

Design and Fabrication of an Automatic Water Hyacinth Removal and Prevention Machine



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Abstract: Water Hyacinth scientifically called as *Eichhornia Crassipes* has been a problem throughout the entire world in terms of water pollution and flow of water. In any country, continuous flow of water in its water bodies is always necessary in order to drain wastewater and supply water to all the places of the country. Out of the four major methods present to drain water Hyacinth, Mechanical and Biological removal of the plant are the most effective methods. The aim of this project is to design and develop a water Hyacinth removal and prevention machine which can effectively collect the aquatic weeds, shred them in large quantities and prevent them from growing again. The major components used in the development of this machine are ramp cutters, guide vanes, propellers, boat base, chain drive, storage tank and a motor.

Keywords: Water hyacinth, aquatic weed, automatic, mechanical control, biological control, collection, prevention.

I. INTRODUCTION

One of the most major problems in water bodies in the tropical and sub-tropical regions of the world is the floating aquatic weed - Water Hyacinth which is scientifically termed as *Eichhornia Crassipes*. The rate of multiplication and growth of water hyacinth is high in the areas where the aquatic plant has been introduced during the recent days. The main reason of the growth of the plant in most of the areas of the world is its eutrophication in water bodies. In addition to this, the presence of natural enemies of the weed in the water bodies would have controlled the growth and high amounts of existence of water hyacinth. One of the effective methods to control the growth of this plant is Biological control of the plant i.e., to control the weed by adding some biologically significant plants into water. However, There isn't a one solution which can control this problem in a much longer extent except perhaps an integrated approach such as one of more control methods applied together can effectively work so as control this weed for a longer time period. So in addition to biological control, other means of controlling measures should also be taken in short intervals of time in order to effectively control the weed,

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The only method in which there are no immediate adverse effects in controlling the aquatic weed is the mechanical control. A Machine must be designed so as to collect large mass of this water hyacinth which is spread throughout a large area in the water bodies. So, a machine which can collect the weeds and also control the weeds biologically is being employed now which can be run using a motor or an engine.

II. PREVIOUS WORK

[1] Omofunmi, O. E., S. A. Ebifemi, and A. B. Eweina. (2016)

In this paper, The design of water hyacinth harvester was done using an electric single phase motor, mower discs, shafts with four blades made up of stainless-steel. Assumptions which included a shear resistance angle of 30 degrees and a coefficient of water adhesion as 3446.99N/m². With the calculation of forces acting on the water per unit depth in the vertical direction as well as the sideways and the resisting force are calculated for the accurate balance of the system on the water.

[6] Prasad V. Shastri, Abhishek V. Bende, Devendra V. Chopade, Sagar T. Ubhe, Prof. Dilip P. Borse.-2017.

The paper aims at the bio-mass destruction of water hyacinth in any kind of water bodies. A shaft, a conveyer, and components such as bearings, cutters are used. A main-frame and a secondary frame for conveyer are designed and analyzed for their strength in ANSYS-18 simulator. A cutter placed when rotates shreds the water weeds which are eventually carried on to the conveyer which in turn will guide the weeds to the storage tank. This machine has 95% effective weed pulling.

[3] Mr. V. Shantha Moorthy, Dhamodharan.S, Chandru.-2017

In this paper, a mechanical model which consists of rollers which are used to pickup the water hyacinth plants which are then collected into the collection tank through an employment of belt conveyor. Further, the weeds will be dumped out after picking up to the land. The machine is designed based on the properties of the water hyacinth which generally has a stem up to 60centimeters. The employment of machine can reduce the amount of water hyacinth by collecting them for a short tenure.

III. METHODOLOGY

The methodology used in the design of an automatic water hyacinth removal and prevention machine is as follows:

- Study of properties of water hyacinth and its effects.
- Analysis on the solutions available to clean water hyacinth.

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- Methods to improve the mechanical efficiency of present machines.
- Selection of standard parts.
- Selection of materials.
- Selection of basic mechanisms used.
- Modelling of individual components.
- Analysis of the components by applying forces.
- Fabricating prototype.

IV. SYSTEM PARTS/COMPONENTS REQUIRED

The design and fabrication of the automatic water hyacinth removal and prevention machine consists of 8 parts:

- Boat base with fiber glass layer
- Storage tank
- Ramp cutter
- Chain drive
- Propellers
- Tail of the boat
- Single Phase 48V DC Motor
- Remote controller/Smart phone
- Seed sprinkler

A. Boat base: The boat base is designed based on the Archimedes principle which states that "Anybody which has partial or complete submergences in any fluid is buoyed or pushed up by a force which is equal to the weight of fluid displaced by the submerged body". The weight of the waste bottles with fiberglass outlay acts downward, and the buoyancy force developed by the displaced fluid acts in the upward direction which makes a system a balanced one.

B. Storage tank: A storage tank is installed in the arrangement in order to collect the weeds which are collected by the vanes arranged on the chain drive. Once the tank is full, the system will be brought back to the land and it will be dumped out to move again into the water body and collect the weeds.

C. Ramp cutter: A ramp cutter is employed to cut the plant at the root which makes it easier for the vanes to collect it and dump in the storage tank.

D. Chain Drive: A chain drive is employed as the center distance is considerably less and needs the maximum mechanical power transmission efficiency. The design of chain drive is calculated, and chain is selected as per the design standards.

E. Propellers: Two propellers are arranged at the rear end of the boat base in order to provide propulsion to move the entire system in the forward direction.

F. Tail Boat: A tail at the bottom of the base is employed to guide the boat directing it in a specific required way.

G. DC Motor: To drive the system, lifting mechanism and carrying the variable loads, a power source in the form of DC Motor is given which will acts as the only source of power to run the machine.

H. Remote Controller: As the system is to be guided and controlled, a remote controller or a smart phone are used to guide the system to move in a particular direction of weeds and to collect them.

I. Seed Sprinkler: A mechanism which is arranged at the rear end of the boat base sprinkles seeds into the water wherever it goes which aids in the prevention of water hyacinth plant growth biologically too. The biological control system employment in this system makes this more efficient in reaching the aim.

V. WORKING PROCEDURE

The automatic water hyacinth removal and prevention machine aids in the aquatic plant cutting, and collection of small pieces of weeds and trash shred in water bodies. Cutters and vanes are designed to cut, collect and unload biomass and debris using a cutters, guide, and chain drive system on the boat. Cutter ramp cut and collect material and bring it aboard the ramp wedge using the chain drive; The chain drive in its movement which has vanes arranged to it collects the weeds and drops them in the storage tank. when the storage tank has reached capacity, cut material is transported to a disposal site. The drive is typically driven by a 48-volt Direct current motor which has 270 rpm and a torque of 24 N-m. Gear with a velocity ratio of 3 with respect to gear is installed and operated. Also, Gear is mounted on base with an angle of 30 degree to the base of main frame. When the motor gives power, the vanes will start moving which will eventually collect all the weeds which are on the vanes of the drive. The chain keeps continuously rotating with the help of gear and sprocket. Due to this continuous rotation of the drive, the weeds are transferred from lower to upper end of the system.

VI. MODELLING OF THE MACHINE

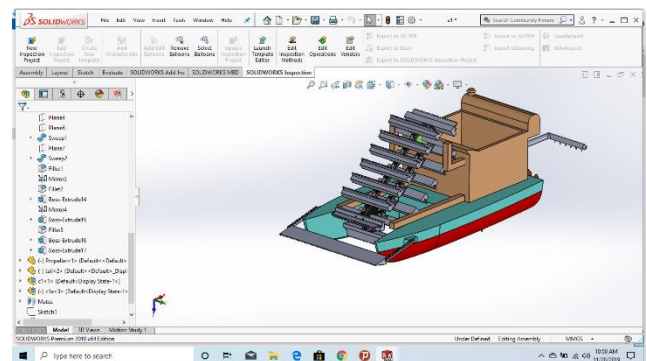


Fig.1. Isometric View of the machine

VII. DESIGN CALCULATIONS

The Motor to be used is LBC-05-B which has specifications as follows:

1. Peak Power = 2000 W
2. Torque = 24 N-m
3. DC Voltage = 48V

Power=678.6 W

Speed is set to 270 RPM using controller.

speed of pinion =270rpm

speed of driven sprocket wheel=90rpm

Gear ration=3

No: of Teeth on sprocket pinion = $Z_1=13$

No: of teeth on sprocket wheel=39

The Load carried is cyclic,
Assuming the variable load with mild shocks
Load Factor $K_1=1.25$
Adjustable support at both ends $K_2=1.0$
Selected $a_p = 100p$
 $K_3=1.5$ (Factor for centre distance of sprocket)
Inclination of the line joining the centre of the sprocket to the horizontal is upto 60 degrees
(Factor for the position of the sprockets)
Selected drop lubrication $K_5=1.0$ (lubrication factor)
Single shift of 8hr a day $K_6= 1$ (Rating factor)
Service Factor $K_s=1.5625$
Design Power =1.06KW
SELECTION OF CHAIN:-
ANSI standard 12B-2
Rolon no – DR1911
Pitch(p)=19.05 mm
Roller Dia = 12.07mm
Width b/w inner plates =11.70mm
Pin body Dia= 5.72mm
Plate Depth=15.95mm
Transverse Pitch =19.46mm
Weight per metre=2.36 Kg/m
Breaking load = 57.85 KN
Diameter of sprocket pinion =0.08m
Diameter of sprocket wheel =0.237m
Velocity of sprocket pinion $V=1.13m/s$
Length of chain in multiple of pitches =227 links or pitches
In order to ensure uniform wear, $l_p = 228 \text{ links}$
Length of chain = 4.344m
Exact Centre Distance = 1.904m
Capacity of the lifting Mechanism:

$$Q = 3.6 * v * \gamma * \varphi * \frac{i_0}{a}$$

Where,

i_0 = capacity of bucket,

a = spacing between buckets in meters

v = chain speed

γ = Bulk weight of the load

φ =bucket efficiency

$$Q = 3.6 * 1.13 * 3 * 0.6 * \frac{2}{1.086}$$

$$Q = 13.49 \text{ Kg/hr}$$

*All the substituted values are in the order of the equation.

DESIGN OF TANK:

Iteration 1: Clearing of tank every hour

$$m = \rho * V$$

$$m = Q * \text{hrs},$$

$$\rho = \text{Density of water hyacinth} = 650 \text{ kg/m}^3$$

$$V = \text{volume of the tank.}$$

$$13.49 = 650 * V$$

$$V = 0.02 \text{ m}^3$$

$$l * b * h = 0.02$$

$$\text{Height} = 0.4 \text{ m}$$

Iteration 2: Clearing of Tank every 4 hours

$$m = Q * \text{hrs}$$

$$m = 13.49 * 4 = 54 \text{ kg}$$

$$54 = 650 * V$$

$$V = 0.08 \text{ m}^3$$

By assuming $h=0.4, l=0.6$, we get

$$b = 0.33$$

The Tank dimensions are:

$$\text{Length} = 0.6 \text{ m}$$

$$\text{Breadth} = 0.33 \text{ m}$$

$$\text{Height} = 0.4 \text{ m}$$

We have selected Iteration 2 for the tank to arrange the components for stability.

The Weight of motor = 20 kg

Weight of sprocket wheel and pinion = 5 kg

Weight of chain = 10.25 kg

Weight of Tank (Al 6061 plate with 4 mm thick) = 10.22 kg

Weight of paddles to move = 4 kg

Weight of cutting blade = 2.2 kg

Weight of buckets = 4 kg

Weight of Boat material (Al 6061 plate with 6 mm thick) = 62.5 kg

Total length of the Boat = 2.6 m

Total width of the boat = 0.5 m

Total height of the boat = 0.9 m

The Lightweight of the boat = 118.17 kg

The dead weight of the boat = 54 kg

Displacement of the boat = Light weight + Dead weight = 172.17 kg

*The displacement changes constantly due to the addition of weight in hyacinth.

Centre of Gravity= 1.04 m from the left.

shearing angle to the cutting blade $\phi = 30$ degree

water friction angle $\beta = 10$ degree

VIII. ANALYSIS OF COMPONENTS

ANSYS analysis of the critical components is carried out and studied for its strength to withstand the amount of load that is applied in different directions.

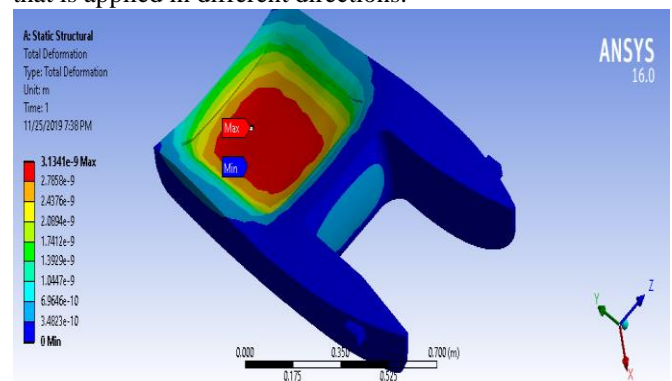


Fig-2: Boat base Total Deformation

Model (A4) > Static Structural (A5) > Solution (A6) >

By assuming $h=0.4, l=1.0$, we get

$$b = 0.05 \text{ m}$$

The tank dimensions are:

$$\text{Length} = 1.0 \text{ m}$$

$$\text{Breadth} = 0.05 \text{ m}$$

Total Deformation

Time [s]	Minimum [m]	Maximum [m]
1.	0.	3.1341e-009

Table-1: Boat base Total Deformation

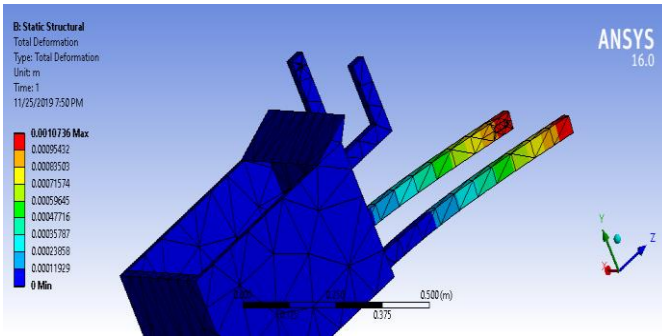


Fig-3: Stroage Tank Total Deformation

Model (B4) > Static Structural (B5) > Solution (B6) >

Total Deformation

Time [s]	Minimum [m]	Maximum [m]
1.	0.	1.0736e-003

Table-2: Storage Tank Total Deformation

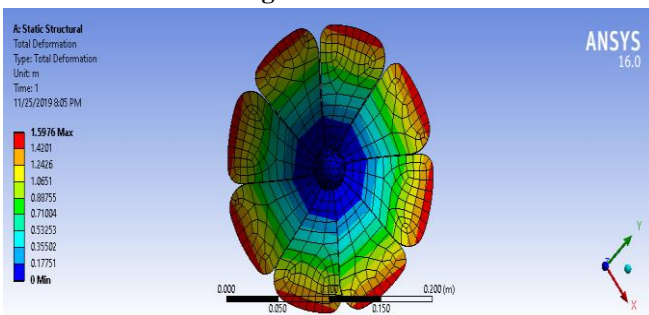


Fig-4: Propeller Total Deformation

Model (A4) > Static Structural (A5) > Solution (A6) >
Total Deformation

Time [s]	Minimum [m]	Maximum [m]
1.	0.	1.5976

Table-3: Propeller Total Deformation

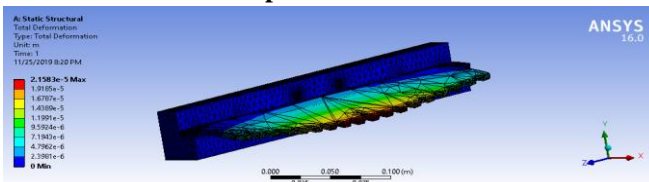


Fig-3: Vane Total Deformation

Model (A4) > Static Structural (A5) > Solution (A6) >
Total Deformation

Table-4: Vane Total Deformation

Time [s]	Minimum [m]	Maximum [m]
1.	0.	2.1583e-005

IX. CONCLUSION

The automatic water hyacinth removal and prevention machine was designed and powered by 48V DC Single phase motor with speed of 270rpm which will enhance physical control of the weed and improve water flow through activities. The efficiency of the system can be improved by increasing the width of vanes and its speed. So, the design and development of an automatic water Hyacinth removal and prevention machine which can effectively collect the aquatic plants and shred them in large quantities is designed and analyzed for its strength. The major components used in the development of this machine are ramp cutters, guide vanes, propeller, boat base, chain drive, storage tank and a 48V DC motor. A seed sprinkler is employed in the system which aids in the biological control of the machine by throwing seeds into the water bodies which prevents the water hyacinth from growing to an extent. This integrated approach to solve this issue increases the efficiency of the system in controlling water hyacinth substantially.

X. FUTURE SCOPE

The automatic water hyacinth removal and prevention machine will be powered by alternate energy sources such as solar and waterpower where in the machine can identify the water weeds by itself and collects them autonomously. The efficiency of the integrated approach for the control of the aquatic weeds will be studied and implemented in different ways of possibilities.

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