A PROJECT REPORT

ON

“HYBRID REMOTELY OPERATED UNDERWATER VECHICLE”

Submitted by

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In partial fulfillment for the award of the Degree

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ANJUMAN-I-ISLAM

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CERTIFICATE

This is to certify that the project entitled

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

___________________ ___________________

Date: __________

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ABSTRACT

"NEED IS THE MOTHER OF INVENTION"

The human brain is full of creativity. Every now and then man aspires of innovative ideas to quench his thirst for various needs and gain technical breakthrough. Keeping the above important fact in mind, we came up with the idea of HROV, the design and mechanism is purely innovative. The aim is for designing and manufacturing of HROV is for serving the purpose for the industries of military, civilian use: broadcast use hobby use hydrographic survey, pipeline surveys, jacket inspections and marine hull inspection of vessels enquiring drowned people from rivers and sea. HROV is used to investigate under water. Now a day, with the advancement of technology it is used not only investigation but also to battle and mining operation.

Sometimes there are some problems throughout the rivers in our country. Many people are lost their lives because of drowning of boat or water vehicle. Therefore, a HROV is designed to solve this problem by investigation underwater. Water and propeller driven by gear motor are used for driving the HROV. It is derived on the principle of jet propulsion. Water is sucked by a propeller which is derived by a pump motor. Then the water passes through the nozzle. Whole system is controlled by microcontroller. Moreover, the system is controlled with the help of remote control.. This design is done perfectly to reduce drag force. Therefore it is an effective design. This investigation has involved the design, construction and testing of a HROV and has allowed a more thorough understanding of key fluid mechanic principles.

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INTRODUCTION

1 INTRODUCTION

1.1 Background:

In the 1970s and '80s the Royal Navy used "Cutlet", a remotely operated submersible, to recover practice torpedoes and mines. RCA (Noise) maintained the "Cutlet 02" System based at BUTEC ranges, whilst the "03" system was based at the submarine base on the Clyde and was operated and maintained by RN personnel.

The U.S. Navy funded most of the early ROV technology development in the 1960s into what was then named a "Cable-Controlled Underwater Recovery Vehicle" (CURV). This created the capability to perform deep-sea rescue operation and recover objects from the ocean floor, such as a nuclear bomb lost in the Mediterranean Sea after the 1966 Palomares B-52 crash. Building on this technology base; the offshore oil & gas industry created the work-class ROVs to assist in the development of offshore oil fields. More than a decade after they were first introduced, ROVs became essential in the 1980s when much of the new offshore development exceeded the reach of human divers. During the mid-1980s the marine ROV industry suffered from serious stagnation in technological development caused in part by a drop in the price of oil and a global economic recession. Since then, technological development in the ROV industry has accelerated and today ROVs perform numerous tasks in many fields. Their tasks range from simple inspection of subsea structures, pipelines, and platforms, to connecting pipelines and placing underwater manifolds. They are used extensively both in the initial construction of a sub-sea development and the subsequent repair and maintenance.

Fig: 1.1 first ROV

Submersible ROVs have been used to locate many historic shipwrecks, including the RMS Titanic, the Bismarck, USS Yorktown, and SS Central America. In some cases, such as the Titanic and the SS Central America, ROVs have been used to recover material from the sea floor and bring it to the surface.

While the oil and gas industry uses the majority of ROVs, other applications include science, military, and salvage. The military uses ROV for tasks such as mine clearing and inspection.

1.1.2 Construction

Work-class ROVs are built with a large flotation pack on top of an aluminum chassis to provide the necessary buoyancy to perform a variety of tasks. The sophistication of construction of the aluminum frame varies depending on the manufacturer's design. Syntactic foam is often used for the flotation material. A tooling skid may be fitted at the bottom of the system to accommodate a variety of sensors or tooling packages. By placing the light components on the top and the heavy components on the bottom, the overall system has a large separation between the center of buoyancy and the center of gravity: this provides stability and the stiffness to do work underwater. Thrusters are placed between center of buoyancy and center of gravity to maintain the attitude stability of the robot in maneuvers. Various thruster configurations and control algorithms can be used to give appropriate positional and attitude control during the operations, particularly in high current waters. Thrusters are usually in a balanced vector configuration to provide the most precise control possible.

Electrical components can be in oil-filled water tight compartments or one-atmosphere compartments to protect them from corrosion in seawater and being crushed by the extreme pressure exerted on the ROV while working deep. The ROV will be fitted with cameras, lights and manipulators to perform basic work. Additional sensors and tools can be fitted as needed for specific tasks. It is common to find ROVs with two robotic arms; each manipulator may have a different gripping jaw. The cameras may also be guarded for protection against collisions. An ROV may be equipped with Sonar and LiDAR equipment.[4]

The majority of the work-class ROVs are built as described above; however, this is not the only style in ROV building method. Smaller ROVs can have very different designs, each appropriate to its intended task. Larger ROVs are commonly deployed and operated from vessels, so the ROV may have landing skids for retrieval to the deck.

1.2 Function of ROV

Remotely-operated underwater vehicles (ROVs) are robots that complete functions underwater on behalf of a crew, located on the surface, with whom the ROV is tethered. These functions include: search/recover, inspection, equipment repair, scientific analysis, dredging/trenching, cable-laying, and surveying. This tether serves as the interface between the ROV and the ship and it provides the ROV with electric power and control commands, while providing the crew with video and data feeds. ROVs in deep or rough water will use a more robust umbilical cable and tether management system.

1.3 Features of HROV

The abilities of ROVs are determined by what instruments are mounted to it. At minimum, an RVO will possess aquatic thrusters, a camera, and lights. Other tools commonly implemented on ROVs include: mechanical manipulators, sonar, magnetometers, various types of cameras, cutting/shearing tools, and other devices to measure characteristics of its environment. Electrical systems are outfitted in oil-filled water-tight or pressurized compartments. High-power applications and tools will receive power from an on-board hydraulic pump.

1.4 Types of HROV

Generally speaking, there are five types of underwater ROVs and one class of autonomous underwater vehicle (UAV):

- Small electric ROVs are the smallest type of ROV. They do not utilize a hydraulic pump and are limited to depths of 1,000 feet or less. These ROVs can only be used for remote observation.

- High-capability electric ROVs also do not utilize a hydraulic pump, and its tasks are therefore limited to deep sea observation and illumination. Most high-capability ROVs are suitable for depths of 20,000 feet. It is primarily used by the scientific and military industries.
- The general class ROV is electrically driven, but may contain a primitive manipulator and sonar. A small, five horsepower electric motor is responsible for underwater locomotion.
- The work class ROV is the smallest iteration of hydraulic ROV. It is outfitted with a seven-function manipulator, a five-function grabber, and can be modified for specific applications. This type of ROV is commonly used in deep water drilling and construction applications. A 12,000-foot depth limit is normal, as is a 50 HP electric motor for propulsion.
- The heavy class ROV is the most capable type of industrial underwater ROV. These ROVs are outfitted with several multi-function manipulators and grabbers, as well as motors capable of generating several hundred horsepower. These ROVs possess the ability to lift 12,000 lb. from the sea floor to the surface, but are limited to working depths of 10,000 ft.
- Autonomous underwater vehicles (AUVs) are developed for military usage and have not yet been marketed to other industries. They primarily stalk enemy ships, protect harbors, and mine sweep. These vehicles do not require a tether or the extent of user manipulation needed for ROVs. AUVs are expected to become available for commercial applications once they have developed a niche in deep sea drilling and construction.

Fig: 1.2 Mines Neutralization Vehicle

1.5 ROV's operation

The operator (pilot) on the surface can see the task site via underwater television cameras and / or sonar devices and other sensors on the ROV. Various manual and hydraulic tools can be deployed by the manipulator to the site to perform tasks. In some cases special tools are designed and built to perform specific tasks. Very complex tasks can be carried out using remote technology whether it is by use of a generic ROV or specially designed equipment for doing specific work.

1.5.1Where are they working?

There are several spots around the world where the majority of ROV operations occur. They are primarily tied, of course, to the production of oil and gas. It is estimated that nearly 400 work class ROVs are in operation at this time servicing the oil and gas industry. The following paragraphs discuss the level of ROV activity around the world.

Europe - The North Sea has always been an area of high ROV activity with systems being operated in both the UK and Norwegian Sectors. One of the largest concentrations of ROVs is in this region with over 100 systems in operation. The majority of operations in the North Sea are in water depths of 492 ft (150 m) or less. Recently, there has been a move to West of Shetlands, designated a "frontier" area where the water is much deeper—1,148 to 3,281 ft (350 to 1,000 m)—and wind and current conditions more severe. Norway has drilled its deepest well in 4,180 ft (1,274 m) of water and they have discovered gas at 12,795 ft (3,900 m) in the Voring basin.

Asia - Much activity stretches from Western Australia (Asia Pacific) to Malaysia and the South China Sea. Mobil and Texaco are conducting seismic studies in the Gorgon field of Western Australia in 2,953 to 5,249 ft (900 to 1,600 m) depths in search of additional natural gas reserves. Expenditures in this region in 1999 may reach 22 percent of the world's total being spent on offshore oil and gas developments.

South America - The majority of ROV operations in South America are occurring off Brazil, mainly in the oil rich Campos Basin. Petrobras continues the race to deeper water in the

Campos Basin in depths up to 6,562 ft (2,000 m). Petrobras' Marlim South development currently holds the record for the deepest on-stream well at 5,732 ft (1,747 m) and has another waiting at a depth of 6,020 ft (1,835 m).

North America - Reports indicate 104 deepwater prospects in water deeper than 9,843 ft (3,000 m) and 31 rigs simultaneously drilling in these deepwater regions. As much as 35 percent of the production in the Gulf in the year 2000 may be in deep water, up from a mere 4 percent in 1995. Between 1987 and 1997, the number of operators in the Gulf has increased from 77 to 157. Over 100 ROVs support work in the Gulf.

Arctic - Russia is opening up, with major developments offshore about to be exploited. Some of these prospects will be in water depths of 1,312 ft (400 m) and in the icy Barents Sea and Kara Sea, where the largest gas reserves in the world may be located.

Africa - West Africa is a major hot spot with new leases available in water to 8,383 ft (2,555 m). For example, Exxon is drilling off Nigeria in 4,836 ft (1,474 m) in the Gulf of Guinea and is exploring in depths to 6,601 ft (2,012 m) offshore of the Congo.

Other - Other areas where ROVs are required are off Newfoundland, Alaska, the Caspian Sea off Azerbaijan, Trinidad, the West Coast of California, off Australia in the Indian Ocean, the Bass Strait in the Tasman Sea and the Mediterranean Sea off Egypt.

1.6 PROBLEM STATEMENT

ROVs are designed to work at desirable depths. It has rigid, double-walled hulls and is steered by turning a rudder left and right. Water- pushing and creating a forward force is done by a propeller. A power source is engaged on this action. It has ballast tank for air and water. So, a mechanical and an electrical system are working together for running the whole process. Followings are the main factors were considered while selecting.

- Design the model with consideration of aerodynamic and hydrodynamic.
- To manufacture the prototype for Educational outreach, Science, Survey and Surveillance use.
- Testing the model to ensure the leak proofing.
- Design the model to sustain the different conditions in & on the water.

CHAPTER: - 02
REVIEW OF LITERATURE

LITERATURE REVIEW

This chapter will describe details about the ROV, literature review on the parts and systems used in the project. It includes the explanation of individual component characteristic and also the advantages of using the particular component chosen for the project. The chapter will explain ROV, motor thrusters, battery supply, and serial communication method used in the ROV project.

2.1 Introduction

This chapter is review about ROV. Remotely operated vehicle is a tethered underwater robot. My project is implemented to produce the low cost ROV. Literature reviews are based in information obtained from valid sources such as books, articles of relevance, published paper or any other source deemed appropriate. The forms of literature include standards of practice, proceeding paper or conference papers such as those from the Power Engineering Conference.

2.2 Background Study

Before any instruments had been made for working on water, underwater task has to be carried out by divers, this was a big problem because the natural conditions could be an restriction for any work for example in deep water is restricted the use of diver for high deep inspection was necessary to build some kind of instruments that can do the inspection work like maintenance and research work. They can be divided in three groups, machines that are controlled and manned by humans (like submarines), Remotely operated vehicles (ROV's) and Autonomous vehicles (AV), first ones are generally used works of inspection and recognition of great areas or as warlike element, in other hand other ROV's was developed unmanned because in some cases despite of being protected by the submarine, the conditions for the work wasn't safe for humans like space, and duration of operation, for this kind of problem the ROV's was used they are remotely operated far away for the place of the operation, maintaining safe of the operator for the risk conditions.

At the beginning the ROV was only implemented for high deeps inspections, because the state of the art was not improved enough to leave a man until there, for this reason, rustic vehicles was implemented, they only carry one camera and the umbilical cable in order to keep the system working and normally it carries communication and power wire, to manipulate the ROV, the operator has to be careful and try to control this new ROV without any help, also while the ROV do the travel for the deep surface to the work area, sometimes it was the most difficult task for the operator. Nowadays the ROV carry out many tasks as new kinds of work are invented for the humans, inspection of sea resources or maintenance work, the actual ROV are adapted to work in high pressure environments and the operators has many helpful tools to guide his robot, extending the scenario or work, for this reasons new kind of these device will be proposed to be able to work in all kind of conditions.

- David Smallwood , Ralf bachmayer [1] researched on designing a platform for rapid development and deployment of novel underwater vehicle systems and to achieve the desperate goals of high thrusts, small size, and precise propeller position instrumentation. Torque generated up to 6.5N-m max and 2.16N-m continuous @ power 1.5KW. Vehicle design goals were achieved by giving size of 1.5m*1m*1m of up to 140kg mass.

- Agus Budiyono [2] presented study on remotely operated vehicles deployed for underwater installation, inspection and repair task.
  1.operation at a safe distance from the sea floor including observations of sea floor using sonar, examination of water composition , sampling of floating creatures
  2.Inspection of hydro-thermal activity
  Difficulties observed through this case study were A) non-linearity of underwater vehicle dynamics. B) Challenges from environment C) Low visibility when using vision sensors

- Andrew D. Bowen, Dana R. Yoerger, [3] results of sea trials of the Nereus hybrid underwater robotic vehicle (HROV) conducted in June 2009 in the Challenger Deep of the Mariana Trench, where the vehicle successfully performed scientific observation and sampling operations at depths of 10,903 m. . Nereus operates in two different modes. For broad area survey, the vehicle can operate as an autonomous underwater vehicle (AUV) .For close up imaging and sampling, Nereus can be converted to operate as a remotely operated vehicle (ROV).

- Elgar Desa , Maya group [4] designed and fabricated underwater vehicle to acquire data from onboard sensors to sense physical, biological and chemical properties in ocean, lakes, rivers, and dams

  1. Total Length 1. 742

  m 2.Diameter 0.234 m

  3. Depth range 200 m Propulsion DC brushless motor

  The small AUV Maya was field tested in two very different environmental settings namely the Idukki Reservoir in Kerala, and a coastal station in the Arabian Sea

CHAPTER: - 03

METHODOLOGY

3.1 OVERALL PROJECT METHODOLOGY:

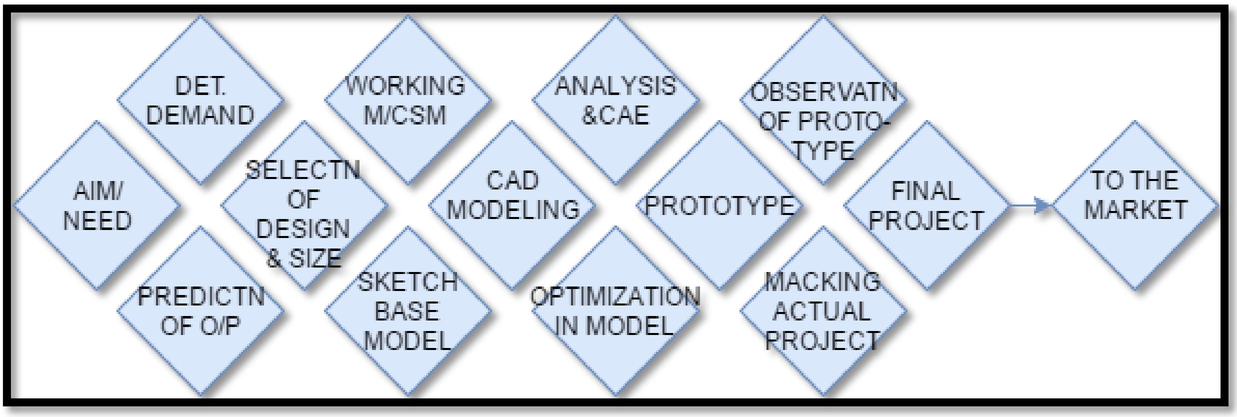


Fig 3.1 flow chart of methodology

AIM: "NEED IS THE MOTHER OF INVENTION" the human brain is full of creativity. Every now and then man aspires of innovative ideas to quench his thirst for various needs and gain technical breakthrough. Keeping the above important fact in mind, we came up with the idea of HROV, the design and mechanism is purely innovative.

The aim is for designing and manufacturing of hrov is for serving the purpose for the industries of military, civilian use: broadcast use hobby use hydrographic survey, pipeline surveys, jacket inspections and marine hull inspection of vessels enquiring drowned people from rivers and sea.

DETERMINE DEMAND:

While doing the survey as such rovs are not present in Indian market under this price segment of our hrov.

PREDICTION OF OUTPUT:

The expected outcome of this project is to fulfill the aim and demand of the rovs.

SELECTION OF DESIGN AND SIZE:

In this stage of methodology team goes through various factor while finalizing the dimensions of the project such as bouncy force, drag, volume displace, and etc.

WORKING MECHANISM:

There are number of mechanism on which actual under water surveillance vehicles are working and while go through each and every mechanism we find most suitable mechanism is modified neutral buoyancy which state as “is a condition in which a physical body's average density is equal to the density of the fluid in which it is immersed”.

CAD MODEL:

Design the actual cad model for the analysis and further process also for actual feel of the project.

ANALYSIS:

Various analyses are done for the finding factor of safety structural failure and others parameters for future predictions.

OPTIMIZATION:

After finding out the CAE results optimization is to be done to minimize the cost of production and its quality.

PROTOTYPE AND ITS OBSERVATIONS:

As per the design make a prototype of the project for actual feel and its output expectations as per the desire.

FINAL PROJECT:

After doing all steps of methodology as per above given, all authentic data is available for the production of final project and it’s made according to that.

CHAPTER: - 04

SELECTION OF COMPONENTS WITH DESIGN AND CALCULATION

4.1 BATTERIES OF ROV'S:

Batteries play a cardinal rule in the standby and propulsion power system of submarine. Batteries are sole responsible to the duration of submerged time of submarine except nuclear technology and air independent propulsion system. So the batteries and its charging/ discharging time are the major criterion for performance evaluation and to know how long it has to snorkel and risk detection during any adversaries .Basically lead acid batteries are widely and commonly used in submarines, but recently their dominancy is becoming low for the new efficient batteries. In the paper, the implemented prototype battery system has been analyzed and side by side also described innovative battery techniques and some solutions over battery drawbacks.

A. Lithium-Ion Battery:

Lithium-ion (Li-ion) batteries have been used to implement the prototype. It is the best option for battery system as its energy density is much higher according to its weight and also slow discharging rate. Moreover, its weight is very less with high electrochemical potential. It is also commercially available. The main advantage of the Li-ion batteries is that it can fit in different sizes and shapes, so it can utilize in any desired location to utilize vacant space. Its self-discharge rate is very less which is about 5 to 10% which is very less than any battery. Moreover, scheduled cycling or memory is not necessary to enhance the battery life. For these attractive characteristics of the Li-ion battery, it has been used in the implemented prototype and in diesel electric submarine to replace lead-acid battery.

Fig: 4.1 Lithium-Ion Battery

B. Lead-Acid Battery:

Lead-acid battery is also widely used in some types of submarine. Its main drawback is its low energy comparing its weight and low energy density comparing its volume. But it can give high surge current and it can also maintain high power to weight ratio [13]. For these reason it is used in some applications of submarine. This lead-acid keeps chemical energy finally to convert it into electrical energy and release that by the external circuit.

C. Molten Salt Battery

Molten salt battery is also another type's battery containing electric cells. It uses molten salts to generate power. It can give better energy density and by appropriate anode and cathode selection it can give better performance. By the use of high conductivity molten salt electrolyte it can give high power density. Basically, the rov which requires more energy density and power density there the Molten Salt battery is used. But the main disadvantage of this battery is that it needs continuous battery charging to keep the electrolyte in liquid state so that it can use at any time [14]. Moreover, if this battery system is not used and become solid then it needs to heat the battery to revive and make liquid for use. But this heating system takes long time which is around three to four days. The most significant instance of this molten salt battery is ZEBRA battery which is first introduced in 1985 and was made by molten sodium aluminum chloride [14]. For its some major disadvantages its usage is limited in submarine. It is widely used in some rov's.

4.2 SELECTION OF MOTOR:

In this project selection motors plays very crucial part of the designing phase as it’s a backbone of our project which propel the robot through jets thrusters. Although these motor are responsible for run the vehicle on different terrains and overcoming different forces on which motor is selected which will be further describe in details. Possibly following motors which are easily available in market and can be used for HROV which are as follow.

4.2.1 BRUSHLESS VS BRUSHED MOTORS:

A typical brushless motor has permanent magnets which rotate around a fixed armature, eliminating problems associated with connecting current to the moving armature. An electronic controller replaces the brush/commutator assembly of the brushed DC motor, which continually switches the phase to the windings to keep the motor turning. The controller performs similar timed power distribution by using a solid-state circuit rather than the brush/commutator system.

Brushless motors offer several advantages over brushed DC motors, including high torque to weight ratio, more torque per watt (increased efficiency), increased reliability, reduced noise, longer lifetime (no brush and commutator erosion), elimination of ionizing sparks from the commutator, and overall reduction of electromagnetic interference (EMI). With no windings on the rotor, they are not subjected to centrifugal forces, and because the windings are supported by the housing, they can be cooled by conduction, requiring no airflow inside the motor for cooling. This in turn means that the motor's internals can be entirely enclosed and protected from dirt or other foreign matter.

Brushless motor commutation can be implemented in software using a microcontroller or microprocessor computer, or may alternatively be implemented in analogue hardware, or in digital firmware using an FPGA. Commutation with electronics instead of brushes allows for greater flexibility and capabilities not available with brushed DC motors, including speed limiting, "micro stepped" operation for slow and/or fine motion control, and a holding torque when stationary. Controller software can be customized to the specific motor being used in the application, resulting in greater commutation efficiency.

The maximum power that can be applied to a brushless motor is limited almost exclusively by heat too much heat weakens the magnets and may damage the winding's insulation.

When converting electricity into mechanical power, brushless motors are more efficient than brushed motors. This improvement is largely due to the frequency at which the electricity is switched determined by the position sensor feedback. Additional gains are due to the absence of brushes, which reduces mechanical energy loss due to friction. The enhanced efficiency is greatest in the no-load and low-load region of the motor's performance curve under high mechanical loads, brushless motors and high-quality brushed motors are comparable in efficiency.

NOTE: Even brush less DC motor have more advantage over brush DC motor but due to the point BLDC motors cannot run in water with direct contact as its requires special water proofing as well as its more expensive. <u>Hence brush DC motors are selected for thruster and jets.</u>

Fig: 4.1 Brush DC motor

4.2.2 SERVO MOTORS:

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system.

Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

FIG: 4.2 9GRMS METAL SERVO **FIG: 4.3 SERVO MOTOR**

4.3 ELECTRONIC SPEED CONTROL:

An electronic speed control or ESC is an electronic circuit with the purpose to vary an electric motor's speed, its direction and possibly also to act as a dynamic brake. ESCs are often used on electrically powered radio controlled models, with the variety most often used for brushless motors essentially providing an electronically generated three-phase electric power low voltage source of energy for the motor.

An ESC can be a stand-alone unit which plugs into the receiver's throttle control channel or incorporated into the receiver itself, as is the case in most toy-grade R/C vehicles. Some R/C manufacturers that install proprietary hobby-grade electronics in their entry-level vehicles, vessels or aircraft use onboard electronics that combine the two on a single circuit board.

4.4 electronic speed controller

Specification:

- ESC 20A Brushed Reverse Motor Speed Controller 1/16 1/18 ROV’S With Brake.
- The male plug connect Motor, the female plug connect Battery
- Dimensions: 35.0*22.0*6.0mm
- Working volt(V):4.8V-7.4V
- Li-Poly 2-3 cells; Ni-MH 4-10 cells Auto Detect

4.4 TRANSMITTER AND RECEIVER:

Radio control (often abbreviated to R/C or simply RC) is the use of radio signals to remotely control a device. Radio control is used for control of model vehicles from a hand-held radio transmitter. Industrial, military, and scientific research organizations make use of radio-controlled vehicles as well.

Fig: 4.5 RC TRANSMITTER (RADIO CONTROL)

Advantages:

- Super active and passive anti-jamming capabilities.
- Very low power consumption.
- High receiving sensitivity.
- 8 model memory, digital control.
- Can be programmed by PC with included software.
- Full range 2.4GHz 6-channel radio.
- Integrated timer. Computer Programmable. USB Socket.
- It covers the entire band width of the antenna bandwidth range (Up to*1 Km). High quality and stability.

Specification:

- Transmitter/Receiver: 2.4GHz Model Name:6 channels transmitters
- Model No:FS-CT6B
- Channels:6 channels Mode
- Type: Airplane, Helicopter, Submarine
- Mode: Left hand or Right hand
- Modulation: Frequency Modulation
- Antenna length:115cm/26mm
- Power:12 VDC RF
- Power: Less than 0.8W

4.5 Material properties used in Analysis and calculation

PVC (poly-venial-chloride) schedule 40.

Density	1380 kg/m^3
Tensile yield strength	80 Mpa
compressive yield strength	90 Mpa
Ultimate tensile strength	250 Mpa
Ultimate compressive strength	250 Mpa
Young's modulus	2.9 Gpa
Poisons ratio	0.3

Acrylic

Density	1150 kg/m^3
Tensile yield strength	80 Mpa
compressive yield strength	120 Mpa
Ultimate tensile strength	140 Mpa
Ultimate compressive strength	140 Mpa
Young's modulus	1.2 Gpa
Poisons ratio	0.3

Stainless steel

Density	7850 kg/m^3
Tensile yield strength	250 Mpa
compressive yield strength	280 Mpa
Ultimate tensile strength	350 Mpa
Ultimate compressive strength	350 Mpa
Young's modulus	2.5 Gpa
Poisons ratio	0.4

4.6 Static Body

Impulsion Pressure

$P=\rho \times g \times h$ [Reference: R.K Bansal]

$P=1000 \times 9.81 \times 20$

P=1.96 bar

Total pressure

$P_{total}=P+P_{atm}$

=1.96+1.013

P_{total} =2.973 bar

Maximum Work Pressure

P_{max}=18.28kg/cm^2 At 23℃

P_{max}=17.92bar

At 20mdepth pressure acting outside the chamber is 2.973

Max. Allowable pressure on chamber as per the material=17.92 bar

Max. Allowable pressure >Pressure acting at 20m depth

Hence, chamber is Safe.

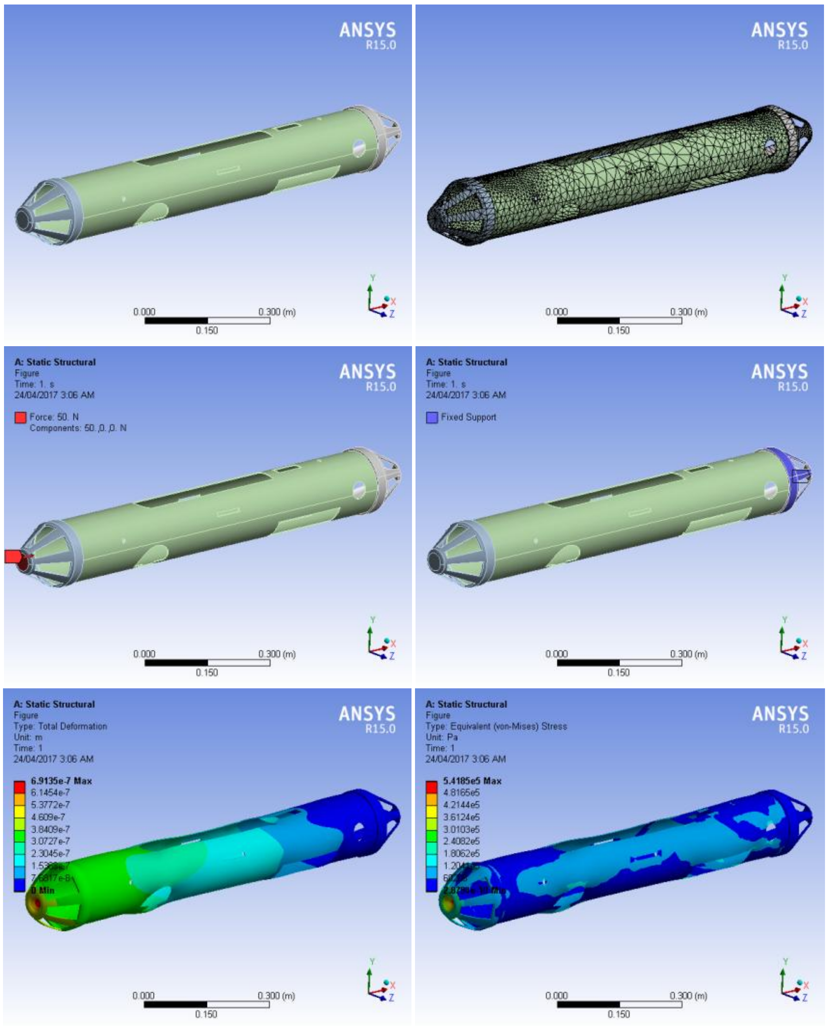
Factor of safety

Factor of safety=$P_{allowable}$÷ P_{total}

=17.92÷2.973

Factor of safety=6.027

The body is subjected to static loading of 50 N. and the rear dome is fixed while the front dome is subjected in impact loading.



4.6 Analysis of body

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	250 MPa	54.18 MPa	5	0.00069mm

4.7 Upper Chamber

<u>Buoyancy</u>

Buoyancy = ρ x g x v [Reference: R.K Bansal]

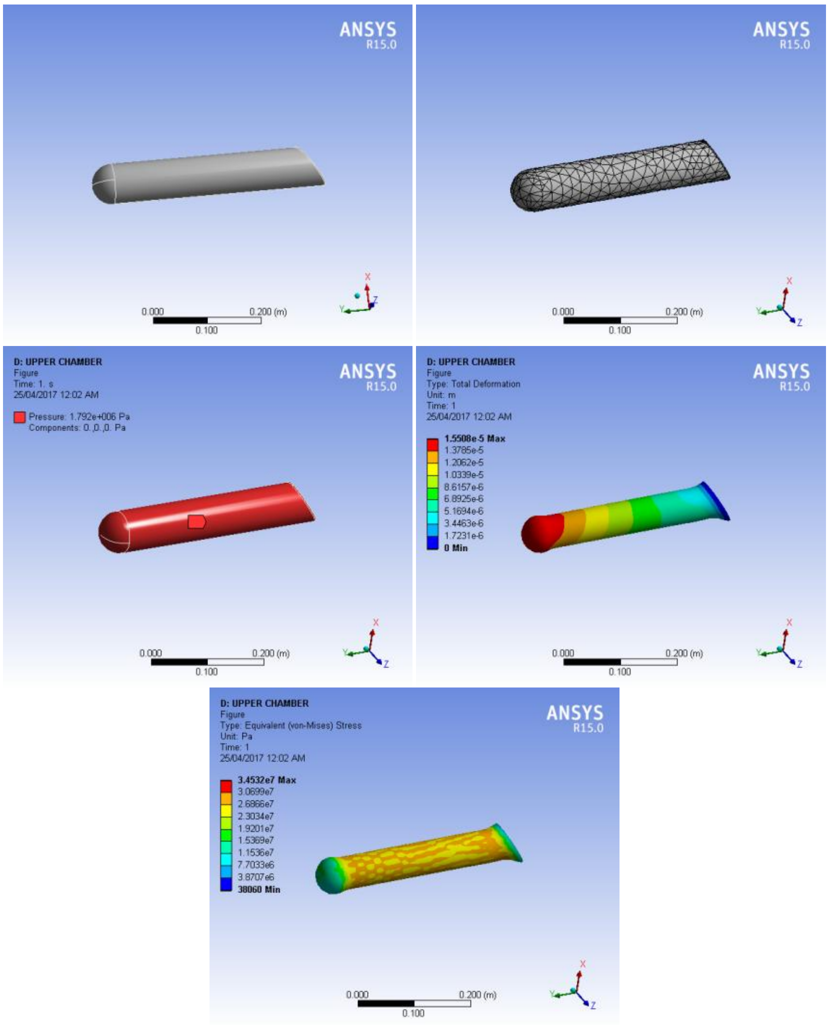
Volume = $(\frac{\pi}{4} \times 0.075^2 \times 0.55)\ 1.4$

= 1000 x 9.81 x 0.00340176

= 33.371 N

= 3.401 Kg

Since the results are in the pressure acting upon the sealed chamber is 2.03 bar but we have applied the pressure, which is ultimate bursting pressure i.e 17.92 bar. Hence for the factor of safety we have applied in the analysis.

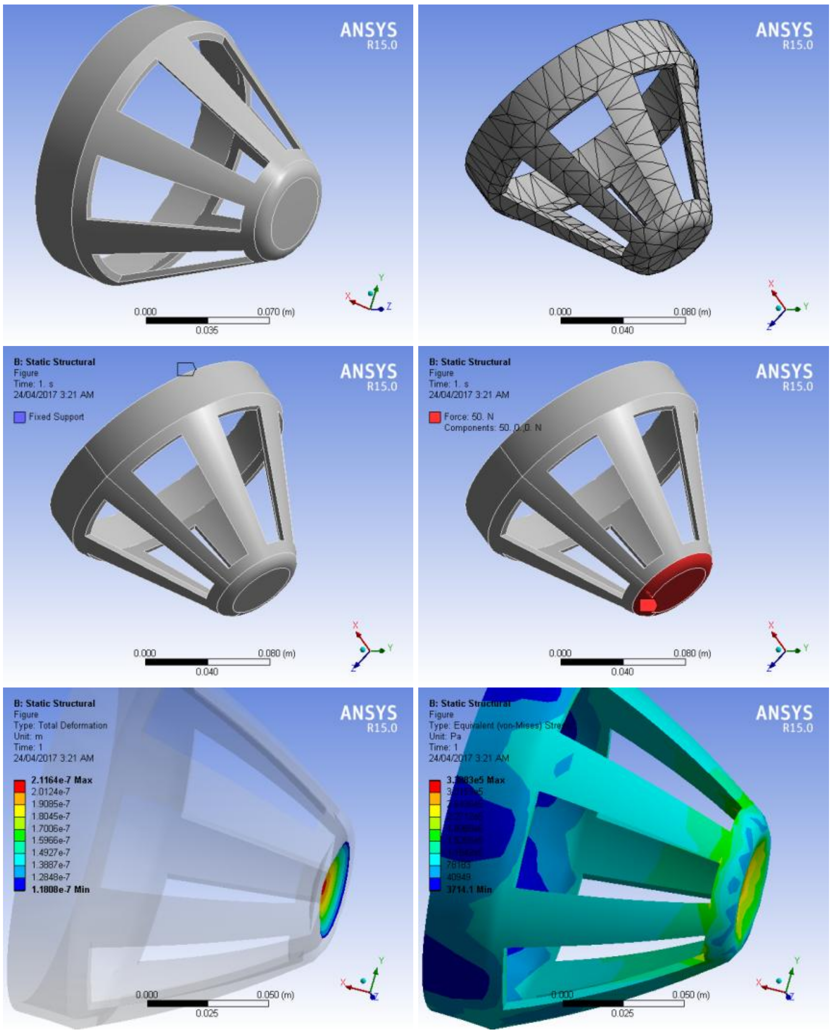


4.7 Analysis of upper chamber

component	Permissible stress	Induced max stress	Fos	Total deformation
Upper chamber	240	34 MPa	7	0.001 mm

4.8 Dome

Since it will also be under the impact force hence we are applying 50 N to front dome analysis.

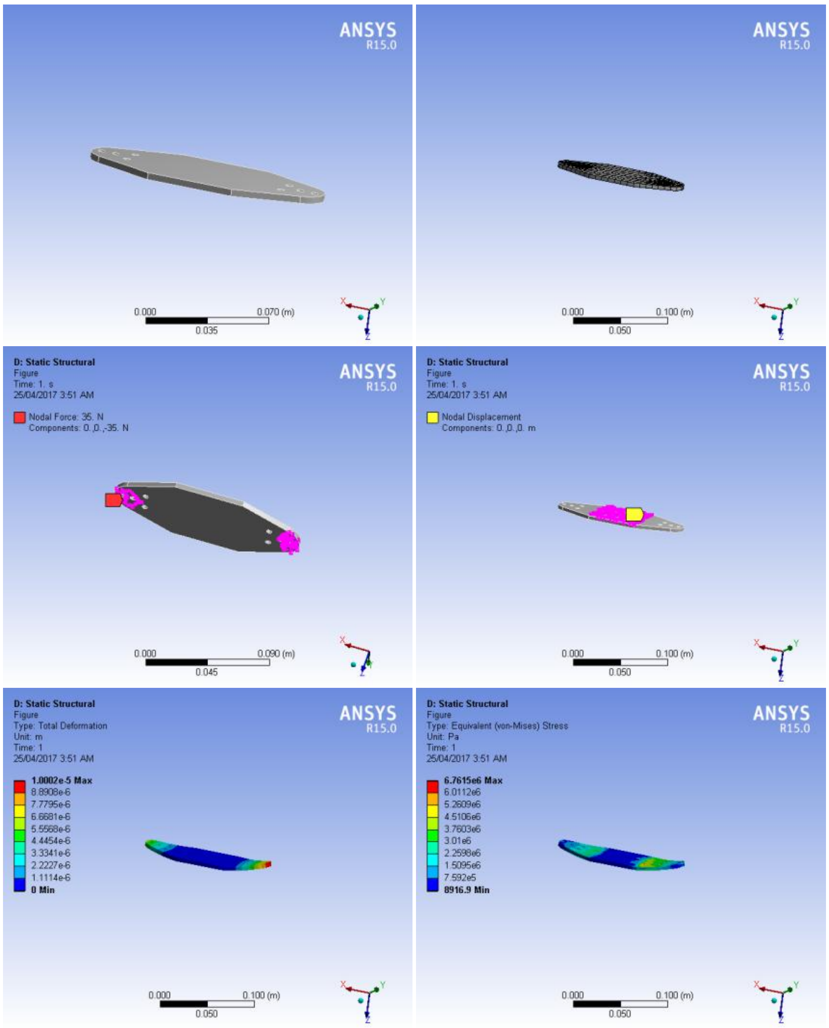


4.8 Analysis of dome

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	280 MPa	33.3 MPa	8	0.0002mm

4.9 Steering base

It is the piece of acrylic which is under loading of 20 N hence we fixed the mid section of the base of steering system and applied the load of 20N on the mounting area of knuckle



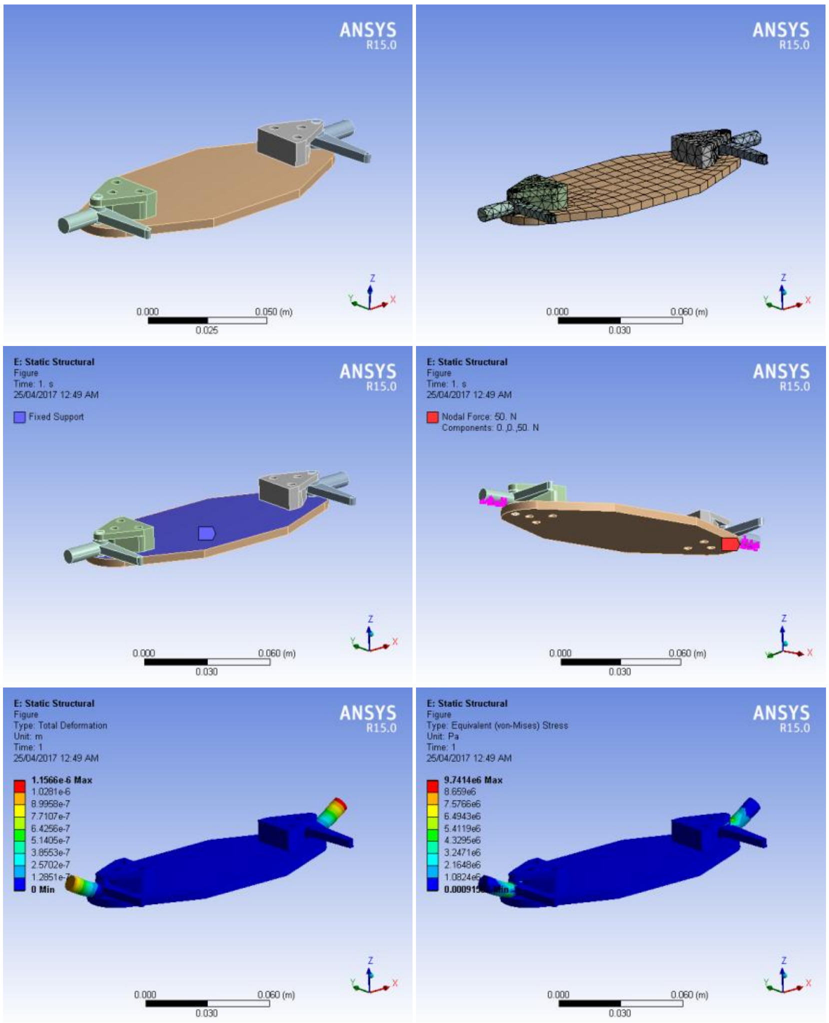
4.9 Analysis of steering base

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	140 MPa	6.76 MPa	20	0.0102mm

4.10 Steering system

In this analysis the whole steering system is under loading of 40N, hence we have fixed the whole base plate and applied the load on knuckle in axial loading in upward direction.



4.10 Analysis of steering system

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	140 MPa	9.71 MPa	14	0.00115mm

4.11 Rudder

Drag at Rudder

Area = (0.018 x 0.010) sin (45)

= 0.012727 m^2

Drag=½xS x A x V^2x Cd

= 0.5 x 1.025 x 0.012727 x 0.1 x 0.95

= 0.0006197 Kg   At V = 0.1 m/s

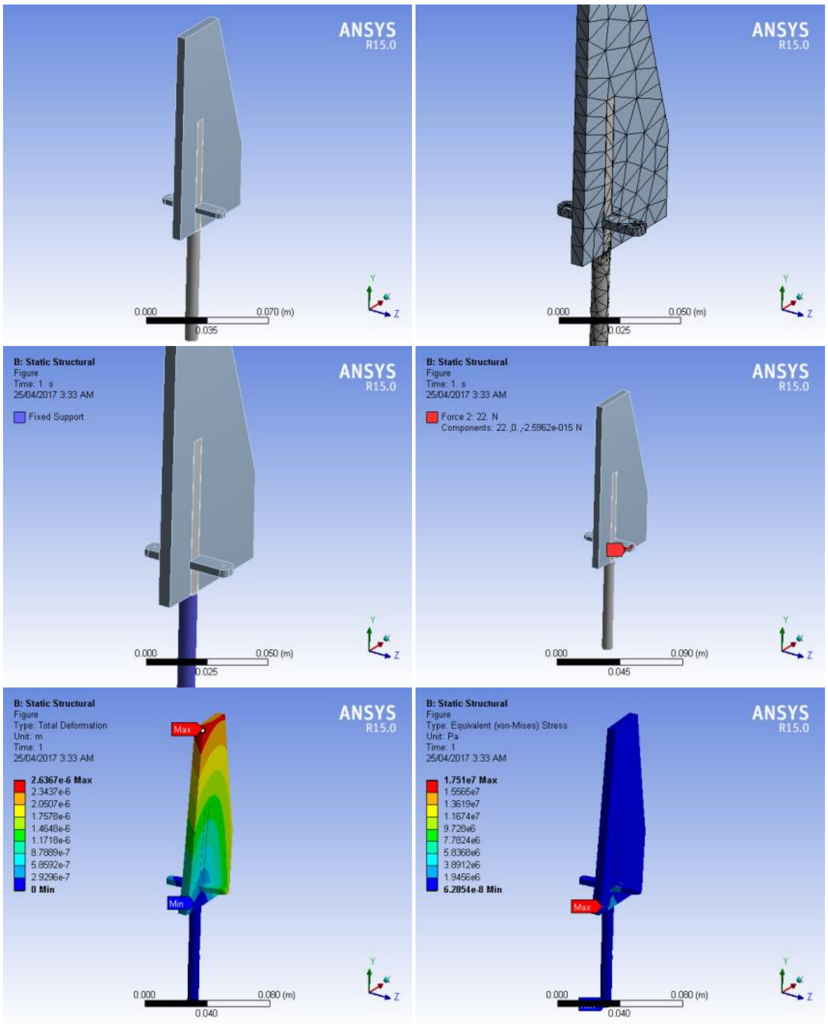
= 0.001239 Kg   At V =0.2 m/s

= 0.001859 Kg   At V =0.3 m/s

= 0.002479 Kg   At V =0.4 m/s

= 0.003099 Kg   At V =0.2 m/s

The rudder is made up of acrylic of 8 mm. it will be under the drag of water hence we are getting the drag force derived from the fluid drag is 40 N. hence the lever on the rudder are fixed and applied the force on the whole area of the rudder.



4.11 Analysis of rudder

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	140 MPa	17.5 MPa	18	0.00026 mm

4.12 Elevators

Drag at Elevator

Area = (0.015 x 0.021) x sin (45)

= 0.02227 m^2

Drag = ½ x S x A x V^2 x Cd

= 0.5 x 1.025 x 0.02227 x 0.1 x 0.95

= 0.0010843Kg At V= 0.1 m/s

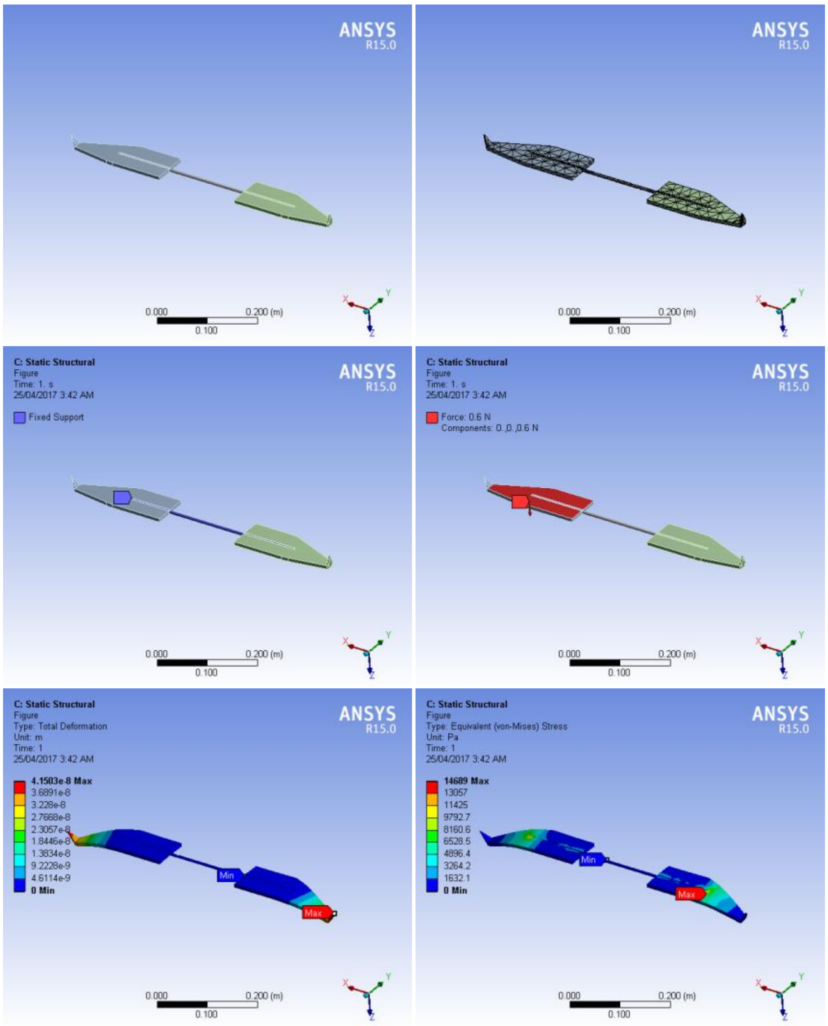
= 0.0021685Kg At V= 0.2 m/s

= 0.0032528Kg At V= 0.3 m/s

= 0.0043371Kg At V= 0.4 m/s

= 0.0054213 Kg At V= 0.5 m/s

The elevator is made up of acrylic of 8 mm. it will be under the drag of water hence we are getting the drag force derived from the fluid drag is 45 N on both side of the elevator. Hence shaft on the elevator are fixed and applied the force on the whole area of the elevator.



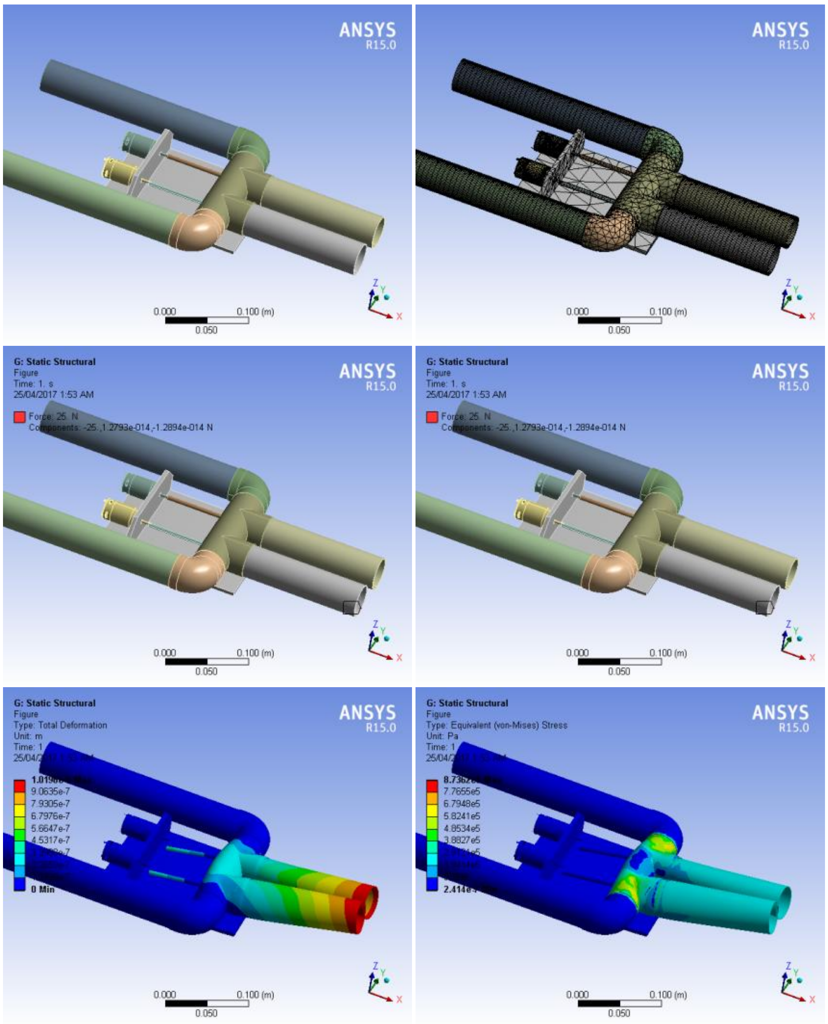
4.12 Analysis of elevator

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	140 MPa	1.75 MPa	180	0.00004 mm

4.13 Rear Jet

In this analysis the jet assembly is subjected to structural loading of 50N since it is the outer most assemble from rear hence in impact loading the force is applied as in case of body and dome, hence the elbows are fixed and the outer face of the jet outlet pipe is applied by 50 N.



4.13 Analysis of rear jet

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	280 MPa	8.5 MPa	32	0.0000126 mm

4.13.2 Rear jet (fluent flow)

Drag in Forward Motion

Drag=½ x S x A x V^2 x Cd [Reference: http://www.rov.org/rov_design_drag.cfm]

S=density of sea water

S=1.025

A= Cross-section area of the front

V= Velocity of ROV

Cd=Coefficient of drag range of 0.8 to 1 (Cd=0.95)

Drag =½ x 1.025 x 0.0225637 x 0.1 x 0.95

Area=$\pi/4 \times (0.075)^2 + \pi/4 \times (0.152)^2$

Area=$0.0225637 m^2$

Drag=1.09857×10^{-3} Kg At V =0.1 m/s

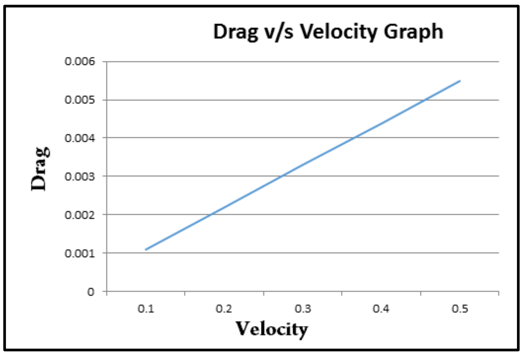
=5.49280×10^{-4} Kg At V =0.05m/s

=2.19710×10^{-3}Kg At V =0.2 m/s

=3.29570×10^{-3} Kg At V =0.3 m/s

=4.39428×10^{-3} Kg At V =0.4 m/s

=5.49285×10^{-3} Kg At V =0.5 m/s



4.14 drag v/s velocity graph

Thrust Produced by Thrusters

$$Thrust = \frac{\rho \text{ x d2 x P x N}}{\pi 6}$$

Thrust = 1000 x 0.036^2x 0.022 x 2000 / π^6

= 0.05932 Kg At N= 2000 rpm

= 0.11862 Kg At N= 4000 rpm

= 0.17794 Kg At N= 6000 rpm

= 0.23725 Kg At N= 8000 rpm

= 0.29657 Kg At N= 10000 rpm

= 0.35588 Kg At N= 12000 rpm

= 0.415199 Kg At N= 14000 rpm

= 0.47451 Kg At N= 16000 rpm

= 0.53382 Kg At N= 18000 rpm

Total Horizontal Thruster for Forward Motion is 4

Thrust at 2000 rpm = 0.059314 x 4

= 0.23724 Kg

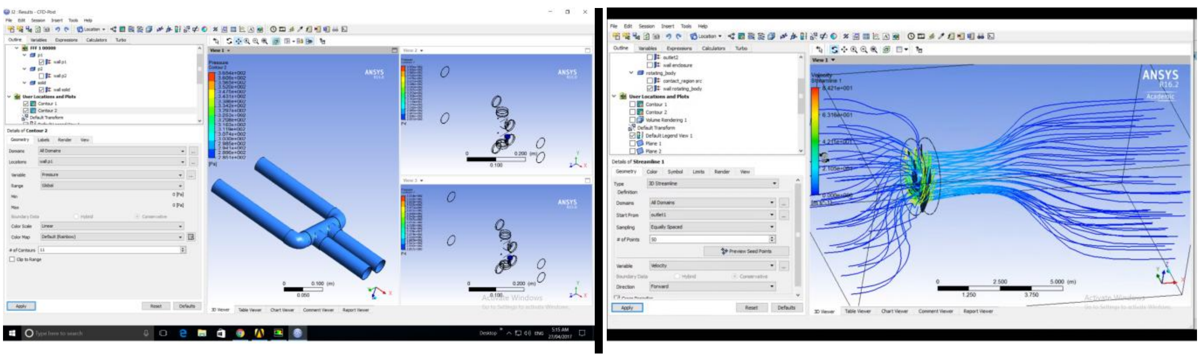
Drag = 0.0010985 Kg

Thrust > Drag

Therefore HROV will move Forward overcoming the Drag

Hence Drag Overcomes

In this analysis the rear jet is subjected to fluid flow analysis. The propeller is made under the casing with two inlet pipes with two outlet pipes. All the casing and pipes are under the confined Boolean. The velocity of jet prop is 32.98m/s.



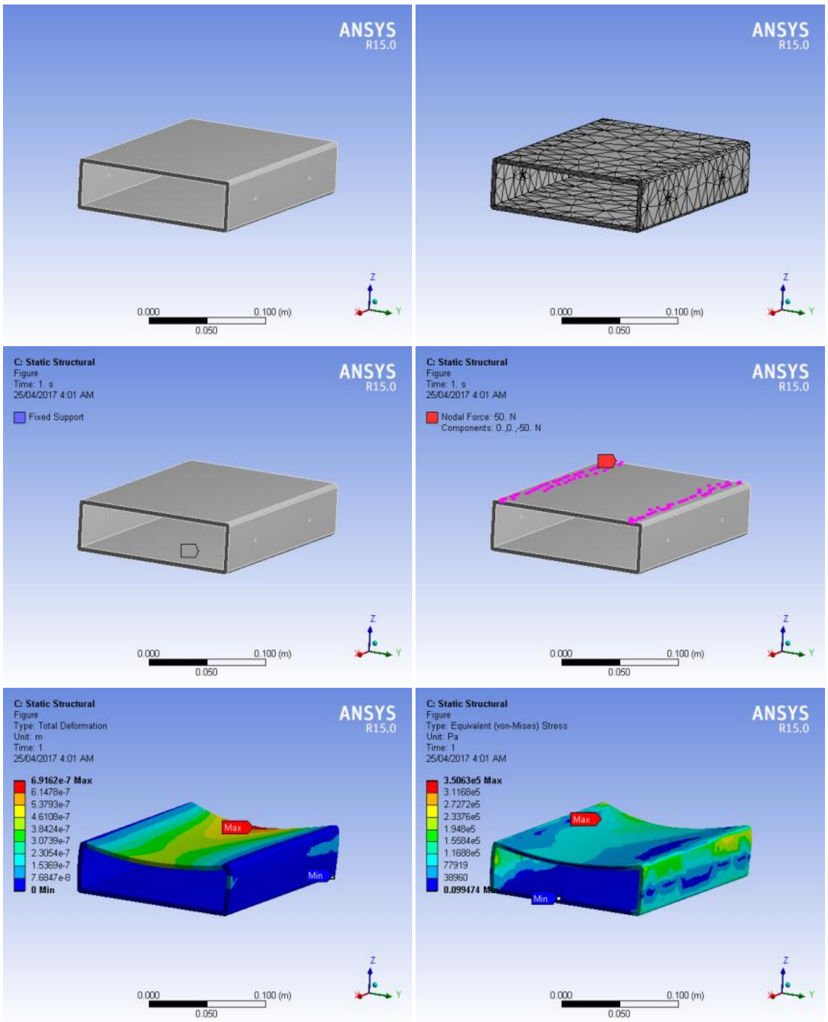
4.15 Analysis of rear jet flow

Hence we got the results in terms of pressure at the propeller and velocity through the inlet and outlet pipes.

Component	Pressure (bar)	Velocity (m/s)
Propeller	0.030654	8.421

4.14 Motor Box

In this analysis the motor box which is made up of acrylic is subjected to buckling load of 40 N hence we fixed the base of the box as fixed and upper face is selected for loading of 40 N.



4.16 Analysis of motor box

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	140 MPa	3.45 MPa	40	0.000069 mm

Motor Torque Calculation

[Reference: EML2322L – MAE Design and Manufacturing Laboratory]

▪ Gross vehicle weight: 4 Kg

▪ Weight on each drive wheel: 0.66 Kg

▪ Radius of wheel/tire: 40 mm

▪ Worst working surface: Sand

Total Tractive Effort = Rolling Resistance + Force required to climb Grade + Force required to accelerate to Final Velocity

Rolling Resistance = Gross Vehicle Weight x Surface Friction

= 4 x 0.06

= 0.24 Kg

Grade Resistance = Gross Vehicle Weight x Sin (Max. Incline Angle)

= 4 x sin(15)

= 1.03 Kg

Acceleration Force = Gross Vehicle Weight x Vmax / 10

= 4 x 1 / 10

= 0.4

Total Tractive Effort = 0.24 + 1.03 + 0.4

= 1.675 Kg

Determine Wheel Motor Torque = Total Tractive effort x Radius of Wheel x Coefficient of Friction

= 1.675 x 4 x 0.15

= 1.005 Kg-cm

Total wheel Torque required is 1.005 Kg-cm

Total No. Of Tires = 4

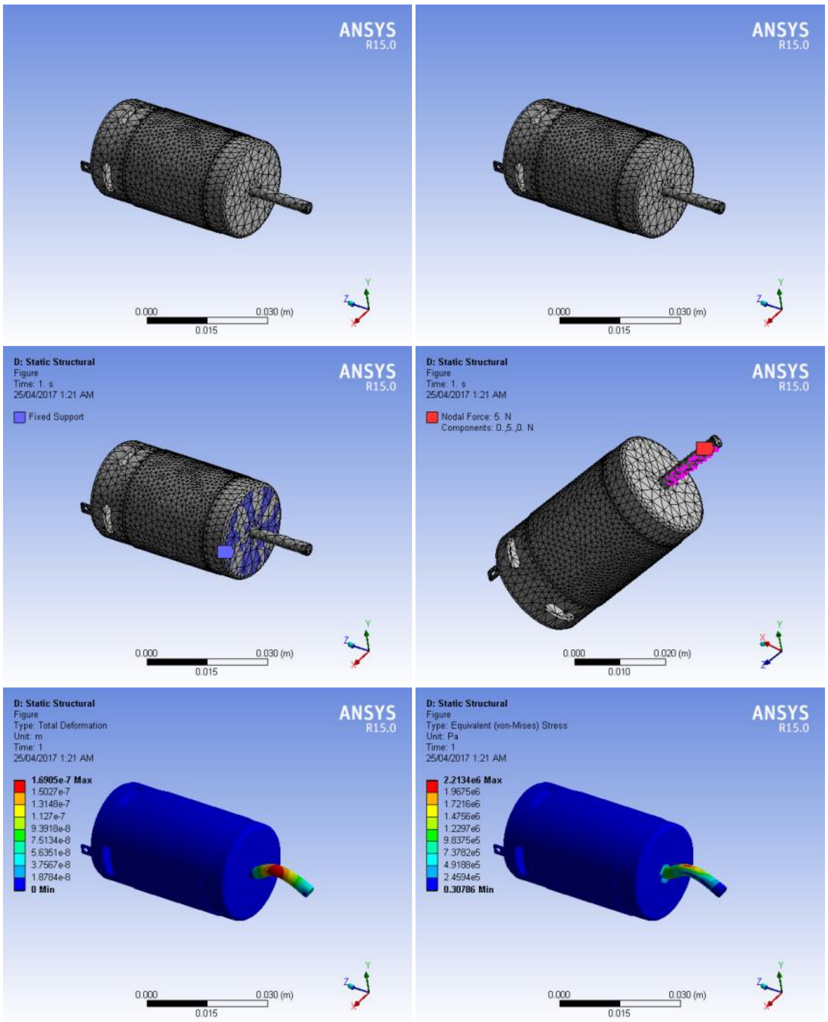
Total Torque required on each wheel = 1.005/4 = 0.25125

Torque available at each motor = 0.36 Kg-cm

Torque available at each motor > Torque required at each wheel

Therefore Vehicle can Starts its Motion Overcoming the Total Tractive Effort required at the initial stall condition.

Motor shaft which is made up of steel is under loading of torsion as well as the bending. The motor body is fixed and the shaft is under torsion of 0.36 kg-cm and loading of 6 N.



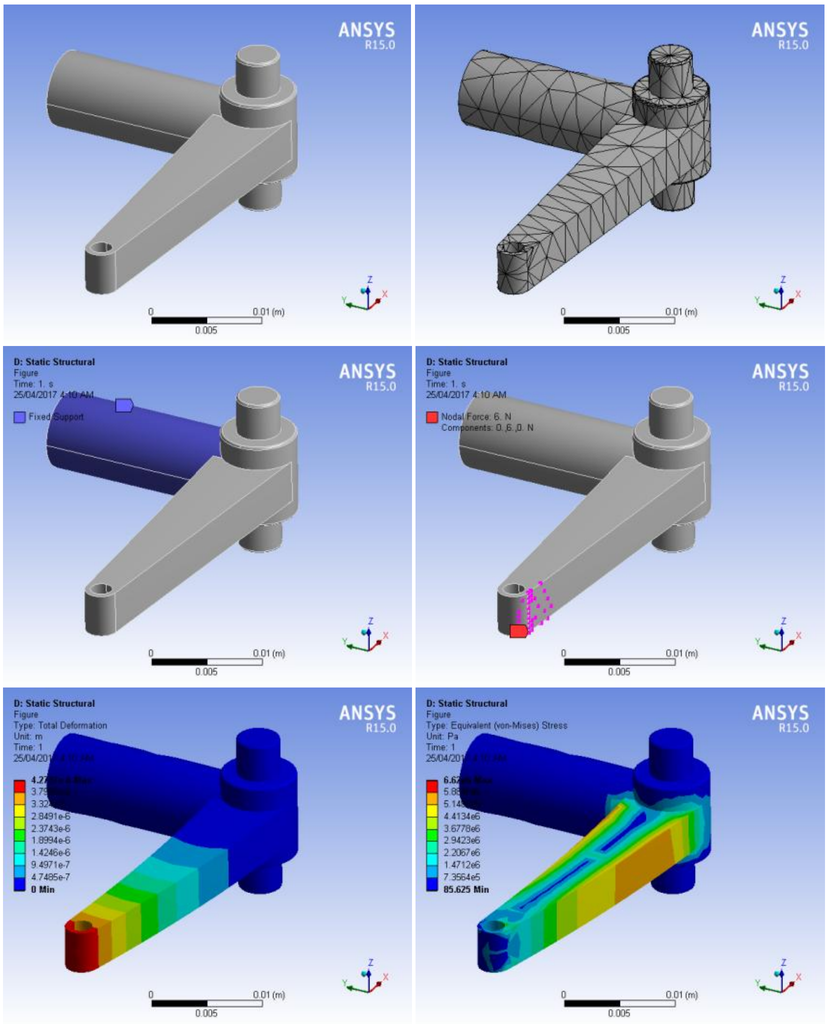
4.17 Analysis of motor

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	350 MPa	2.21 MPa	18	0.000176 mm

4.15 Knuckle

Knuckle is the component which is made up of acrylic and give the steering effort to tyre to steer the ROV. Hence we fixed the tyre shaft and applied the load on the steering/knuckle arm as 10 N.



4.18 Analysis of knuckle

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	140 MPa	6.626 MPa	21	0.0004226 mm

4.16 CG/Vertical Thruster

Drag Calculation for UP and DOWN motion inside the Water.

Drag=½ x S x A x V^2 x Cd

Area = (0.152x1) + (0.055x0.055) + (0.015x0.018)

Area = 0.15529 m^2

Drag=½ x 1.025 x 0.15529 x 0.05^2 x 0.95

Drag= 0.003781 Kg   At V=0.05 m/s

Drag= 0.007561Kg   At V=0.1 m/s

Drag= 0.011341Kg   At V=0.15 m/s

Drag= 0.015121Kg   At V=0.2 m/s

Thrust Calculation for UP and DOWN motion inside the Water.

Thrust = 1000 x 0.036^2x 0.022 x 2000 / μ^6

= 0.059314 Kg   At N= 2000 rpm

= 0.11862 Kg   At N= 4000 rpm

= 0.17794 Kg   At N= 6000 rpm

= 0.23725 Kg   At N= 8000 rpm

= 0.29657 Kg   At N= 10000 rpm

= 0.35588 Kg   At N= 12000 rpm

= 0.415199 Kg At N= 14000 rpm

= 0.47451 Kg   At N= 16000 rpm

= 0.53382 Kg   At N= 18000 rp

Total Vertical Thrusters for UP and DOWN Motion = 2

Thrust at 2000 rpm = 0.059314 x 2

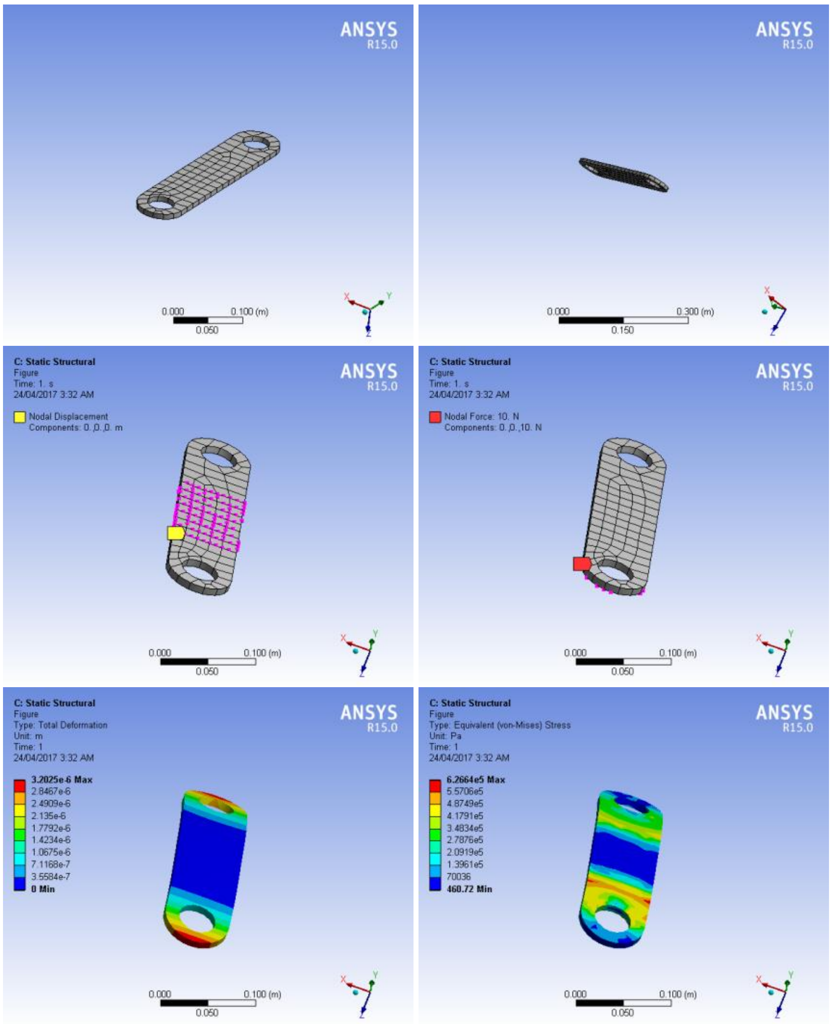
= 0.118628 Kg

Thrust > Drag

Therefore HROV will move downward overcoming the Drag

Hence Drag Overcomes

The CG thruster/vertical thruster is made up of acrylic and two jets is mounted to either side of it. Hence we fixed the area under the body and applied the load which is derived from thrust of jet as 20 on each side.



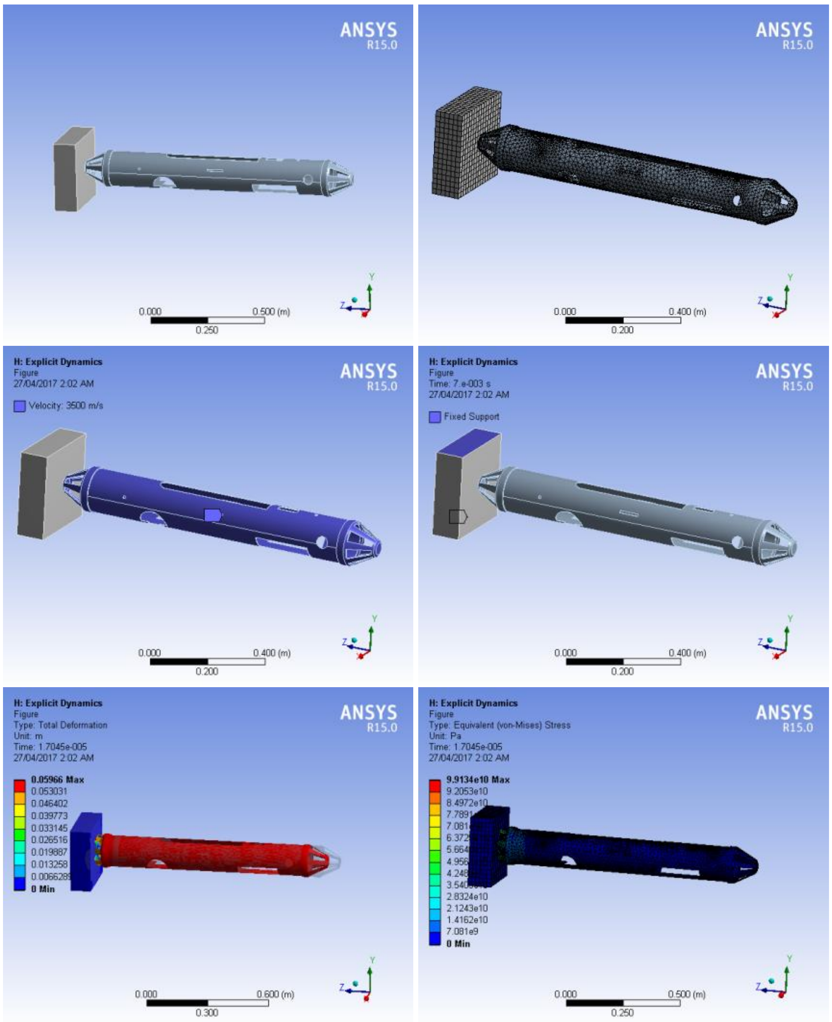
4.19 Analysis of thrusters

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	140 MPa	6.2665 MPa	22	0.0003205 mm

4.17 Crash Analysis

In this analysis the body is subjected to crash analysis. When the body is moving with the velocity of 3.5m/s and gets crashed with a rigid element (wall).



4.20 Analysis of crash

Hence we are getting the following results

component	Permissible stress	Induced max stress	Fos	Total deformation
Front Dome	250 MPa	54 MPa	5	0.0082 mm

4.18 CAD model

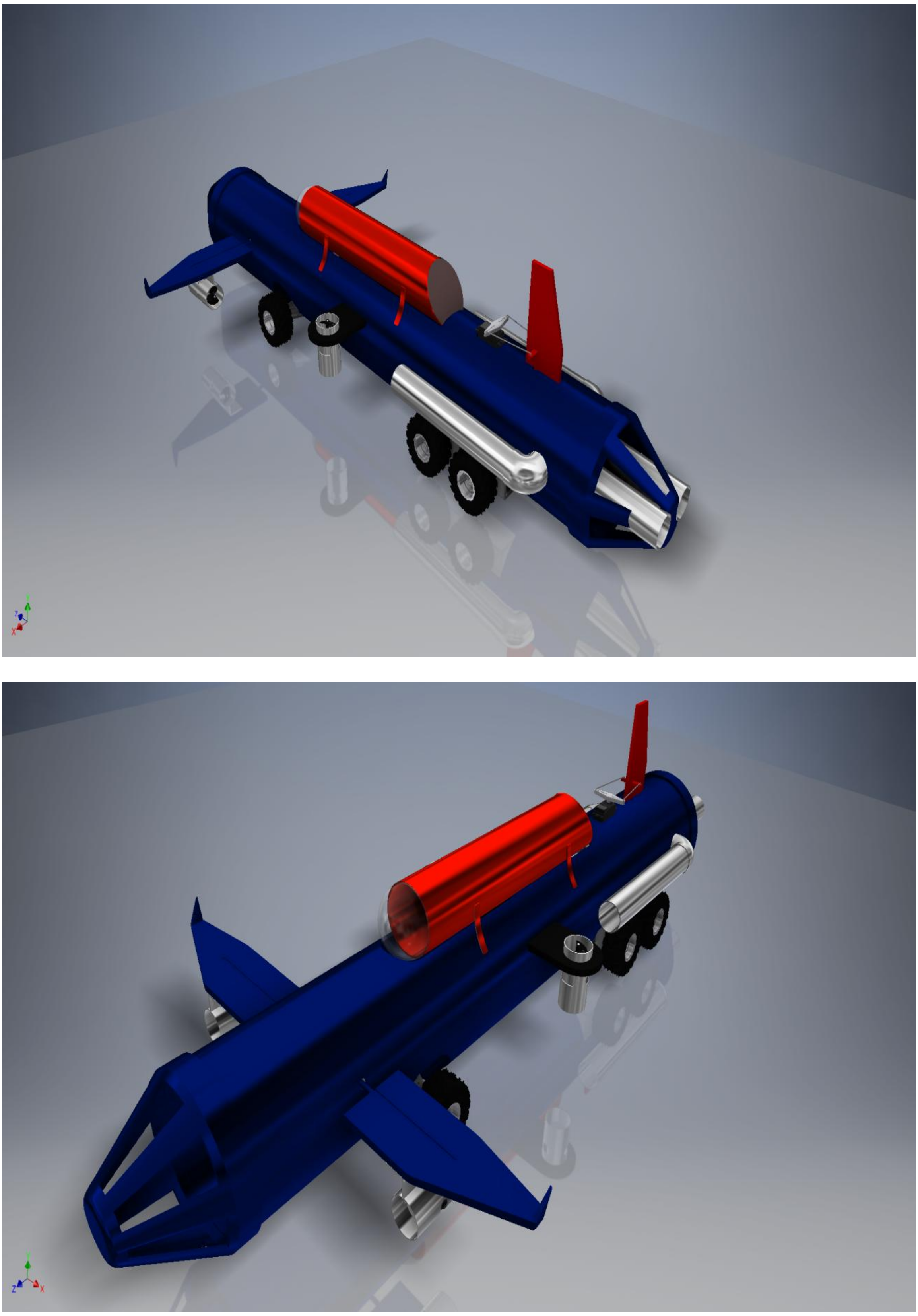


Fig 4.21 CAD model

CHAPTER NO.:- 05

FABRICATION

FABRICATION OF HROV

5.1 Objectives

1. Designing, creating and maintaining manufacturing systems and processes
2. Understanding of production procedures, creative problem solving skills
3. Compare differences between CAE and hands-on product assembly

5.2 Stages of fabrication: the project has been made in different stages which are as follows:

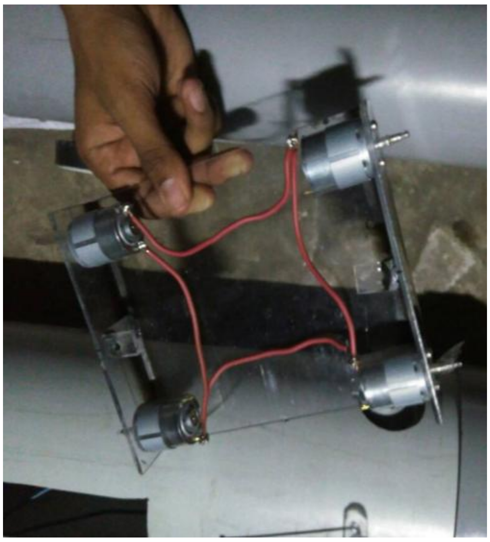
Stage 1 PVC body frame making

The HROV has"CYLINDER-SHAPE" appearance.The PVC pipes of schedule 40 as per the literature review. The material that used the lowest cost and with the best Depth to Cost Ratio was selected. The material PVC was given the shape of HROV as per the design invented in Inventor software. The 6 inch pipe and 4 inch of PVC was first dipped in the water to check the material strength and leak proofing. Accordingly to the design PVC pipe was cut to the dimensions by the Hand Grinder and the Hack Saw.

Fig: 5.1 body frame of HROV

Stage 2 Steering System and Power Transmission to Tires

The steering system consists of 2tires on the front side of the HROV and 4tires on the rear side. The rear side was mainly used for power transmission for the tires. Each tire is attached to the DC motor 3500 rpm. The rectangular box type used for the rear tires mounting is of acrylic sheet of 4mm thickness on which the dc motors are mounted. The front steering system is also have base plate of acrylic sheet shape of rectangular with the ends V-type shape .At the end three drills are made to ensure that the tires mounting will easily fit and one for the tilting the tires with the help of servo motors. The Servo motors used and it is so attached that it can fulfill the need of steer the tires.



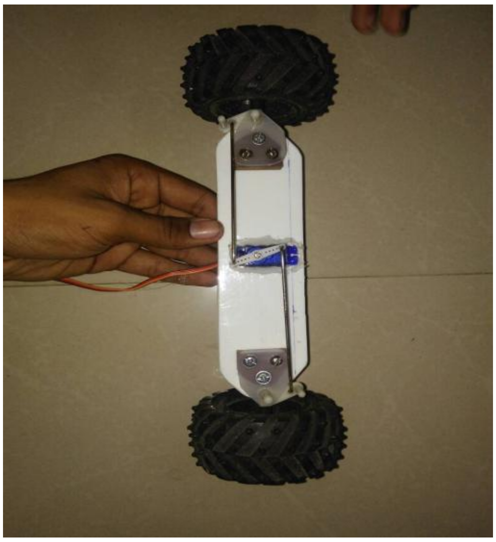


Fig 5.2 steering mechanism of HROV

Stage 3 Jet Thrusters

The Jet Thruster is a maneuvering system based on water pressure. An electric pump suctions water underneath the boat with large volume through hoses or pipes and is forced into small outflow openings. The jet thruster system does not need large holes cut into the ROV, but relies on small jet nozzles mounted in the body frame. To achieve the maximum speed of HROV we designed the jet thrusters. The jets consist of two thruster of two DC motor attached to two propellers respectively. While fabricating we cut the circular section of diameter 40 mm at the end of the ROV body frame. The T-section PVC as selected and we joined both .The each t-section consisted of one DC motor with the propeller for the trust effects. The both section was joined with the best fitting PVC pipe at the ends of the HROV body frame. The water will be entering from either side of the pipe and will exit from the rear end.

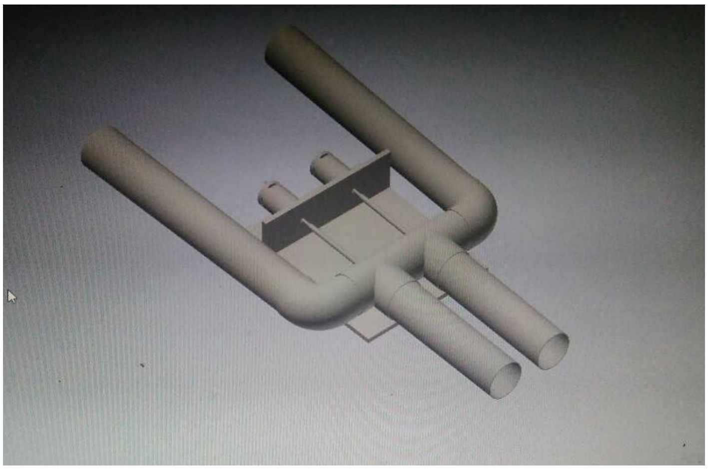


Fig 5.3 cad model of jet

Stage 4 Elevators and Rudders

Elevators are used to change the altitude of ROV in the water. An increased downward force, produced by up elevator, forces the rear portion down and the front portion up. At constant speed, the increased wing angle of attack causes a greater lift to be produced by the wing, moving the HROV upwards. The drag and power demand also increase or decreased downward force at the rear, produced by down elevator, allows the rear to rise and the front to sink. At constant speed, the decrease in angle of attack reduces the lift, accelerating the aircraft downwards. Elevators consist of acrylic sheet of 8mm thickness of flat shape. Elevators of HROV are connected by means of single shaft on both the side of diameter 5mm. The shaft is attached to the servo motor by means of base plate. When the supply of power is given to the servo motor, the elevator will start to tilt by means of lever. The elevators are also having thruster on both the side of elevators and it is use to change the altitude and also provides additional thrust to change the altitude. Elevator end is bent upward known as winglets for the aerodynamic purpose and to reduce turbulence over the elevator.

Fig 5.4 elevator of the project

A rudder is a primary control surface used to steer a ship, boat, submarine, hovercraft, aircraft, or other conveyance that moves through a fluid medium (generally air or water). A rudder operates by redirecting the fluid past the ROV (watercraft), thus imparting a turning motion to the ROV. In basic form, a rudder is a flat plane or sheet of acrylic material attached with hinges to the craft's stern, tail, or after end. Often rudders are shaped so as to minimize hydrodynamic or aerodynamic drag. On simple ROV, a tiller essentially, a stick or pole acting as a lever arm is attached on the lower side of the rudder to allow it to be turned by a controller. Rudder main function is to change the direction of the HROV in the water. The rudder is also made of acrylic sheet. It is mounted on top of the HROV on the rear side. The movement of HROV is controlled by servo motor geared type.

Fig 5.5 rudder and its mechanism

Stage 5 Vertical Thruster

A thruster is a propulsive device used by watercraft for station keeping, altitude control for long-duration, low-thrust acceleration. Underwater Thrusters where DC motor and propeller combined in single unit to propel the ROV. In HROV there are 2 vertical thrusters for the movement of HROV in vertical direction. Casing is made for the thruster. The casing is attached on the CG of HROV, on both the sides. Thruster consists of DC motor and propeller attached to it. The mounting of thruster in casing is done with help of nut & bolts. The main function of this thruster is to control the altitude of HROV. The DC motor of 18000rpm is connected to the esc which is used to help to control the speed of propeller.

Fig 5.6 vertical thrusters

Stage 6 Wiring

An electric circuit is like a pathway made of wires that electrons can flow through. A Li-po battery of 1800 mAh is provided to give the power supply to all the electrical system, like receiver, dc motor, and servo motors. In the electrical circuit Electronic speed controller (ESC) is provided for each dc motor system, which get connected to receiver to provide the current according to the desired speed. For servo motors, it is only connected to the receiver and it gets the electrical power source the receiver. The receiver has power supply since it is connected with esc; hence it provides 5 volts to the servo motor. There are 3 esc's provided, one for the power transmission motor box which will provide the tractive effort to tires, one for the jet thrusters and one for the vertical thruster. Each servo of elevator, rudder and steering system are connected to the receiver at remaining desired channel.

Fig 5.7 wiring

Stage 7 Assembly

After all the fabrication of all the components and wiring of the HROV it is now to assemble all the components in their order and location. Firstly all the components parts where painted with the acrylic paint which is best suited for it. After painting all the dc motors where placed in their respective location and position. Most of the components where transition fit which ease for assembly. According to design, step by step all the components where placed in their location. The PVC pipe of 4inch housing consists of Lipo battery and esc. The nuts and bolts where tightened and all the components where fixed systematically. The tires were attached to the shaft of the dc motors and steering system accordingly.

Fig 5.8 final assembly of project

CHAPTER: - 06

COST ESTIMATION

6. COST ESTIMATION

Cost estimation may be defined as the process of forecasting the expenses that must be making, tool, making as well as a portion of the general administrative and selling costs.

6.1 Purpose of cost estimating

1. To determine the selling price of a product for a quotation or contract so as to ensure a reasonable profit to the company.
2. Check the quotation supplied by vendors.
3. Determine the most economical process or material to manufacture the product.
4. To determine standards of production performance that may be used to control the cost.

6.2 Basically the budget estimation is of two types:

1. material cost
2. Machining cost

6.2.1 Material cost estimation:

Material cost estimation gives the total amount required to collect the raw material which has to be processed or fabricated to desired size and functioning of the components.

These materials are divided into two categories.

1. Material for fabrication: In this the material in obtained in raw condition and is manufactured or processed to finished size for proper functioning of the component.
2. Standard purchased parts: This includes the parts which was readily available in the market like Allen screws etc. A list is forecast by the estimation stating the quality, size and standard parts, the weight of raw material and cost per kg. for the fabricated parts.

6.2.2 Machining cost estimation:

This cost estimation is an attempt to forecast the total expenses that may include to manufacture apart from material cost. Cost estimation of manufactured parts can be considered as judgment on and after careful consideration which includes labor, material and factory services required to produce the required part.

6.3 Procedure for calculation of material cost

The general procedure for calculation of material cost estimation is

1. After designing a project a bill of material is prepared which is divided into two categories.
   a. Fabricated components
   b. Standard purchased components
2. The rates of all standard items are taken and added up.
3. Cost of raw material purchased taken and added up.

6.4 Labour cost:

It is the cost of remuneration (wages, salaries, commission, bonus etc.) Of the employees of a concern or enterprise.

Labour cost is classifies as:

1 Direct labour cost
2 Indirect labour cost

6.4.1 Direct labour cost:

The direct labour cost is the cost of labour that can be identified directly with the manufacture of the product and allocated to cost centers or cost units. The direct labour is one who counters the direct material into saleable product; the wages etc. of such employees constitute direct labour cost. Direct labour cost may be apportioned to the unit cost of job or either on the basis of time spends by a worker on the job or as a price for some physical measurement of product.

6.4.2. Indirect labour cost:

It is that labour cost which cannot be allocated but which can be apportioned to or absorbed by cost centers or cost units. This is the cost of labour that doesn't alters the construction, confirmation, composition or condition of direct material but is necessary for the progressive movement and handling of product to the point of dispatch e.g. maintenance, men, helpers, machine setters, supervisors and foremen etc.

The total labour cost is calculated on the basis of wages paid to the labour for 8 hours per day.

Cost estimation is done as under

Cost of project = (A) material cost + (B) labour cost + (C) indirect cost

(A) Material cost is calculated as under :-

i) Raw material cost

ii) Finished product cost

Hence the cost of material is as follows:

Table 6.1

Parts	Quantity	Cost	Total Cost
1800mAh 3S Lipo Battery Pack	2	1400	2800
Lipo Battery Charger/ discharger	1	600	600
4 mm gold connectors (10 pairs)	50	2	100
6" Diameter Sch. 40 PVC pipe by ft	4	75	300
40 mm Diameter PVC pipe by ft.	3	15	75
4" Diameter Sch. 40 PVC pipe in ft.	3	50	150
DC Motors (18000 rpm)	4	160	640
DC Motors (3500 rpm)	4	120	480
Tires(tubeless off road tires)	6	60	360
Sealing proof products(araldite, m-seal)	3	100	300
Acrylic color	10	100	1000
Servo motor	3	300	900
ESC(3’ Pin 12V motor controller)	3	680	2040
Clear acrylic by sq.ft	8	100	800
6 channel transmitter/ receiver	1	3500	3500
PVC 6" cap	2	200	400
Wire in mt.	6	15	90
Propeller	6	20	120
Jumper wire	4	120	480
Miscellaneous	-	-	3500

Direct cost (b):-

Table 6.2

SR. NO.	OPERATION	HOURS	AMOUNT
1.	Turning	5	-
2.	Drilling	5	200
3.	Cutting	10	200
4.	Grinding	8	600
			1000/-

Indirect cost (c):-

Transportation cost = Rs.1000

Project report cost = Rs.2000

C = Rs.3000

Total cost

STD Parts Cost + Direct Labour Cost +Indirect Cost

= A + B +C

= 18635+1000+3000

= **22635/-**

CHAPTER: - 07

FUTURE SCOPE OF ROV

FUTURE SCOPE OF ROV

The ROV of the future will have increased intelligent autonomous behaviour and will use logic driven circuitry for routine tasks like turning valves, pulling and installing flying leads, inspecting assets for integrity, installing nodes. They will also posses better sensors, more dexterous manipulators and tooling along with thin fibre optic umbilical ,that decrease the systems overall weight. More compact deepwater work class ROV are also beginning to increase in number and are interesting for work that does not require carrying heavy payloads. The cost for development and deployment of advanced robotics for deepwater applications is forecast to decrease along the next decade, as the number of operational deepwater ROV increase.

Completely or partially autonomous ROV or HROV are already a reality, these will eventually have a high durability on-board power supply to make long duration dives viable, in-built control and navigation systems as well as full data-logging capability. With this the capital equipment costs would decrease, along with reduced support ship costs. In almost all of today's ROV, the umbilical or tether is identified as the single most restrictive item. If a ROV needs more power for a task then the umbilical grows, hydrodynamic drag increases and more power is required. The challenge here is for the non-umbilical ROV system to allow for the functions that the umbilical controlled ROV systems have. Deepwater docking systems for autonomous Hybrid ROV are also in the works, as these would allow charging batteries, uploads of data and downloads of new command parameters without bringing the HROV to the surface.

CHAPTER: - 08

Results and Conclusion

Results and Conclusion

The aim of this project was to design and construct a HROV from the start. In order for the project to be successful, all the right parts and components had to be found and put together properly. This was one of the parts during the whole process and took most the time and effort. During this project, some problems appeared. Most of them were solved, but not all of them. Therefore the project has a lot of space for further improvements. Even though the HROV does not have all intended features implemented, the system is functional at this point. Therefore, the main goal, constructing and controlling a small scale HROV, can be considered as accomplished. As further improvements, the ROV could have a temperature sensor that provide the temperature that is inside the water, and compass sensor that shows the direction of the ROV. This investigation has involved the design, construction and testing of a HROV and has allowed a more thorough understanding of key fluid mechanic principles be developed through application. Resistance testing confirmed most predicted theoretical fluid concepts as discussed and the HROV performed well in its operational testing hence further confirming the design and construction employed efficient hydrodynamic features. For the purpose of this project, a relationship between buoyancy, materials, propulsion, and size was determined. The fact that a neutrally buoyant ROV can be directed in all axes with the proper placement of thrusters made this option more appealing and cost effective The HROV proved to be capable of completing all task within a timely manner. Finally, a clear link can be seen between the findings within the detailed literature research and the choice of components, their dimensions, form and finish.

CHAPTER: - 09

REFERENCES

Journal Paper

- [1] David Smallwood1 , Ralf Bachmayer, 1999,"A New Remotely Operated Underwater Vehicle for Dynamics and Control Research"11th International Symposium on Unmanned Untethered Submersible Technology,pp.19-22,

- [2] Agus Budiyono*2009, "Advances in unmanned underwater vehicles technologies", Indian Journal of Marine Sciences , [E-mail: budiyono@alum.mit.edu], 38(3), pp. 282-295

Thesis

- [3] Andrew D. Bowen, Dana R. Yoerger ,Chris Taylor,2010" Field Trials of the Nere us Hybrid Underwater Robotic Vehicle in the Challenger Deep of the Mariana Trench "

- [4] Elgar Desa , 2006,"Researced on the Autonomous Instrumentation For oceanography" * National Institute of Oceanography, Goa, India

Miscellaneous

https://en.wikipedia.org/wiki/Remotely_operated_underwater_vehicle

http://www.noveltyjournals.com/download.php?file=Design%20and%20Fabrication%20of%20a%20Submarine-71.pdf&act=book.

https://en.wikipedia.org/wiki/Scorpio_ROV