a small car. The modified remote-control was then used to power a flagpole.

3.RESULT AND DISCUSSION

Figure 4. Final product

Figure 5. The assembled pulley

Figure 4 shows the final design of the self-rising flag machine. The machine is made of acrylic and has a simple, modern design. The machine is easy to use and can be raised and lowered with the remote control. The flagpole is now able to raise and lower the flag automatically. The modification of the control car engine to create the

motor for a self-rising flag is a significant improvement over the traditional method of raising and lowering flags. The traditional method of raising and lowering flags requires someone to manually pull on a rope or chain. This can be difficult and time-consuming, especially if the flagpole is tall. The self-rising flag system is much easier to use. The self-rising flag system is a valuable tool for schools, businesses, and government organizations. It is a reliable, efficient, and respectful way to raise and lower flags.

During testing, the project objectives were successfully achieved. Firstly, the fabrication of the project can be deemed a success as the machine functions as expected. Secondly, during testing, the rope remained untangled due to the effective operation of the pulley system, which ensured its straight alignment. One strength test was conducted on this machine by excluding the use of the flag rope. During the test, certain deficiencies was identified in the machine and subsequently altered the machine's circuit design. The revised concept involves dividing the machine's circuit into two parts: placing the battery below and the motor above. This arrangement allows for the inclusion of a pulley system to raise the flag.

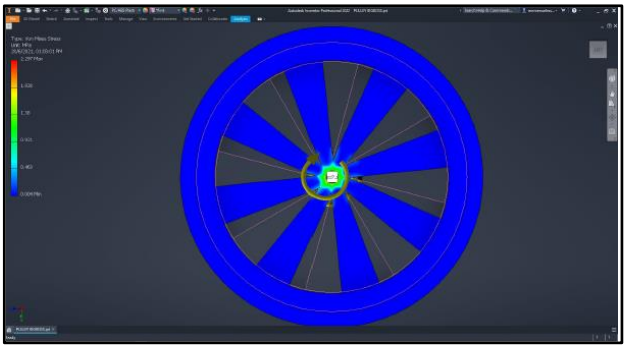

Figure 6. Stress simulation using FEA

Based on the stress simulation conducted, it was determined that the pulley can withstand a maximum stress of 2.297 MPa before experiencing deformation. In the context of the project, this pulley can be utilized since the load exerted by the flag is only 0.2 Pa. Therefore, whether it can withstand the load will depend on the circuit design.

The inclusion of cost management is crucial for the project, as it allows for the comparison of progress and actual expenses with the allocated budget. Table 1 displays the actual cost of the self-rising flag machine. The affordability of this machine is evident through the percentage of the cost incurred, highlighting its low-cost nature.

Table 1. Actual Cost

ITEM	QUANTITY	PRICE PER UNIT (RM)	AMOUNT (RM)
Acrylic hinges (45 mm)	2 pcs	4.50	9
Acrylic lock pad (A)	2 pcs	6.00	12
Acrylic sheet (Clear) (2.0mmX4'X6')	1 sheet	100	100
Remote control car	1 pc	95	95
Filament (PLA)	1 pc (1kg)	65	65
Super glue	4 pcs	1.50	6
Multi-purpose silicon sealant	1 pc	9	9

Flag strap (10m)	1pc	12	12
TOTAL		**RM 308**	

4.CONCLUSION

The self-rising flag machine offers convenient flag-raising and lowering capabilities, adjustable speed options, user comfort, and labour-saving advantages. Researchers have utilized simple materials like polycarbonate, PVC, and remote-control car motors to develop innovative applications that leverage knowledge of both simple and complex machines. The school highly recommends the use of self-rising flag machines for teachers and students. These machines incorporate a flag timer mechanism operated via remote control, supported by a battery-powered control car motor. They are designed to be portable, moderately sized, and user-friendly.

One significant benefit of the self-rising flag machine is its ability to minimize twisting of the flag strap. Additionally, it assists in reducing the time required for flag preparation during assembly. It is important to ensure that the rope is neither too tight nor too loose on the pulley. An excessively tight rope may cause the motor to automatically shut off due to the heavy load, resulting in overheating and potential circuit damage. On the other hand, a loose rope may not provide sufficient grip.

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THE STUDY OF HYDROXYAPATITE IN CLAMSHELL TO ENHANCE THE QUALITY OF BRICKS

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Abstract

This study is to add hydroxyapatite in clamshell as an additive inside the concrete brick. The objective of this study is to determine that hydroxyapatite can help to produce better quality concrete bricks in terms of its strength and infiltration rate. The scope of research for these projects is the strength of the bricks and the infiltration rate after adding Hydroxyapatite, a comparison between burnt brick and brick that contain Hydroxyapatite which produces without burning it, the synthesis of calcium carbonate to calcium phosphate and the characteristic of the shell. The ratio of Hydroxyapatite in making a complete brick is 1:2:4:1. The ratio of cement, sand, aggregate, and water is fixed so that the product will not be disturbed by other mixtures while the ratio of Hydroxyapatite changed on each mold where mixture A 100 g HAp, B 200g HAp, C 300g HAp. It can be seen that bricks that contain HAp slurry in the range of 100g of HAp have a lower infiltration rate than concrete brick points that do not contain HAp while in terms of strength, bricks that contain HAp slurry have lower strength compared to the control brick point, but still within the target strength which in range of 43.94 N/mm².

Keywords: Concrete Bricks, Hydroxyapatite, Clamshell, Strength, Additive

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1.INTRODUCTION

This study is to add hydroxyapatite, which is in clamshells as an additive inside concrete blocks. The addition of this material is to test whether it can increase the strength of the concrete block. This is because concrete bricks have low compression strength and tend to be of low quality. While these bricks can be used for fences and internal brickwork to their minimal maintenance requirements, noise reductions, and heat resistance qualities. Concrete brick is not always readily accepted in some parts of the industry, so adding Hydroxyapatite to the ingredient of concrete brick will help to expand the range of use of concrete brick. The higher cost of concrete brick production can be reduced by replacing the ratio of cement with hydroxyapatite slurry and no heating is needed. There are a lot of waste shells that can be found at the beach or landfill. Waste shells can be utilized by using it in the production of bricks.

The aim of this study is to determine that Hydroxyapatite can help to produce better quality concrete bricks. Besides to produce unburned brick using Hydroxyapatite slurry as an additive and help to reduce cost production and environmental protection purpose also help to manage the shell waste disposal wisely.

The scope involved in this work is the strength of the concrete bricks after adding Hydroxyapatite slurry, infiltration rate after Hydroxyapatite slurry is added, comparison between burnt brick and unburnt bricks, synthesis of Hydroxyapatite slurry, the characteristic of the shell used in this study.

2.SUMMARY LITERATURE REVIEW

The shell has a calcium carbonate (CaCo3) the nature of that just as lime makes it suitable for use in construction where if shells are mixed into the brick mix, it can increase the strength in the mixture. The CaCO3 helps to increase the early strength, due to the accelerator effect and high rate of hydration which hardens the concrete quicker. At matured age, the concrete with the CaCO3 addition exhibits lower strength as compared with concrete without CaCO3, but still within the target strength. Brick is one of the most durable construction materials available. They are a low-maintenance option for most types of buildings, but they are susceptible to extreme weather conditions. Building with bricks is also time-consuming and labor-intensive. Bricks are incredibly strong; known as a load-bearing material they can fully support a building. Hydroxyapatite (HAp) is a kind of bioceramic-based material that has been used extensively in many medical applications. Owing to nearly similar mineral contents to natural bone, the material has been accepted as an implant to improve osteointegration with the bone tissue. In this work, an alternative processing route from waste materials, namely clamshell in producing HAp powder is presented.

2.1.Synthesis of Hydroxyapatite

Materials containing calcium carbonate (CaCo3) can be used to produce calcium phosphate (Ca (PO4)2) can be found in clamshells. The chemical precipitation method can be used to produce calcium phosphate by reacting calcium carbonate with phosphoric acid.

Chemical Precipitation Method

$$CaCO_3 \rightarrow CaO$$

The clamshell powder which is calcium carbonate (CaCo3) is then oxidized for 3 hours to remove organic matter and turned it into calcium oxide (CaO).

$$CaO + H_2O \rightarrow Ca(OH)_2$$

The powder is mixed with distilled water to transform it into calcium hydroxide (Ca (OH)2).

$$Ca(OH)_2 + H_3PO_4 \rightarrow CaO\ (PO_4)(OH) + H_2O$$

Phosphoric acid (H3PO4) was added little by little into the calcium hydroxide (Ca (OH)2) slurry and stirred until it reached the pH range which is between 6.5 and 8.5 to produce hydroxyapatite (HAp)

3.METHODOLOGY

3.1.Process flow for synthesis CaCO3 to CaO

The process flow below explains the process for the synthesis of Calcium Carbonate to Calcium Oxide for this project. The Calcium Carbonate is gained from the clamshell and we synthesize this calcium carbonate into Calcium Oxide by heating the clamshell for 3 hours at a temperature 900 degrees Celsius. The heating process remove the organic matter and turned it into Calcium Oxide. Together we attach the picture of the process flows as an illustration.

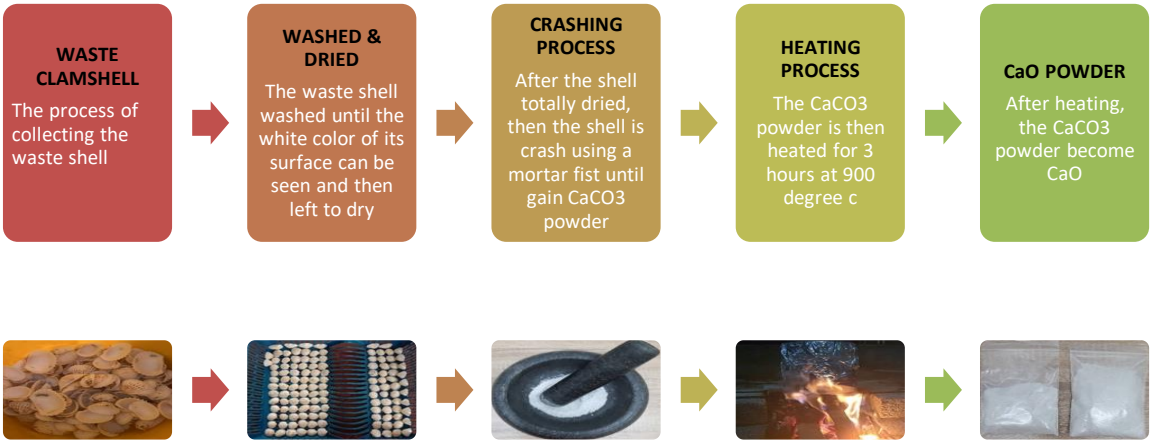

Figure 1. Process flow for synthesis CaCO3 to CaO

3.2.Process flow for synthesis of Hydroxyapatite slurry

Process flow below explain about the process flow for synthesis of the Calcium Oxide to Hydroxyapatite slurry.

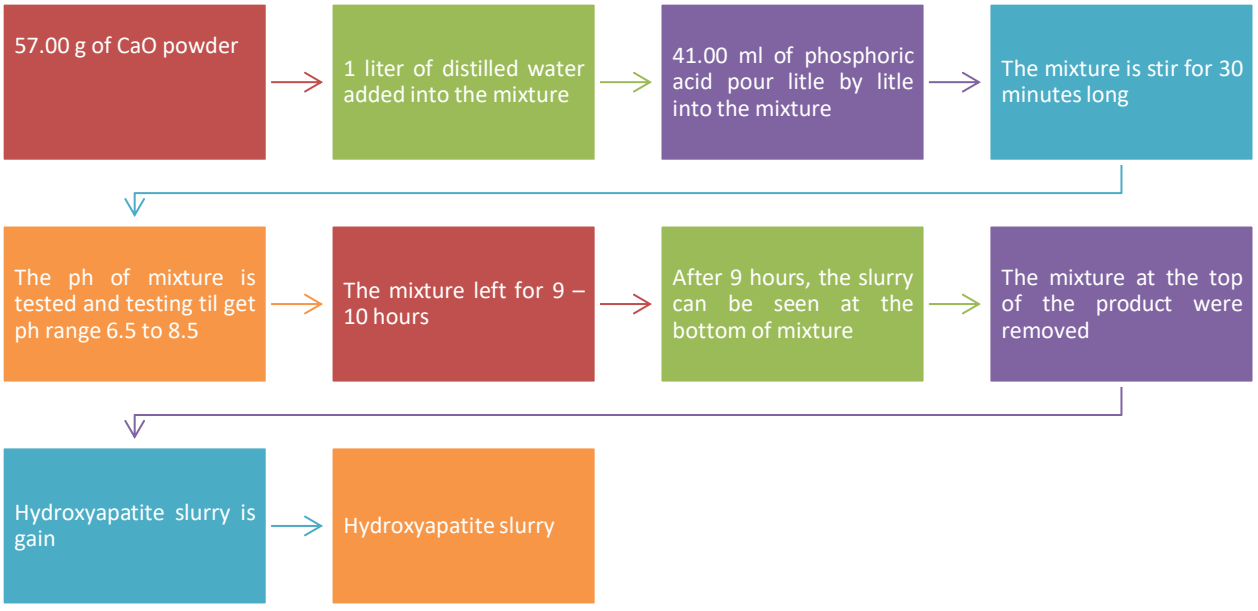

Figure 2. Process flow for synthesis of Hydroxyapatite slurry

3.3.Process for Concrete Brick Gred 20P

Process flow below explain about the process flow for process of Concrete Brick Gred 20P. This gred of brick are used in this study while this gred also is a industrial gred uses.

This study follows the standard dimension of industrial brick and ratio of brick gred 20P. We produce 3 sample of brick with standard dimension and ratio of water, sand, cement, aggregate and we added Hydroxyapatite as an additive with different ratio in each sample. This is to do the analysis on the bricks.

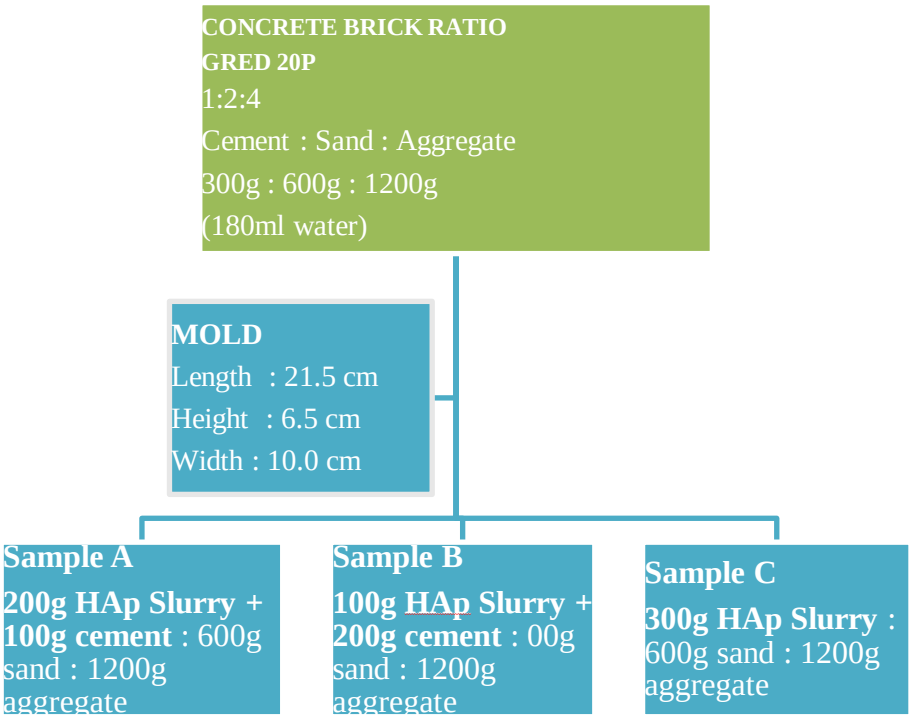

Figure 3. Process for Concrete Brick Gred 20P

4.RESULT & DISCUSSION

4.1.Strength Testing

For the scope of strength, we are producing 7 concrete brick blocks in total whereas samples A and B both consist of 2 concrete brick blocks with the same ratio because they will be tested on 7 days and 14 days. We also made a control brick point with a ratio of 1:2:4 which 300 g of cement, 600 g of sand, and 1200 g of aggregate with water 180 ml. The purpose of this control brick point is to test the different strengths of concrete brick and concrete brick that were added to hydroxyapatite slurry. We will compare the strong result and do the analysis. We also make this control brick point 2 blocks in total because it also will be tested on 7 days and 14 days. This strength test is conducted at GeoSpec Sdn Bhd using 100Kn Concrete Brick Compression Test Machine. The result is shown in Table 1.

Table 1. Result for Strength Result Test

Sample		Compressive Strength
	Sample A	35.62 N/mm^2

7 days	Sample B	24.20 N/mm^2
	Control Brick Point	44.31 N/mm^2
14 days	Sample A	43.94 N/mm^2
	Sample B	36.32 N/mm^2
	Control Brick Point	48.33 N/mm^2

In Table 1, we can assume that the concrete brick with the hydroxyapatite slurry exhibit lower strength as compared to the control point brick. However, we can see that the strength still increases from day 7 to day 14 is increase. According to the previous study, the CaCO3 helps to increase the early strength, due to the accelerator effect and high rate of hydration which hardens the concrete quicker. At matured age, the concrete with the CaCO3 addition exhibits lower strength as compared with concrete without CaCO3, but still within the target strength which is 49N/mm².

4.2.Infiltration Testing

The purpose of this test is to know how long the concrete brick will absorb the water with a specific volume which we fixed to 100ml of water. Commercial concrete brick absorbs water faster than concrete brick that contains HAp and this shows that brick that does not absorb more than 20% is good.

For the infiltration scope of the study, we are making 6 blocks of concrete brick Sample A consist of 2 blocks, sample B consists of 2 blocks. This is because the infiltration test will be conducted at 7 days and 14 days and this infiltration rate test cannot use the same concrete for 7 days and 14 days because the density after getting wet is different. Moreover, we also made a control brick point to compare the result of the infiltration rate for concrete brick with the additive of Hydroxyapatite and without the additive of Hydroxyapatite in concrete brick.

For the infiltration rate test, we are preparing a circle cup to put at the top of the concrete brick surface and covering all the space around the circle cup to make sure no water will spill out. Then, after covering all, 100 ml of water will pour into the circle cup and the time will start to calculate how long the water will absorb into the concrete brick. This step is the same for all concrete brick samples and for control brick points. The result is shown in Table 2.

Table 2. Result for Infiltration Rate Test

Sample		**Infiltration Rate**
7 days	Sample A	79.28 in/hr
	Sample B	101.93 in/hr
	Control brick Point	1698.84 in/hr
14 days	Sample A	149.27 in/hr
	Sample B	178.38 in/hr
	Control Brick Point	1049.29 in/hr

In Table 2, we can see the brick that contains 100g of HAp slurry in 7 days is the best concrete because it has a lower infiltration rate. The lower the infiltration rate, the good brick it can be commercialized. It contains 200g of cement and 100g of HAp slurry which means the cement function as a binder with the help of Hap slurry which makes it lighter and have a lower infiltration rate. This is a good combination of the ratio.

4.3.Comparison between burnt brick and unburned brick

When compared to unburnt brick, burnt brick has a higher strength. However, in this study, our objective is to

prove that adding hydroxyapatite as the ingredient of making burnt brick, will produce better quality concrete bricks. From what we knew, as for the burnt bricks, to meet the mechanical indicators, it is necessary to use high temperatures to have enough solidity. While as for the unburnt bricks, after the material is put into the brick mold, it will cure itself and still achieve the mechanical requirements such as compressive strength and a better infiltration rate after adding the hydroxyapatite. The result is shown in Table 3.

The table below explains the weight differences between burnt brick and unburnt brick that contain HAp after 7 days and 14 days. As can be seen, the brick that contained HAp after 7 days of being dried and containing 100g of HAp was lighter than burnt brick. Burnt brick is stronger than concrete and many building materials and this study want to prove the effect of adding HAp into a concrete brick in term of its weight only.

Table 3. Compares the Result

Burnt Brick	**Unburnt Brick**	
2.72 kg	Sample A (7 days)	Sample A (14 days)
	1.976 kg	2.049 kg
	Sample B (7 days)	Sample B (14 days)
	2.014 kg	2.011 kg

4.4.Characteristics of shell used in this study

The shell that we used in this study is known as Blood Clamshell or the other name is Anadara Grakosa/Tegillarca Granosa. This shell lives mainly in the intertidal zone at one to two meters of water depth, burrowed down into sand or mud. Besides, there are 5 groups of this shell. To synchronize our project work, we are using group 1 of the shell.

Group	**Size (mm)**
1	20 – 30
2	31 – 40
3	41 – 50
4	51 – 60
5	61 - above

Table 4. Chemical Composition of Blood Clamshell Powder (Anadara Granosa)

Component	**Content (% by weight)**
Calcium Carbonate ($CaCO_3$)	98.7
Sodium (Na)	0.9
Phosphorus (P)	0.02

Magnesium (Mg)	0.05
Ferum (Fe) Cuprum (Cu) Nikel (Ni) Boron (B) Zink (Zn) Silicon (Si)	0.02

Based on these chemical compounds, blood clams can be used as an alternative to the main raw material or substitute material for making calcium phosphate. Blood clam shells also can be optimized as raw material for making environmentally friendly calcium phosphate. Furthermore, blood clam shells have the same hemisphere attached to each other at the boundary of the shell, and ribs on both halves of the shell are very prominent. The shell is slightly longer than the height of the protrusion.

5.CONCLUSION

The main purpose of this project is to study Hydroxyapatite in clamshells to enhance the quality of bricks. As conclusion of this project, brick that contains Hydroxyapatite as an additive can produce a better quality of brick in terms of its infiltration rate. This is because bricks that contain HAp slurry have a lower infiltration rate than concrete brick points. On the other hand, in terms of strength, bricks that have been mixed with HAp slurry have lower strength compared to the control brick point. Despite that, the sample bricks that contained hydroxyapatite seem to be lighter than the control brick point. In addition to this, the sample bricks which contained HAp also have a whiter and smoother surface than the industrial concrete bricks. Over and above this, by doing this project we managed to produce unburned bricks that contained hydroxyapatite slurry as an additive. For good measure, by using hydroxyapatite slurry we can reduce the cost of cement used if it is produced in large quantities. Finally, the objective of environmental protection purposes is obtained because of using waste clamshells.

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