

Beach Cleaner Crab Machine

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Abstract : The pollution of the beach in Malaysia is quite worrying. There are some plastics, bottles, and similar to that where the visitors commonly leave their food, drinks, and other waste everywhere which makes the place a bad view to others. All of this trash, plastic trash has the most tremendous potential to harm the environment, wildlife, and humans. Communities and volunteers regularly conduct awareness campaigns on the importance of maintaining cleanliness and doing trash collection activities. The method of collecting trash still uses ordinary equipment which is tedious, hazardous, and time-consuming. Given the limited time of certain campaigns or cleaning activities that are involving the volunteers, there might be not much cleaning that can be done and so much more can be achieved with better equipment. Some researchers began to create tools to facilitate the process of collecting trash such as beach cleaner machines. This tool is seen to have the potential to speed up the task of collecting trash as well as reduce the rate of injury to users when collecting trash such as glass fragments. The Beach Cleaner Crab Machine was fabricated to speed up the time in collecting the trash on the beach by using raking and sifting technology. This beach cleaner machine uses a roll-picking system, and the excavator arm can pick up trash buried in the sand. These arms can lift up any trash including small things like straws and rubber bands. The arm-end effector is designed to filter out sand and transport cans into the reservoir. The results showed that Beach Cleaner Crab Machine requires 80% less time and energy than a manual pick-up. This machine has been enhanced in various aspects which is easy for the users to manage or handle and more environmentally friendly.

Keywords: Beach Cleaner Crab, Beach Cleaning Machine, Beach Pollution

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1. Introduction

Recently, the problem of trash pollution in the coastal environment in Malaysia is becoming more and more worrying. Areas such as coastal areas need to be preserved and cared for common use. However, some people always underestimate the importance. This is because their level of awareness of environmental care is still low. In addition, these areas are also often popular among tourists coming for a vacation in Malaysia. Thus, such pollution would tarnish Malaysia's good reputation in the eyes of the world caused by certain parties that lacks civic awareness.

These are the most visible types of beach pollution. Litter such as cigarette butts, food wrappers, and plastic bottles can simply be left behind by beachgoers. It can be found floating at the surface, suspended in the water column, or on the bottom of almost all water bodies. It is transported by rivers to the ocean, where it moves with the currents, and is often eaten by birds and fish, concentrating toxic chemicals in their tissues, and filling their stomachs, causing them to starve. As seen in **Figure 1(a)**, the issue of plastic aquatic debris extends far beyond aesthetic concerns. In 2021, Malaysia is ranked 28th top plastic polluter in the world, with 56 kg per capita/year of plastic consumption [1]. Data was collected in 2018 by Reef Check Malaysia (RCM). A clean-up of beaches in the country earlier this month revealed that most of the waste debris collected (2700 kg) was made from plastic as shown in **Figure 1(b)**. The items ranged from water bottles to plastic bags. This is evidence that urgent action is needed to address plastic pollution in oceans. The clean-up, organized by RCM, was conducted in 16 locations and involved more than 500 people from 20 organizations. They cleaned up trash along 15 km of coastline. Filling nearly 400 trash bags. The trash collected was 15,874 plastic water bottles, 6884 plastic bags, 2368 cigarette butts, and 203 diapers [2]. Most of the trash is slow to degrade.

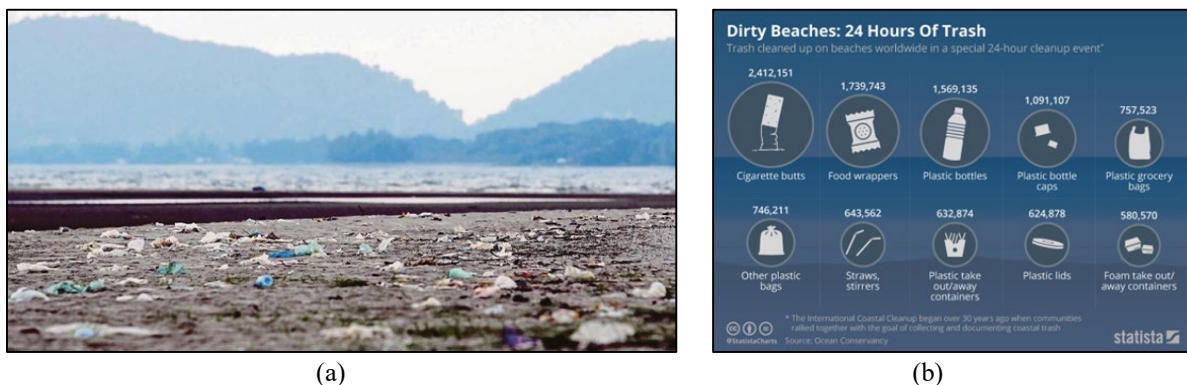


Figure 1: (a) A beach strewn with plastic debris washed up from the sea [1] and (b) statistic trash at the beach in Malaysia [2]

Different processes transform this waste into something that may be utilized. A deposit system for plastic drink bottles, enhanced recycling programs, barriers in rivers to discourage trash from drifting to the ocean, the conversion of plastic into valuable items, and funding for coastal towns are some potential remedies. Campaigns to raise awareness of the value of keeping cleanliness and carrying out trash collecting activities are constantly carried out by communities and volunteers. However, the approach to trash collection continues to employ standard tools. Researchers have also started to develop equipment like beach cleaning devices to make it easier to gather trash. This tool is thought to have the ability to both speed up the process of trash collection and lower the risk of tool user injury when collecting waste like glass pieces.

The main purpose of this project is to fabricate a beach cleaner machine that can collect trash in the sandy area. This beach cleaner machine uses a roll-picking system and the excavator arm can pick up trash buried in the sand. The arms end effector is designed to filter out sand and transport cans into the reservoir. These arms can lift up any trash including small things like straws and rubber bands.

2. Literature Review

Communities and volunteers regularly conduct awareness campaigns on the importance of maintaining cleanliness and doing trash collection activities. But the method of collecting trash still uses ordinary equipment. The current methods of trash collection are tedious, hazardous, and time-consuming. Given the limited time of certain campaigns or cleaning activities that are involving the volunteers, there might be not much cleaning that can be done and so much more can be achieved with better equipment. Some researchers also began to create tools to facilitate collecting trash such as beach cleaner machines. This tool is seen to have the potential to speed up the task of collecting trash as well as reduce the rate of injury to tool users when collecting trash such as glass fragments.

2.1 Manual method

Typically, volunteers use their hands and basic equipment to clean the beach. This practice risks injuring the volunteer and is not conducive to good hygiene. Injuries can occur while collecting sharps waste such as glass pieces and unclean waste such as pampers and stale food containers. **Figure 2(a)** shows volunteers cleaning the beach using tools such as trash collectors, rakes, and scrapers. They collect trash and put it in plastic bags while carrying it around the beach during the trash collection process. It's a bit tiring and unsafe for volunteers. **Figure 2(b)** shows a tool that can be used by volunteers to collect trash on the beach. This device makes it easy for the volunteers to pick up the trash without the need to bend their bodies every time the trash is collected. This tool helps the volunteers to do the work without back pain and the work done will be faster. **Figure 2(c)** shows a trash scraper to collect trash in one place. The tool will help volunteers to collect trash faster.



Figure 2: (a) Volunteers clean the beach using the cleaning tools manual [3], (b) picker trash [4], and (c) trash scraper [5]

2.2 Existing beach cleaning machines in the market

A beach cleaner machine is a simple machine that is used to clean the beach from any kind of waste material or similar to that. This machine has been improved in many ways, making it simple for consumers to use or handle. The machine is equipped with safety equipment in order to protect against any damage to the user while using the machine, where there are safety measures that are taken to operate the machine. Besides, it is equipped with suitable equipment to scoop the trash well which is the type of hook that plays a big role in the machine in order to operate well. All the reinventing of the machine that has been stated before has proven that this project has improved in different ways where many beach cleaner advances have been produced.

There were few commercially available beach cleaning machines in the current market. **Figure 3(a)** shows Rockland Beach King-Model II-Beach Cleaning Machine which was designed by Environmental Industry Companies. This machine is designed with support from tractors and this machine consists of equipment with advanced technology. There was improved belt action, which is sand that is going to be cleaned is sifted through a belt that bounces where it keeps the sand out of the bucket that makes it easy to clean the beach also has a good scoop system to collect the trash [6].

The Delfino-Self Propelled beach cleaner, which is smaller than the machine in **Figure 3(a)**, is shown in **Figure 3(b)**. This machine works by loading sand and trash into a sieve with a loading roller. The waste is then gathered and dumped into a trash basket, and the surplus sand falls out of the basket and falls to the ground. The machine is made to be compact, which increases its durability in tight spaces like those between seats and other objects [2].

Figure 3(c) depicts the simple machine (Rio-Model Ld-1500) which is operated by dragging along the beach where it sifts the trash and other matter from the sand continuously. The spline-mounted pump in the machine allows the beach cleaner to sift a variety of trash that can get at the beach. Then, the waste debris is collected and put in the collecting tank where the collecting tank of the machine is controlled by a hydraulic drive. Then, the trash will be directly tipped onto the tractor or the truck. It can be used in any condition of the beach either in wet or dry conditions.



Figure 3: (a) Rockland Beach King-Model II [6], (b) Delfino-Self Propelled Beach Cleaner [7] and (c) Rio-Model Ld-1500 – Beach Cleaner [8]

Table 1: Limitations of the beach cleaning machines

| Limitations | Rockland Beach King-Model II | Delfino-Self Propelled | Rio-Model Ld-1500 |
|--|---|---|--|
| Difficulty level to handle the machine | The machine is hard to handle because it needs to be handled by the expert that involves the tractor and also to handle the machine itself. | The machine is small and also has a comfortable place for the users to stand which makes it easy to handle. | The machine is hard to handle because it has to use a tractor to move this simple machine and also it does not have a roller or any kind of roller that makes it hard to move. |
| Noisiness level of the machine | The machine produces more noise with a 92 dBA sound level and also a tractor that is attached to the machine moves the machine. | The machine also produces noise with an average of 88 dBA sound level to the surrounding where it uses such a propelled fan to operate the machine. | This machine produces less noise because it did not involve many types of equipment that produce noise with an average of 82 dBA sound level. |
| Cost buy or fabricate | The machine costs a lot of money because it uses some equipment with advanced technology and next makes it more expensive to buy that due to the item used. | The cost to fabricate it is more costly because there are a few items in the machine that make it expensive at the market price. | This machine is expensive due to its complexity in design and also the equipment that the machine uses to make it well function in a sandy condition. |
| Maintenance | The machine produces more noise and also a tractor that is attached to the machine moves the machine. | Hard to do maintenance because the machine is completely compact with many equipment and costs to buy a spare part which also needs a lot of costs. | Hard to do the maintenance due to the compactness of the equipment at the machine. |

However, the beach cleaning equipment that is now on the market has limitations in terms of how difficult it is to use, how loud it operates, how much it costs to make, and other factors. The limits of the Rio-Model Ld-1500, Delfino-Self Propelled, and Rockland Beach King-Model II are shown in **Table 1**. The limitations of the machine are related to the difficulty level to handle the machine, the noisiness level of the machine, the cost to buy or fabricate, and its maintenance.

2.3 Common technology used by beach cleaning machines

There are two technologies used by beach cleaning machines which are raking and sifting. Raking technologies works on the both dry and wet sand. A spinning conveyor belt with hundreds of tines combs through the sand and eliminates surface and subsurface trash while leaving the sand on the beach when this approach is used. Small stones, shards of glass, and cigarette butts can all be removed using raking devices, as can larger trash like seaweed and driftwood. **Figure 4(a)** illustrates how raking machines may travel at high speeds by leaving the sand on the beach and just lifting the trash.

The beach cleaning machine that used sifting technology is shown in **Figure 4(b)**. It is carried out on soft surfaces and dry sand. The sand and trash are collected onto a vibrating screening belt by the vehicle's pick-up blade, which leaves the sand behind. The trash is collected in a collecting pan, which is usually found in the vehicle's back. Sifters must give time for the sand to sift through the screen and back onto the beach because sand and trash are lifted onto the screening belt. The hole size in the installed screen determines the size of the items eliminated.

Figure 4(c) illustrates a system that combines raking and sifting technology. Unlike pure sifters, it scoops sand and debris onto a vibrating screen with spinning tines rather than depending solely on the pick-up blade. The position of the tines can be changed to better guide different-sized materials onto the screen. Once on the screen, integrated rake and sifting machines remove undesired particles from the sand using the same technology as standard sifters.

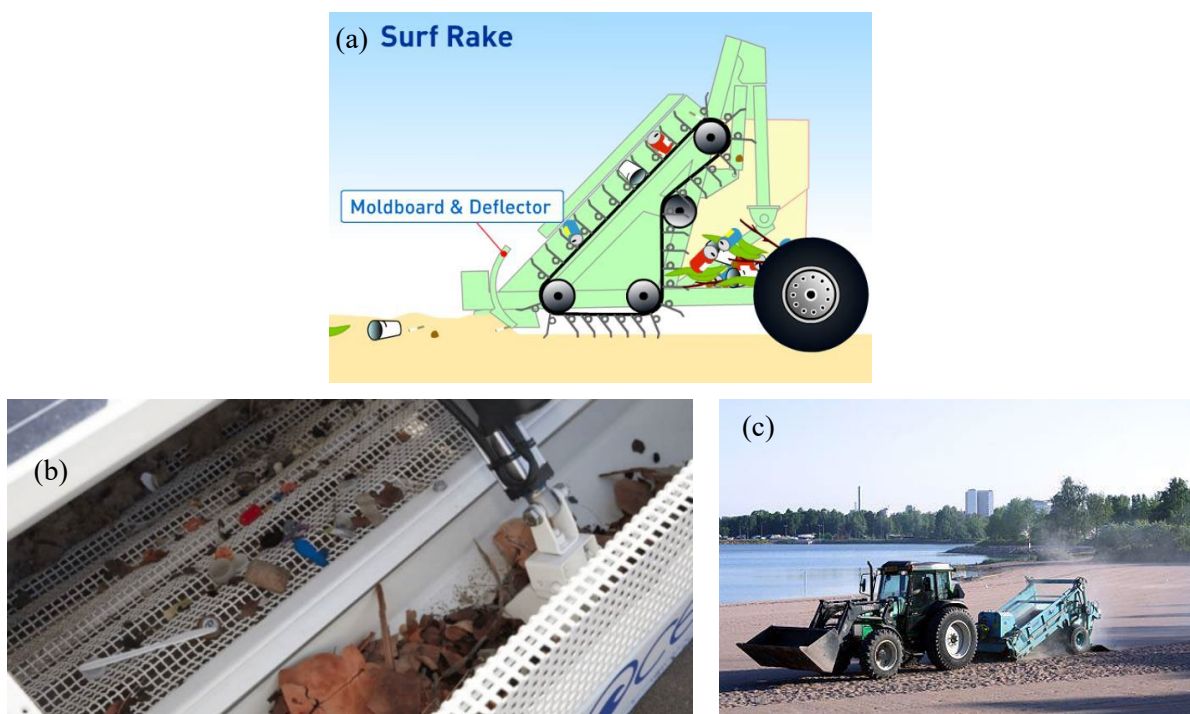


Figure 4: (a) Raking technology applied in existing product [8], (b) sifting technology [9] and (c) a tractor-pulled beach cleaner [10]

3. Methodology

The fabrication of the Beach Cleaner Crab Machine needs to follow the required process and fabrication for the project testing. There are several important elements that need to be studied in designing a product so that the production of products works well and is user-friendly. Among the elements that need to be studied are the type of materials and components used, the correct application process, objective analysis products, as well as the cost of each material and component used. The Beach Cleaner Crab Machine is shown in **Figure 5**. Gear is used at the shaft where one is used to reeling out the sprocket and push another sprocket to reel the excavator arms chain.

Figure 5(a) is the conveyor and hook. It is to collect the trash at the beach, the excavator's arm is built custom and used for this machine. It is custom sizing from stainless steel because the material can withstand rust for a long rate of time as this machine will be used in coastal areas. The excavator's arm is arranged in four rows on the belt with a 20 cm distance between itself. The excavator's arm has five hooks that were affixed to the rod. **Figure 5(b)** is the tyre. This machine is used on a sandy surface. It's become difficult to pull the machine if you don't use high-quality tyres. The machine uses tyres with thick flowers on the tyre surfaces. The dimensions of the tyres are (15 x 3) in. The quantity of tyres that

are used in this machine is four. **Figure 5(c)** is a rod. The rod on this machine is used to connect the belt to the motor and the hook to the chain. This rod's dimensions are (2.54 x 2.54) cm. Stainless steel was chosen as the material for this rod because of its durability. This substance can move the sprocket with a lot of force.

Figure 5(d) is a sprocket. This machine uses a sprocket to move and rotate the conveyor chain. This sprocket is a type of 18 teeth and measures 3.98 in diameter. The size of this sprocket is strong in being able to move the chain well. The number of sprockets used is four. **Figure 5(e)** is the conveyor chain. In order to link the hook to the rod and transmit power from the motor to the sprocket, the thinner crab chain is used on the beach. It can assist the machine in picking up trash on the beach. The chain used has a diameter of 2.85 cm and a thickness of 0.22 cm to 0.23 cm. The material chosen is stainless steel, which may be utilized for an extended period of time. **Figure 5(f)** is a trash bin. It is intended to accommodate the trash collected by the excavator's arm. The material chosen for the trash bin is plastic. This is to facilitate the cleaning process after emptying the trash. Its size is (70 x 25 x 57) cm.

Figure 5(g) is the bearing to serve to rotate the tyre handle shaft. The bearing will also reduce the resistance to the rod being subjected to force by the engine, rotating well. The bearings used are steel and ceramic and have inside and outside diameters of 20 mm and 47 mm. **Figure 5(h)** is throttle. It is to make it easier for users to use the Beach Cleaner Crab, this machine also has a throttle to push the machine. This throttle is a type of rubber that is easy to install and comfortable to hold. The amount used is two seeds for the left and right-hand holders. **Figure 5(i)** is a square net. The excavator's arm is attached to a square net to filter out all the trash that is covered with beach sand. This helps to separate the trash instead of scooping up the sand. This net is a type of aluminum and can be replaced in the event of damage or leakage. The size used was (127 x 127) mm.

Figure 5(j) is a square pipe. Due to its strength and ability to give the machine longevity so that it may be used for a long time, aluminium square pipe is utilized [11][12][13]. The square pipe size used is (5 x 8) mm. This square pipe is also easy to be formed and joined and does not require a high cost to purchase. The shaft that is crucial for moving this machine is seen in **Figure 5(k)**. The shaft will be used to secure the Beach Cleaner Crab's tyres. For strength, the shaft is composed of stainless steel. The dimensions used are (2.5 x 2.5) cm.

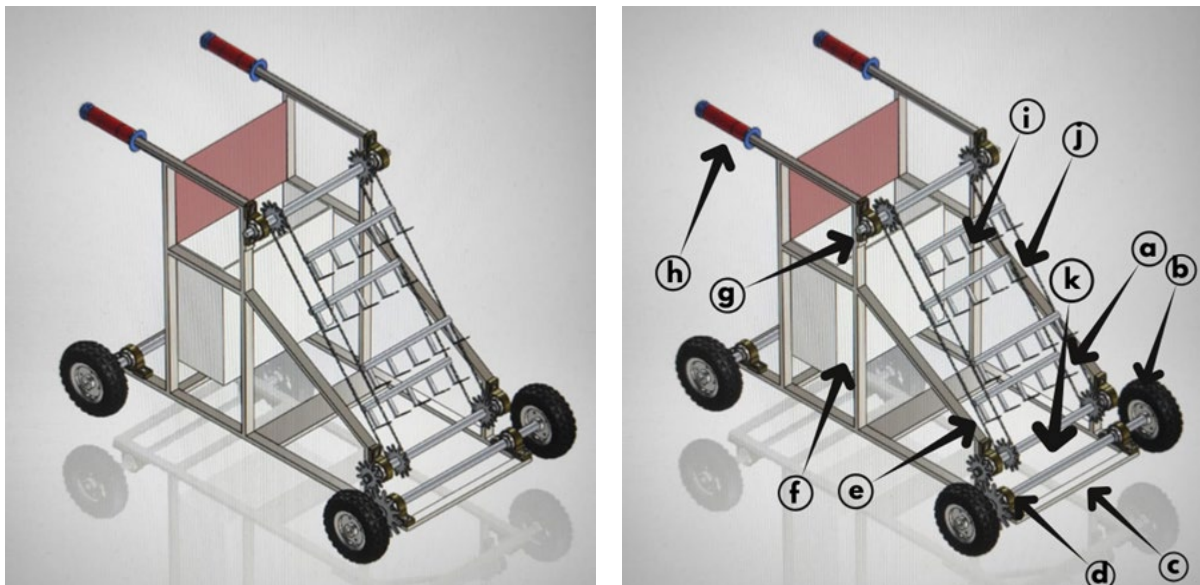


Figure 5: Beach Cleaner Crab Machine SolidWorks drawing

4. Experimental Setup

The primary goal of Beach Cleaner Crab Machine product manufacture is to gather beach trash. For the Beach Cleaner Crab Machine to work properly, the following procedure must be done. Install a plastic bag to fill the trash that will collect. Next, make sure the chains are in line to easily push this machine. After that, push the machine to make the rotation by gear working well to reel the excavator's arms.

4.1 Collecting ability

In this test, this machine is tested to ensure that the function of this machine can be used either on wet or dry surfaces. This test depends on the tyre used. Beach Cleaner Crabs use tyre that have flowers already and a strong surface grip on the ground. It allows this machine to work well on wet or dry surfaces. Next, this test also tests the effectiveness of the excavator's arm and belt components and whether they can pick up debris or not.

The energy is produced by the gear to rotate the sprocket attached to the rod. The excavator arm that relies on the belt moves according to the force applied to the rod. There was no problem with the excavator's arm while picking up the trash. Trash collected consists of various sizes such as empty bottles, empty water boxes, food skewers, straws, and so on. A square net placed on the excavator's arm can also filter debris well from scooping up sand on the beach. This clearly shows that the belt and excavator arm components can work well to pick up the waste of debris on the beach.

4.2 Size and evaluation of trash that can be collected by Beach Cleaner Crab Machine

The Beach Cleaner Crab Machine is an environmentally friendly machine with few restrictions on the trash it gathers. This machine can gather several forms of trash that are commonly seen on the coast. Cigarette butts, plastic and glass bottles, polystyrene containers, beverage cartons, and straws are among them. On average, this trash is the result of reckless human behavior on the beach.

This machine's development makes it easier for many individuals to maintain the beach clean. The trash as little as a cigarette butt and as large as a 1.5 liter bottle of mineral water may be scooped up by the machine's arms, depending on the process used. The machine's arm can take up trash measuring 1 inch to 20 inches long and 1 inch to 5 inches broad. This demonstrates that the size of the trash that this machine can gather is large due to the usage of nets on each arm. This net can assist the machine in collecting small-scale trash.

4.3 Evaluate the amount of trash that can be collected by Beach Cleaner Crab

Beach Cleaner Crab is a trash excavator machine that can accommodate a load of trash collected on the beach. Tests are held to determine the amount of trash that can be accommodated by this Beach Cleaner Crab Machine. The load imposed on this machine will affect the movement of this machine on the sandy surface. It proves that the heavier the machine the harder it is to walk on beach sand. From there, incremental loads of 1 kg are added until the machine is difficult to move.

5. Result and Discussion

The user will push the Beach Cleaner Crab Machine around the beach to do the experiment. The first phase of the experiment is the difference in collecting trash either on wet or dry surfaces by using the Beach Cleaner Crab Machine. The second phase is to determine the amount of trash that can be accommodated by this Beach Cleaner Crab. The last phase of the experiment is a square net to ensure that the sand can be separated from the trash when harvested. This test is tested whether the machine wants to need vibration or not when the trash is collected so that the rate of sand that follows is not much.

5.1 Working principle of Beach Cleaner Crab Machine

The Beach Cleaner Crab Machine moves using human energy that pushes the machine as long as it is on a sandy surface. Initially, the machine was built according to a design that had a motor that required dry cell energy or an electric current to propel it. After evaluation and research, this machine has advantages if modified to a geared system that can prevent any contamination. The machine speed is set at 5 km/h if using a motor. When using human energy, this machine can move at a rate of 3 to 4 km/h on the shore surface. This machine can also be used well on the beach. The machine was tested by being pushed on the sand surface. The tyres used can grip the sand well and not sink in sandy areas. The use of these tyres is desirable, even if they are taken from used items. The effectiveness of this machine tyre also enables the machine to move well and fast without any obstacles.

The Beach Cleaner Crab Machine is seen in **Figure 6**. **Figure 6(a)** shows the handle at the very rear of the machine. The handle helps the user push the machine more easily while working. The handle can reduce the load on the user and is even equipped with good safety features such as back protection. Pushing the handle will allow the user to begin operating the device. The sprocket is shown in **Figure 6(b)**. In order to serve as gear applications, the two sprockets needed to lean against one another. It is intended to use the force from the rotation of the tyres to move the excavators' arms on the conveyor chain. Once rejected, this part will function. **Figure 6(c)** shows the situation where the trash has been hauled by the excavator's arms on a sandy surface and brought up along a track on a conveyor chain. **Figure 6(d)** shows the excavator arm moving upwards on its track. Each leg of the arms will be attached to the chain. The trash will next be placed into the trash plastic that is shown in **Figure 6(e)**, which is the last stage.



Figure 6: Beach Cleaner Crab Machine

5.2 Analysis of Collecting Ability

Based on the observation of the movement of this machine, the excavator arm can rotate well on its track. According to the technical drawing in SolidWorks, the excavator has 6 arms that are spaced 2 feet apart along the chain track of the machine. Due to the excessive distance, this issue involves several parties. The arm can only pick up the rubbish that is directly in front of it when it is in use.

This shows that this machine can not pick up the whole trash if it is in a close-scale distance condition on the sand as shown in **Figure 7**. Trash can be collected if it is more than one foot away from each other to ensure that trash can be picked up by hand. Improvements need to be made to ensure that the trash can be collected properly regardless of the distance between the trash on the beach.



Figure 7: Trash left behind due to arm distance

5.3 Size of trash that can be collected by Beach Cleaning Crab

The Beach Cleaner Crab is an environmentally friendly machine and does not have many specifications on the trash it collects. Various types of trash that are often found on the coast can be collected by this machine. Among them are cigarette butts, plastic and glass bottles, polystyrene containers, beverage boxes, and straws. This trash, on average, stems from irresponsible human attitudes while on the beach.

The production of this machine makes it easier for many people to keep the beach clean. Based on the procedure carried out, trash as small as a cigarette butt and trash as big as a 1.5 litre bottle of mineral water can be picked up by the arms of the machine. Trash measuring 1 inch to 20 inches long and 1 inch to 5 inches wide can be picked up by the arm of the machine. This proves that the size of the Trash that can be collected by this machine is extensive due to the use of nets on each arm. This net can help the machine collect small-scale trash.

5.4 Evaluate the amount of trash that can be collected by Beach Cleaner Crab

As a result, the machine is able to function and move well on the beach. This test was repeated with loads of 2 kg, 3 kg and 5 kg. It still shows the same effect. After placing a load of 6 kg, the machine looked quite difficult to move because the load on the Beach Cleaner Crab Machine caused the machine to be difficult to move as the tyres could not run well on the sand. This test shows that this machine is capable of handling a trash load of 5 kg at a maximum rate. Based on observations, this machine is indeed able to collect 5 kg of trash, but it causes heavy trash plastic to be dragged on the beach surface under the machine. The waste plastic will leak and tear if this is disregarded. As a precautionary measure, improvements need to be made to the site of the plastic trash dump. The machine needs to be placed on a plate that can accommodate the load of trash. This plate must be made of durable and strong material to be able to withstand a load of 5 kg.

6. Impact of Design and Material Used on Environmental and Sustainability

Based on the design that has been made for this machine, it has been modified to function without the use of materials that can contribute to pollution. Smoke and motor noise, for instance, are the main causes of air and noise pollution from diesel engines. To ensure that this machine can prioritize environmental and sustainability concerns, the available design is changed in accordance with applying the gear function in moving the excavator arms in this machine. The application of the gear system can avoid any pollution and waste as it only uses natural energy from humans to push the machine. When the tyres rotate, the gear system will help the machine move the excavator's arm. In addition, the well-being and sustainability of this environment can be maintained after all the materials used are safe and non-polluting. This machine does not emit any waste like dirty oil as it only uses clean materials. Additionally, reusable components like iron, net sprockets, and other materials were used to construct this machine.

7. Conclusion and Recommendation

Beach Cleaner Crab Machine is seen to have the potential to speed up the task of collecting trash as well as reduce the rate of injury to tool users when collecting trash such as glass fragments. This machine has been enhanced in various aspects which is easy for the users to manage or handle. This beach cleaner machine uses a roll-picking system and the excavator arm can pick up rubbish buried in the sand. The arm-end effector is designed to filter out sand and transport cans into the reservoir. These arms can lift up any trash including small things like straws and rubber bands. The machine is equipped with a safety feature to protect the user, where there are safety measures that are taken to operate the machine. It is also equipped with suitable tools to scoop the beach debris properly which plays a big role in order for the machine to operate well. This beach cleaner machine is more environmentally friendly than other beach cleaners since it doesn't use high-speed motors or engines to generate noise or emit harmful smoke. Used of stainless steel for a machine's body helps prevent rust or corrosion. As a result, the equipment may be operated for a long period if proper maintenance is performed.

The Beach Cleaner Crab will next be improved by adding a motor to drive the excavator's arm and using a solar power system to conserve energy and make the product more environmentally friendly. The next step is to make improvements by putting a board underneath the waste plastic so that it can support the weight of the rubbish that is put inside of it. To ensure that no trash is left behind when being scooped up by the excavator's arm, the number of arms on the arm will also be increased, and the space between the arms will be decreased.

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