International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

Design and Fabrication of Amphibious Seaboard Trimmer

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Abstract - *Seaboard Pollution is one of the major hazards faced by the entire coastal countries. Marine litter and its accumulation on beaches is an issue of major current concern due to its significant environmental and economic impact all over the world. In order to solve the difficulty in litter collection, a beach cleaning machine is designed and fabricated in a cost-effective manner. With a wide range of accessory equipment, the range of operation for this compact machine extends way beyond the beach like, floating litter collector in sewage canal. The machine is designed in such a way that it can be attached to a moving vehicle in beach. It consists of a sieved conveyor in which the pollutants are separated and taken to the waste collecting lobby. The sand will be sieved back to the beach while the litter will get collected in waste bin. And this waste can be treated afterwards in proper manner. The machine can also be installed in flowing water so that the floating waste pollutants can be collected properly.*

***Key Words*: Seaboard, Marine litter, sieved conveyor**

1. INTRODUCTION

Marine litter and its accumulation on beaches is an issue of major current concern due to its significant environmental and economic impacts. Beaches play a major role in tourism economy and marine ecosystem. Pollution of the seashore and water bodies is the alarming threat in this arena. Eighty percent of marine debris consists of plastic pollutants. One of the hallmarks of the Anthropocene has been the dumping of millions of tons of plastic waste into the oceans. No part of the world's oceans is free from plastic debris. Plastic ingestion and entanglement are killing millions of marine organisms per year, including birds, sea turtles and marine mammals. Plastic pellets and micro beads are poisoning marine life with persistent organic pollutants.

The removal of plastic debris from the oceans is far too great a task for us to manage. The debris is simply too widely disbursed and too abundant. The most important step in ridding the oceans of plastic is to clamp down on the plastic debris that enters the oceans.

Lack of proper pollution controlling equipment in beaches makes the situation worse. Seashore cleaner is a machine which collects solid waste from the beach and water bodies using a specially designed conveyor and hook mechanism.

2. COMPONENTS

2.1 PMDC MOTOR

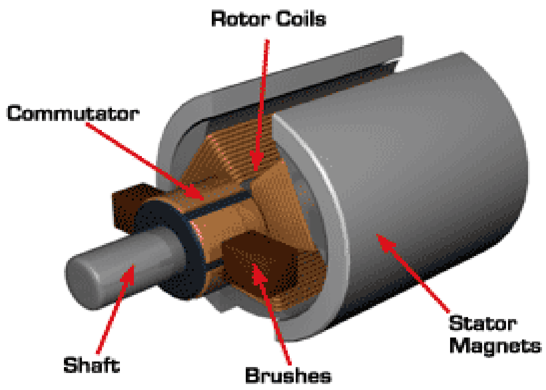

Fig 2.1 PMDC motor

In a DC motor, an armature rotates inside a magnetic field. Basic working principle of DC motor is based on the fact that whenever a current carrying conductor is placed inside a magnetic field, there will be mechanical force experienced by that conductor.

All kinds of DC motors work in this principle only. Hence for constructing a DC motor it is essential to establish a magnetic field. The magnetic field is obviously established by means of magnet. The magnet can by any types i.e. it may be electromagnet or it can be permanent magnet. When permanent magnet is used to create magnetic field in a DC motor, the motor is referred as permanent magnet DC motor or PMDC motor. Have you ever uncovered any battery operated toy, if you did, you had obviously found a battery operated motor inside it. This battery-operated motor is nothing but a permanent magnet DC motor or PMDC motor. These types of motor are essentially simple in construction. These motors are commonly used as starter motor in automobiles, windshield wipers, washer, for blowers used in heaters and air conditioners, to raise and lower windows, it also extensively used in toys.

As the magnetic field strength of a permanent magnet is fixed it cannot be controlled externally, field control of this type of DC motor cannot be possible. Thus, permanent magnet DC motor is used where there is no need of speed control of motor by means of controlling its field.

2.2 LEAD ACID BATTERY

Fig 2.3 lead acid battery

The battery which uses sponge lead and lead peroxide for the conversion of the chemical energy into electrical power, such type of battery is called a lead acid battery. The lead acid battery is most commonly used in the power stations and substations because it has higher cell voltage and lower cost.

2.3 MILD STEEL SHAFT

Fig 3.4 Mild steel rod

Mild steel is the most widely used steel which is not brittle and cheap in price. Mild steel is not readily tempered or hardened but possesses enough strength.

Mild steel contains –

carbon 0.16 to 0.18 % (maximum 0.25% is allowable)				
Manganese	0.70	to	0.90	%
Silicon		maximum		0.40%
Sulphurmaximum				0.04%
Phosphorous		maximum		0.04%

Mildest grade of carbon steel or mild steel contains a very low amount of carbon - 0.05 to 0.26%

Mild steel is an alloy. An alloy is a product made by mixing metals and non-metals. Sometimes a pure metal cannot fulfil all the properties needed for manufacturing product. So, additives are included in the pure metal to obtain some specific properties necessary for the production. Mild steel is made by adding carbon and other elements in the iron. These elements improve the hardness, ductility and tensile strength of the metal. A small amount of carbon makes mild steel to change it properties. Different amount of carbon produces different types of steels. There are small spaces between the iron lattice. Carbon atoms get attached to these spaces and makes it stronger and harder. The harder the steel the lesser the ductility. The modulus of elasticity calculated for the industry grade mild steel is 210,000 Mpa. It has an average density of about 7860 kg/m3.Mild steel is a great conductor of electricity. So, it can be used easily in the welding process. Because of its malleability, mild steel can be used for constructing pipelines and other construction materials. Even domestic cook wares are made of mild steel. It is ductile and not brittle but hard. Mild steel can be easily magnetized because of its ferromagnetic properties. So electrical devices can be made of mild steel. Mild steel is very much suitable as structural steel. Different automobile manufacturers also use mild steel for making the body and parts of the vehicle. Mild steel can be easily machined in the lathe, shaper, drilling or milling machine. Its hardness can be increased by the application of carbon. Mild steel is very much prone to rust because it has high amount of carbon. When rust free products are needed people prefer stainless steel over mild steel.

2.4 HOLLOW STRUCTURAL SECTION

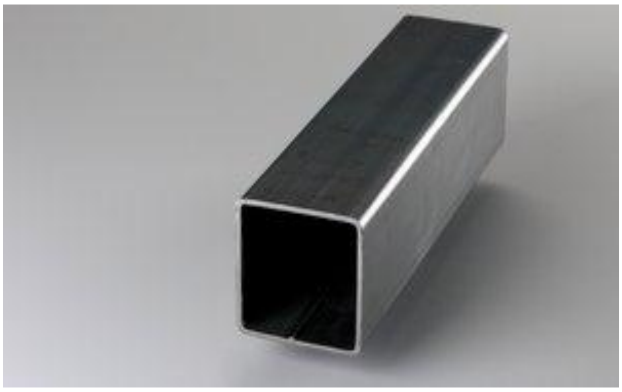

Fig 3.5 Hollow structural section

A hollow structural section is a type of metal profile with a hollow tubular cross section. The term is used predominantly in the United States, or other countries which follow US construction or engineering terminology.

Hollow structural section members can be circular, square, or rectangular sections, although other shapes such as elliptical are also available. Hollow structural section is only composed of structural steel per code.

Hollow structural section is sometimes mistakenly referenced as hollow structural steel. Rectangular and square hollow structural section are also commonly called tube steel or structural tubing. Circular hollow structural section are sometimes mistakenly called steel pipe, although true steel pipe is actually dimensioned and classed differently from hollow structural section. (Hollow structural section dimensions are based on exterior dimensions of the profile; pipes are also manufactured to an exterior tolerance, albeit to a different standard.) The corners of hollow structural section are heavily rounded, having a radius which is approximately twice the wall thickness. The wall thickness is uniform around the section. Hollow structural section, especially rectangular sections, are commonly used in welded steel frames where members experience loading in multiple directions. Square and circular HSS have very efficient shapes for this multiple-axis loading as they have uniform geometry along two or more cross-sectional axes, and thus uniform strength characteristics. This makes them good choices for columns. They also have excellent resistance to torsion.

Hollow structural section can also be used as beams, although wide flange or I-beam shapes are in many cases a more efficient structural shape for this application. However, the hollow structural section has superior resistance to lateral torsional buckling.

The flat square surfaces of rectangular hollow structural section can ease construction, and they are sometimes preferred for architectural aesthetics in exposed structures, although elliptical hollow structural section is becoming more popular in exposed structures for the same aesthetic reasons.

3.5 BALL BEARING

Fig 3.6 Ball bearing

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races.

He purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least three races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other.

Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races.

2.6 CHAIN DRIVE

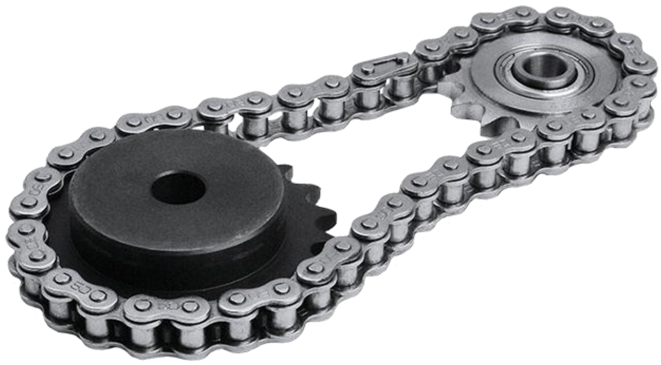

Fig 3.7 Chain drive

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. Most often, the power is conveyed by a roller chain, known as the drive chain or transmission chain passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force into the system.

Roller chain and sprockets is a very efficient method of power transmission compared to (friction-drive) belts, with far less frictional loss.

Although chains can be made stronger than belts, their greater mass increases drive train inertia.

Drive chains are most often made of metal, while belts are often rubber, plastic, urethane, or other substances.

Drive belts can slip unless they have teeth, which means that the output side may not rotate at a precise speed, and some work gets lost to the friction of the belt as it bends around the pulleys. Wear on rubber or plastic belts and their teeth is often easier to observe, and chains wear out faster than belts if not properly lubricated.

One problem with roller chains is the variation in speed caused by the acceleration and deceleration of the chain as it goes around the sprocket link by link. It starts as soon as the pitch line of the chain contacts the first tooth of the sprocket. This contact occurs at a point below the pitch circle of the sprocket. As the sprocket rotates, the chain is raised up to the pitch circle and is then dropped down again as sprocket rotation continues. Because of the fixed pitch length, the pitch line of the link cuts across the chord between two pitch points on the sprocket, remaining in this position relative to the sprocket until the link exits the sprocket. This rising and falling of the pitch line is what causes speed variation.

In other words, conventional roller chain drives suffer the potential for vibration, as the effective radius of action in a chain and sprocket combination constantly changes during revolution. If the chain moves at constant speed, then the shafts must accelerate and decelerate constantly. If one sprocket rotates at a constant speed, then the chain must accelerate and decelerate constantly. This is usually not an issue with many drive systems; however, most motorcycles are fitted with a rubber bushed rear wheel hub to virtually eliminate this vibration issue. Toothed belt drives are designed to avoid this issue by operating at a constant pitch radius.

Chain drive was a popular power transmission system from the earliest days of the automobile.

2.7 SPROCKET

Fig 3.8 Sprocket

A sprocket or sprocket-wheel is a profiled wheel with teeth, or cogs, that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth.

Sprockets are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery either to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc. Perhaps the most common form of sprocket may be found in the bicycle, in which the pedal shaft carries a large sprocket-wheel, which drives a chain, which, in turn, drives a small sprocket on the axle of the rear wheel. Early automobiles were also largely driven by sprocket and chain mechanism, a practice largely copied from bicycles.

3. DESIGN

3.1 DESIGN OF CHAIN AND SPROCKET

Parameters taken from standard specifications of sprocket.

Number of teeth on the sprocket = 17
Speed of sprocket = 100 rpm
Outside diameter of sprocket , Do = 0.223 m
Pitch circle diameter of sprocket, Dp = 0.204 m
Center to center distance , a = 1.928 m
Angle subtended by pitch length, r = 360/17
= 21.176
Pitch of chain, p = Dsin(r/2)
= 0.204sin(21.176/2)
= 0.03748 m
Diameter of the chain roller ,d1
Do = Dp + 0.8d1
0.223 = 0.204+0.8d1
d1 = 0.02375 m
= 23.7mm

Tooth flank radius , Re = 0.008 d1 (T^2+180)
= 88.9mm
Roll seating radius, r1 = 0.505d1 +0.069
= 12.0375mm
Roll seating angle (α)

Maximum roll seating angle = (140-90)/T
= (140-90)/17
= 2.94°
Minimum roll seating angle = (120-90)/17
= 1.76°
Root diameter Df = Dp-2r1
= 0.204-2×12.03
= 179.99mm
Velocity ratio of chain drive

Here two sprockets are of same diameter and same no: of teeth
Speed of tooth sprockets are same N1=N2=100rpm.
Average velocity of chain v = (π×Dp×N)/60
= (π×0.204×100)/60
= 1.068 m/s
Length of chain L = m*p
No: of chain links m = (2×a)/p+(T1+T2)/2+[(T2-T1)/2π]^2×D/a
= (2×1928)/37.48 +(17+17)/2 = 119.88
Length of chain L = m*p
= 119.88×0.03748
= 4.493m
Power transmitted to chain= 52.33 w

We have power transmitted to chain=p1*V watts
P1 = Allowable tension
V = velocity of chain
= 1.068m/s
Tension in the chain = power transmitted/velocity
= 52.33/1.068
= 49N

3.2 DESIGN OF MOTOR

Load F = 10kg = 100N
N = 100rpm
Torque T = F×r
Radius of shaft of motor = 50mm
T = 100×0.05
= 5Nm
Power P = (2ΠNT)/60
= (2π×100×5)/60
= 52.33W

3.3 DESIGN OF BALL BEARING

d = 50mm
Radial force Fr = 100N
Axial force Fa = 0 N
Shock factor Ks = 1.25
(Assuming Minor shocks)
Equivalent load P = Fr×Ks
= 100×1.25
= 125N

From Data book table 24.60

Recommended Load carrying capacity Cr = 43600N
L10 = 5×365×3 = 5475hr,s
L = (60NL10)/10^6 = (60×100×5475)/10^6 = 32.85

Millions of revolutions
L = (C/P)^m
C = PL^1/m
C = 125×(32.85)^1/3
= 400.33N
C< Cr, therefore selected bearing is suitable
Bearing no:50BC02 6210 10

3.4 DESIGN OF SHAFT

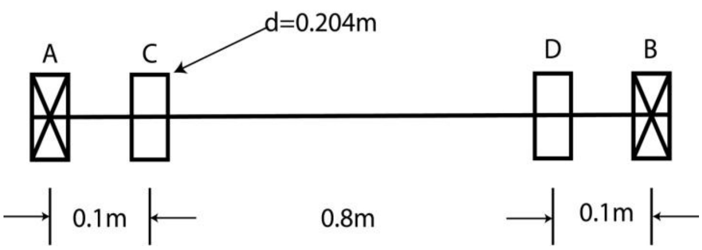

Fig 4.1 Shaft dimensions

Pulley C and Pulley D are symmetrical and Identical.

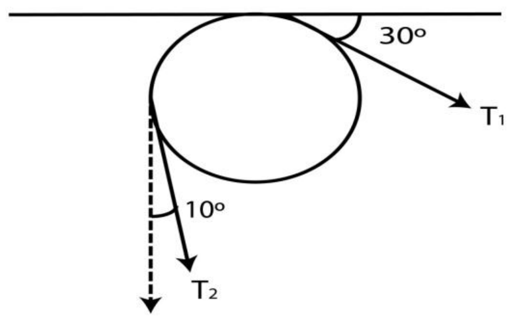

Fig 3.2 Free body diagram of sprocket

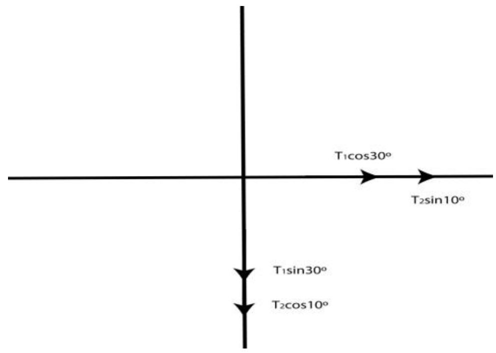

Fig 3.3 Components of tension

T1/T2 = e^μɵ
ɵ = 140̊ , μ =1
T1 = 50N
T1/T2 = e^2.44
T1/T2 = 11.47
T2 = 50/11.47
= 4.36N
Torque T = (T1-T2)×R
= 45.64×.204/2
= 4.65N

3.4.1 Vertical load diagram

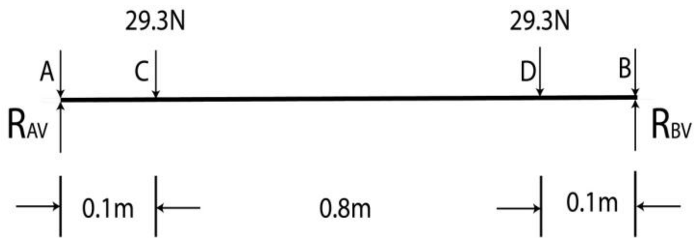

Fig 4.4 Vertical load diagram

Rav +Rbv = 58.6
Ma = 0
Rbv×1-29.3×.9-29.3×0.1 = 0
Rbv = 29.3N
Rav = 29.3N
Mc = Rav ×0.1
= 2.93N

3.4.2 Vertical bending moment diagram

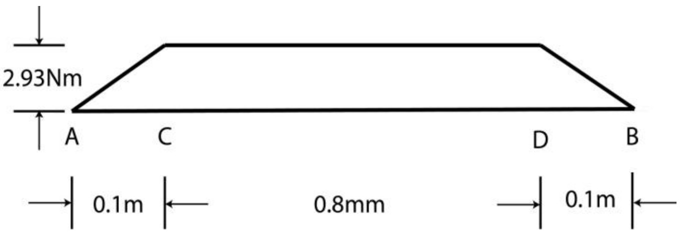

Fig 4.5 Vertical bending moment diagram

3.4.3 Horizontal load diagram

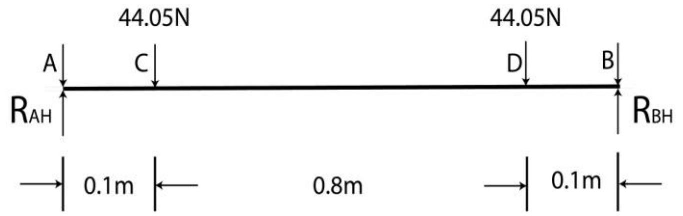

Fig 3.6 Horizontal load diagram

Rah + Rbh = 88.11
Rah = Rbh
= 44.05N
Mc = Md
= 4.4Nm
Mb = (Mv^2 +Mh^2)^1/2
= (2.93^2 +4.4^2)^1/2
= 5.28Nm

3.4.4 Horizontal bending moment diagram

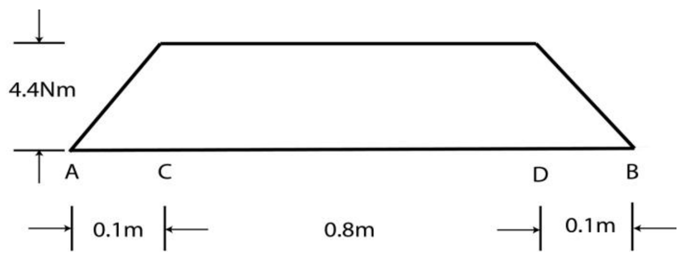

Fig 3.7 Horizontal bending moment diagram

3.4.5 Resultant bending moment diagram

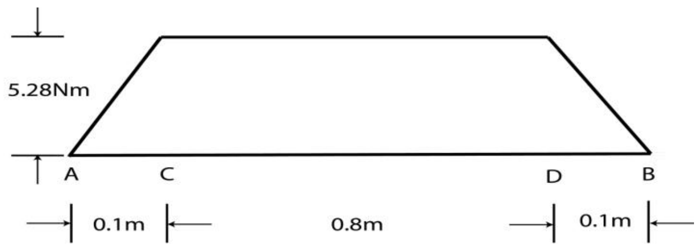

Fig 3.8 Resultant bending moment diagram

3.5 TWISTING MOMENT (Mt)

F = 10kg =100N
N = 100 rpm

T = F×r
r = 5cm
T = 100×.05
= 5Nm

From data book

D = {16/πσ[KbMb+{(KbMb)^2+(KtMt)^2}^1/2]}^1/3
Substituting D = 50mm , Kb = 1.5 , Kt = 1, Mt = 5Nm , Mb = 5999.28Nm
We get σ = 0.7MPa
That is working stress = 0.7 MPa
Yield stress for M.S = 250MPa

4. METHODOLOGY

4.1 PROJECT IDEATION / BENEFITS OF PROJECT

As pollution is the most alarming threat in both land and water we developed a machine which can be used in both water and seashore. The machine collects floating waste from water as well as from seashore. The benefits of this machine are

- Aquatic ecosystem will get preserved
- Promotion of tourism and there by empowering the economic development
- Huge manpower requirement can be reduced.
- Make awareness towards clean environment

4.2 PROBLEM DEFINITION

Pollution of the seashore and water bodies is the prime hazard in the present world. Lack of proper cleaning machine of these natural resources make the situation worse. The existing machines are either runs on a complicated mechanism or it will be costly.

4.3 OBJECTIVES OF MODEL

- To design and fabricate a cost effective Amphibious beach cleaning machine.
- To clean the sea shore and to make it pollutant free.
- To collect afloat sewage from drainages and running water bodies.
- To protect the aquatic eco system

4.4 WORKING

Power required for running the conveyor is taken from a 12V lead acid battery. A PMDC motor attached to the battery rotates the shaft connected to bearing on chassis. The shaft is fitted with two sprockets on either end. The sprocket rotates the conveyor system in clockwise direction by the action of sprocket and chain mechanism. Equidistant specially designed hooks and brushes are attached on a solid iron bar. The iron bar is screwed to the chain. The hook is used to ploughs the solid waste from the sand or from the water depending where the machine is used. The brush is used to sweep away the litter through sieve attached beneath it. This helps to separate the solid waste and sand through sieve. The size of hook determines the depth of ploughing action. As the chain conveyor rotates the litter will get swept away and get collected on the waste bin provided at the rear end of the machine.

Fig 4.1 Working model

4.5 CAD DRAWING

The Design drawing was done using Autodesk fusion 360

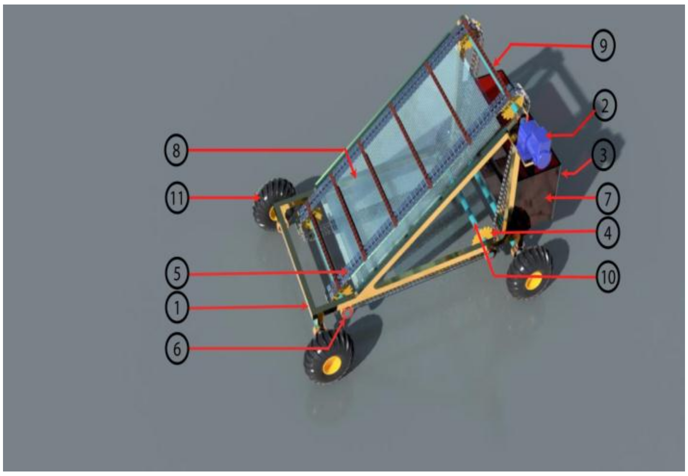

Fig 4.2 CAD drawing

Table 4.1 Components

Serial No	Components
1	Chassis
2	PMDC motor
3	Battey
4	Sprocket
5	Chain
6	Bearing
7	Collecting bin
8	Sieve
9	Brush
10	Shaft
11	Tyre

4.6 STATIC STRUCTURAL ANALYSIS

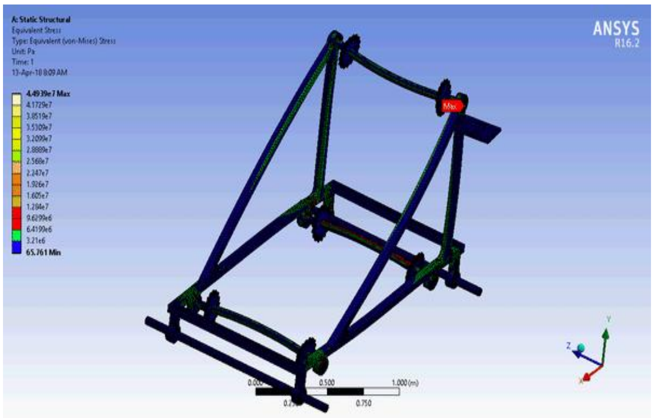

Fig 4.3 Static structural analysis

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes) Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The kinds of loading that can be applied in a static analysis include:

- Externally applied forces and pressures
- Steady-state inertial forces (such as gravity or rotational velocity)
- Imposed (non-zero) displacements

The procedure for a static analysis consists of three main steps:

1. Build the model.
2. Apply loads and obtain the solution.
3. Review the results.

The maximum stress obtained from analysis is 44.93 MPa which is less than the material yield stress.

5. CONCLUSIONS

The design, analysis, fabrication and testing of the seaboard trimmer was successfully done. According to the tests conducted and results obtained certain alterations and improvisation of design can improve the overall performance of the machine fabricated. The major alterations recommended are:-

- Attaching machine to a mud drive vehicle so that ploughing action can be done with more power and less time.
- While using the machine in water bodies automatic height adjusting platform can increase the waste collecting efficiency.
- Power requirement for drive can also be found by harvesting the solar and kinetic energy of water.
- Redesigning the machine with a propeller and motor, it can also be used to collect floating waste from still water bodies.
- Remote controlled cleaning can be done with necessary electronic components incorporated in machine.

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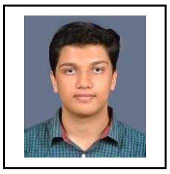

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