Advantage Materials Letters (AML)

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Improving the performance of Tidal power

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Abstract— The tidal turbines need to be retrieved from the seabed, so in this project a design for a lifting device able to be attached to a lifting point on the top of the tidal turbine to lift it to the surface, where the design can be operated from above the surface. The device will be supplied by guidance system from the subsea, where the device will be securely connecting to the nacelle. The main factors will be considered in this design are ; the lif materials and dimensions where the lifting mechanism should be able to lift the weight of the tidal turbine approximately 20ton to the surface, and the guidance system design which should be 20m subsea. A new design for the mechanism of lifting was presented in this using solidworks software, and then the design was simulated using Finite Element Analysis. The finite Element analysis was obtained, by creating the suitable mesh size, and then the loads was applied to the design in order o find, the stress, the strain and the factor of safety.

***Keywords*— tidal, lifting, renewable**

I. INTRODUCTION

The modern world today is centrally dependent on electricity, and the global demand for power generation is increasing every day. Non-renewable sources of energy – mainly fossil fuels – dominate the energy supply everywhere. These sources have a lot of disadvantages owing to their limited sources, high costs, as well as rising greenhouse gas (GHG) emissions leading to environmental pollution and climate change. A lot of energy-based economies have therefore started to look towards renewable energy sources due to their huge potential of surpassing the energy demand across the world. Hydropower is one of the most widely used energy sources for sustainable electricity generation. In fact 16.6 percent of total global electricity generation with hydroelectricity was reported in 2015, which comprises 70 percent of all the electricity produced from renewable sources)[1] . Tidal energy is a hydropower form that has been not been explored much, and thus offer a great potential for the future power portfolio of this world. The reasons behind the limited use of this source has been low availability of sites with high enough tidal ranges or flow velocities, and higher costs.

There are also significant maintenance issues when it comes to tidal turbines, especially when they are deployed underwater [2]. In case of technical failure, collision of blade with marine organisms or sensor checks, accessibility becomes an issue. For checking up on subsea devices, the maintenance personnel either has to go underwater to perform their tasks, or have the devices brought to the surface. In the latter case the tidal turbines need to be detached from their subsea position and pulled up through a suitable lifting device. The purpose of the current project is closely related to such technology. Such technology is not inherently related to tidal turbine technology, but can be understood as an independent lifting mechanism. The literature will focus more on lifting mechanisms and developing such devices, rather than tidal power technologies. To follow a comprehensive design process for the lifting device, certain considerations

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about the tidal turbine system however has to be taken into account while going about the design process of such a lifting device. Before getting into technological developments, a better outlook on tidal power technology in terms of the operating turbines is necessary [3].

II. LITERATURE REVIEW

Tidal power is generated by using four main different methods – tidal stream generator (TSG), tidal barrage, dynamic tidal power (DTP), and tidal lagoon. The relevant generating technology to this project is the first method i.e. TSG. The kinetic energy of the water during tidal movements is used to rotate turbines installed and connected to a grid[2]. The turbines function similar to wind turbines in that they are powered by the kinetic energy of the medium and converts that into electricity. These tidal turbines can be installed horizontally, vertically, in the open, with ducts, or near the column of water at the bottom with the highest tidal velocities [3]. There are some drawbacks that seems to be the focus of relevant research and development work, which are:

- Tidal power has low capacity factor
- Sites with high tidal ranges and water velocities are limited,
- Installation and maintenance costs are high

The main advantages of tidal energy are the following:

- It is clean and non-polluting
- It is reliable
- It is completely predictable, unlike waves and wind.
- Offers a huge potential as a renewable energy source
- Helps reduce carbon emissions

Owing to these advantages, a lot of research has been continued for technology development in this area. Turbines are essential components of any power generation project, including for a hydroelectric dam or a tidal barrage. Tidal turbines are generally installed at points with high tidal current velocities and/or with strong ocean currents that flow continuously. This helps with optimum energy extraction by the turbines from the flowing water.

These turbines can be visualised as windmills running underwater, but with fast moving continuous ocean currents driving the rotors [4]. Since water is denser than air by factor of 832, the submerged tidal turbine rotors are made much smaller than wind turbines so that they are deployed much closer together to generate equivalent electricity.

Tidal turbines along with other equipment used to harness marine current energy face unique engineering challenges when it comes to their designing, installing and maintaining. This is further unique with the type of tidal power devices used. Table 1 provides a list of different types of tidal turbines and devices used, along with their features.

Table 1 - Different types of tidal devices [3].

Type of turbine	Features
Axial flow turbine	❖ Closest to traditional windmills ❖ Open or ducted ❖ Placed anywhere in water column, bottom mounting is done more often ❖ Main environmental concerns: collision between turbine blades and marine organisms, EM fields, noise, chemicals
Cross flow turbine	❖ Cylindrical shape, on horizontal axis ❖ Open or ducted ❖ Placed anywhere in water column, bottom mounting is done more often ❖ Less environmental concern in terms of collision between blades and organisms
Reciprocating device	❖ No rotating components ❖ Hydrofoil pushed back and forth through lift or drag by the flow ❖ Most commonly implemented: oscillatory devices ❖ Moves slower than turbines but more freely,

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	concerns on collision
Tidal Kite	❖ Cable tethered underwater kite at a fixed point ❖ Lifting a hydrodynamic wing by leveraging water flow ❖ Speed increase around turbine as kite flies through the water in a loop ❖ Kite is neutrally buoyant ❖ Collision concerns owing to free movement of kite
Archimedes Screw	❖ A helical surface around a ventral cylindrical shaft ❖ Generates energy with device rotation by up spiral movement of water ❖ Low noise and collision risk, but other issues like EM fields, physical systems, chemicals.
Tidal Lagoon	❖ Embedded retaining walls with reversible low-head turbines ❖ Turbines surround a large reservoir ❖ Function similar to traditional low-head hydrokinetic dam
Tidal Barrage	❖ Dams built across estuary ❖ Similar to low-head hydrokinetic dam ❖ Works in both directions ❖ Issues: construction impact ecosystem along shorelines, collision, noise, socio-economic

To understand tidal turbines better, focus can be on designing underwater turbines which are essentially the same thing. Fig.1 shows the different components of an underwater turbine below.

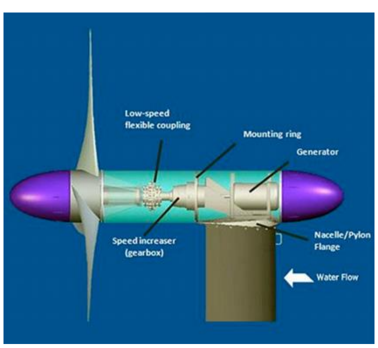

Figure 1 Underwater turbine components [5].

A basic understanding has already been addressed on these tidal turbines, so some literature is presented on their operation and maintenance. Lifting these turbines up from their subsea positions is an important part of the maintenance process. Much of the maintenance literature relevant to this project is therefore centred on this particular step.

Lifting Mechanism

Li and Florig (2006) focussed on tidal turbine technology as they analysed the economics of the operating multiple tidal turbines in an energy farm. The authors proposed a model for planning such a tidal turbine energy farm in terms of its operation and maintenance (O&M). Life cycle assessment was applied on the system that accounted for different time-dependent variables. Key parameters included operation and maintenance cost per unit energy production, power of the tidal current energy converter. The model took into account of all factors that affect the life and failure rate of the component which include:

- ❖ Environmental factors: weather, ocean conditions, and tidal flow speed
- ❖ Farm configuration factors: offshore distance, farm size, and device geometry
- ❖ Others: mechanical loading, transmission coefficients, electrical efficiency coefficient, component operational lifetime (nominal), and discount rates for labour and materials [6].

A numerical simulation was carried out with a case study involving a marine current turbine (MCT) potentially installed in a given site. Results showed that the O&M costs per unit energy can be brought down by deploying larger quantity of tidal turbines closer to the shore. This study indirectly allows an insight into the maintenance of tidal turbines. Other research have been continued to come up with newer technologies to ease down the O&M of tidal turbines, economically and otherwise.

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The tidal power device by TidalStream of UK for instance, boasted of a novel floating tidal stream generator to rectify tough maintenance issues of offshore marine turbine systems. Armstrong (2010) presented this concept known to be the Triton platform concept that ensured easy installation and simple maintenance. It was a 10 MW capacity system allowing an adaptable platform and installation of different types of turbines. The Triton platform system could use single pile, pinned located or gravity base foundation, at half of the cost of single installed tidal turbines with comparable energy costs. The said tidal power device is shown in Fig.2 below.[7]

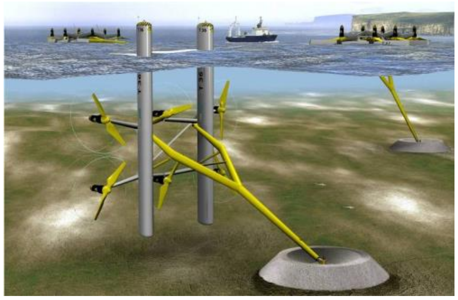

Figure 2 – TRITON: Tidal power device by TidalStream with 6 turbines [8].

Table 1 showed the type of tidal device, information on which is to be known for deciding the type of lifting device, in addition to detailed knowhow of the other design requirements of the latter itself. The most important design consideration for lifting mechanisms is knowing the required elevation or in this case – the depth. The depth at which the turbine is located, and how it will be pulled up needs to be known first – which is provided in project requirements already. The next thing to consider is the object orientation, i.e. what orientation will the object (tidal turbine) will be picked up [9]. The lifting mechanism is to be decided also based on if the tidal turbine to be lifted is required to stay in the same orientation that it was when picked up till it is brought to the surface. The joint in this case should suppress rotation, thereby act as a linear elevator. The next design consideration is to know the size of the object being lifted, then if it can lift the given weight without the joint getting strained in the process. The size and shape of the nacelle of the turbine in this case is to be taken into account. Then the complexity of the mechanism is to be accounted for; if a linear lifting mechanism is enough to lift the turbine up to the surface against the ocean currents and other external factors, then it is the best option owing to its simplicity. The following design consideration is to choose the motors or actuators involved in the pulling mechanism. Since the lifting device is assumed to be automated and not solely manually operated, power requirements of the device is to be decided in terms of the motor characteristics for example. Some commercially available lifting devices for this purpose are now discussed for a better reference, in addition to other relevant research articles.

ICF Marbek (2012) presented a review on some tidal power technologies reporting on horizontal axis turbine, vertical axis turbine, oscillating hydrofoil, venture, tidal kite, and other designs. The report was for the turbine manufacturing company Jupiter Hydro who had been making progress in the helical turbine technology that was claimed to be cost effective, reliable and efficient. The report addressed the used of crane barges for installation and maintenance particularly for lifting the power train from the structure for support. The maintenance costs rise significantly due to the submerged operation of devices, which makes maintaining the reliability of powertrain a challenging goal. The changing ocean weather moreover limits the accessibility of the devices. A failsafe method of retrieval was suggested in cases where the lifting mechanism failed. The latter is described to be equipped with reliable operation, fault diagnosis, and condition monitoring from remote location. The maximum capacity of the lifting device is an essential constraint in determining the mass of the structural components, each components not to weight more than 200 tonnes to result in an overall gravity based structure weighing 1000 tonnes. To take care of this constraint, the support structure is proposed to be in form of a steel frame

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consisting of 6 ballast blocks for support, resulting in improve turbine system efficiency [10].

Maksoud (2002) discussed some innovative lifting devices used in subsea operations. The issue at focus was on safe and efficient retrieval and repositioning of subsea equipment from the sea floor. One of the lifting devices addressed is the Zip-Lift which can be operated on remotely and can be used in any depth of water column. A novel double-zip-nut technology is used by this device which can be connected or disconnected robotically to the heavy loads [11].

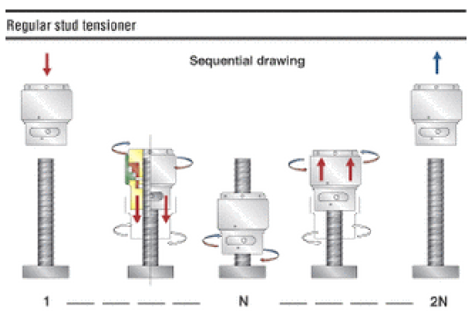

Figure 3 - Comparison of mechanics of zip stud tensioner with a regular stud tensioner [11].

The Zip-Lift features the push on/pull off stud tensioner which sets its mechanics apart from a conventional stud tensioner, as illustrated in Fig.3. Instead of having to rotate the nut around the bolt for securing it, the zip nut open its thread segments to let the bolt slip under it and then releases the segments to mate together without any rotation, thereby helping with saving space. This lifting device could be designed to lift 40 tonnes of load, while being applicable to various kinds of lifting activities. It had been tested as per ASTM A193-B7 standards with 11/4-in threaded rods, UNC threads with 16,500 lb rated handle. Endurance test of 700 cycles was successfully performed on the tool without failure [11].

Keynvor Morlift Limited (2012) produces marine heavy lifting machinery that aids in the installation of the tidal turbines of weights over 125 tonnes. Emergency contingency lift is also provided, in addition to turbine recovery from water, maintenance lifts, rotation lifts, and other miscellaneous service lifts. Fig.4 shows one such marine heavy lifting device transporting a turbine [12].

Figure 4 - A commercial lifting device in action [12]

In a report by Det Norske Veritas (2014), a good discussion is presented on lifting devices used in subsea operations. The main purpose of the report or document was to provide guidance and recommendations on operating parameters, technical challenges, risk management, engineering solutions, and maintenance and inspection, involved with subsea lifting operations. The documents suggests analysing all load and their effects during the planning and preparation phase of the lifting operation in accordance to recognised methods and environmental impact. Particular standards are to be adhered to when designing lifting equipment, important DNV standards being listed in Table 2. DNV Standard for Certification No. 2.22 or DNV STC 2.22 at the end is the relevant reference for the present design, although some of the other references are to be taken into account in the actual design process. Subsea operations may cover offshore Oil and Gas operations, offshore windmills, and wave power devices, in addition to tidal power technology. The basic design requirement for

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lifting device is more or less the same, only the load and environmental factors differ.[13]

Table 2 - DNV standards and service documents [13].

Reference	Title
DNV-OS-C301	Stability and Watertight Integrity
DNV-OS-E101	Drilling Plant
DNV-OS-E303	Offshore Fibre Ropes
DNV-OS-E407	Underwater Deployment and Recovery Systems
DNV-OS-H101	Marine Operations, General
DNV-OS-H102	Marine Operations, Design and Fabrication
DNV-OS-H204	Offshore Installation Operations (VMO Standard Part 2-4)
DNV-OS-H205	Lifting Operations (VMO Standard Part 2-5)
DNV-OS-H206	Loadout, transport and installation of subsea objects (VMO Standard Part 2-6)
DNV-RP-A203	Technology Qualification
DNV-RP-C204	Design Against Accidental Loads
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV-RP-D102	Failure Mode and Effect Analysis (FMEA) of Redundant Systems
DNV-RP-E301	Design and Installation of Fluke Anchors in Clay
DNV-RP-E302	Design and Installation of Plate Anchors in Clay
DNV-RP-E304	Damage Assessment of Fibre Ropes for Offshore Mooring
DNV-RP-H101	Risk Management in Marine and Subsea Operations
DNV-RP-H102	Marine Operations during Removal of Offshore Installations
DNV-RP-H103	Modelling and Analysis of Marine Operations
DNV Ship Rules	Rules for Classification of Ships
DNV STC 2.22	Lifting Appliances

Cowie (2015) from Ecosse Subsea Systems presented some new subsea heavy lifting technologies. A new concept of ambient lifting was introduced that accounted for subsea lifting and positioning, with a flexible mechanism that used incompressible gas facilitating the ascent, descent and underwater positioning control for offshore structures. It is claimed to be of simple build, with safe, robust and cost-effective design. Compared to traditional lifting appliances, ambient lifting devices can bring the cost by half, reduce weather risk, and increase choice of vessel. It has been recommended for Oil & Gas, Offshore wind, decommissioning, wave energy, and tidal energy [14].

Innovative lifting and handling solution for subsea applications are also provided by Baltec Lifting Solutions.Their lifting devices are designed to minimise human intervention and hence enable safe and reliable automation. Popular applications include renewable energy construction projects, deployment of subsea equipment, marine operations, engineering lifts, installing suction pile, single and multi-point lifts, and turret and buoy lifts. A much marketed tool is Baltec's LiftLOK^{TM} (shown in Fig.5), used for lifting heavy loads. It features a simple, robust and high handling and lifting capacity design that is based on ball and taper gripping mechanism [15].

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Figure 5 - The LiftLOK^{TM} lifting and handling tool [15]

A quick look at a couple of patents relevant to the present project should help with refined generation of design ideas. Ilfrey et al. (1979) had invented a marine riser system applicable for deep water drilling operations. Patented as US 4147221 A, it was a riser set-aside system that allowed its lower end to detach from the wellhead to enable the riser to be sided in a position clear of the wellhead. Suitable components are provided for guiding the riser between the wellhead and support. This device was designed to be operated from a floating vessel for offshore operations - primarily drilling, although the technology is relevant to lifting operations in tidal turbine systems. Fig.6 shows an elevated view of a schematic of this invention[16].

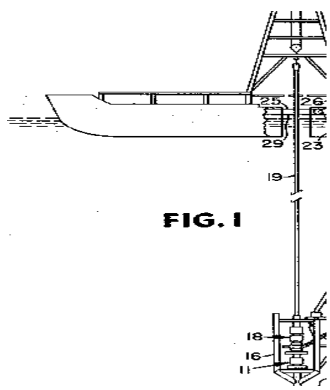

Figure 6 - Riser set-aside system from elevational view [16]

Rosman (1988) patented a hydraulic lift mechanism US 4761953A that is composed of charged hydraulic accumulator and vertically positional load actuator with a power integrator connected in between. A prime-mover link is also added with the power integrator that accommodates a preselected average load level. The mechanism is shown in a schematic layout of the hydraulic circuit diagram proposed in this invention along with a fragment of the electric-control circuit; the prime mover can be reversed, and a traditional car-lifting cylinder (jack) had been employed for the actuator[17].

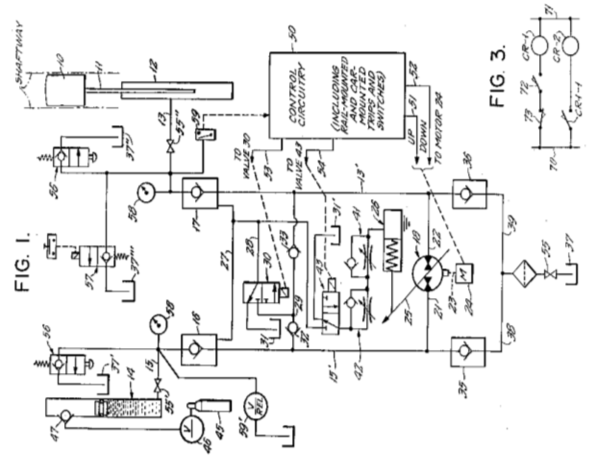

Figure 7 – Hydraulic and electric-control circuits of Hydraulic elevator mechanism [17].

Another noteworthy invention was by Grayson and Beak (1993) of attachment equipment that connected a load with a lifting mechanism. It was patented as US 5244243A, and featured a hollow annular body with a radial slot that extended from the body's periphery towards the central aperture. The locking connection involved a bolt being linked by a release mechanism operating on an actuating link.

US 6231265 B1 is another relevant patent filed by Rytlewski et al. (2001). It was a latching assembly with

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two mating portions that were restrained adjacent to each other with rotational relativity. It was self-aligning with the help of cam members mounted corresponding to the two portions that inter-fit with each other's profiles. Further inventions continue with on-going research on subsea lifting devices and mechanisms to increase the reliability, safety and efficiency of operation and maintenance of tidal power systems[18].

The present project can draw from this literature in terms of the design concepts, patent reviews and competitive features of commercially available products to establish verified design specifications, through a proper design method and investigation system.

III.RESULTS

The lifting of the tidal turbine is a big challenge, which has weight about 20 ton, so the cross sectional area of the lifting should be studied clearly . Where the tensile stress effect on such area

$$\sigma = \frac{F}{A}$$

Where

F: the tension force

A: the cross sectional area

σ : The tensile stress

The Permissible tensile stress can be calculated according to the yield strength of the selected materials as shown in the following equation ,

$$\sigma_{prem} = \frac{\sigma_y}{N}$$

σ_{prem}: The permissible normal stress

N: The factor of safety which will be taken as N= 8 for heavy loads [21].

σ_y : the yield stress

The yield strength was used for design criteria because the design should be operated in elastic region which means the plastic deformation in this design is not acceptable. The yield stress for each material was taken as the average value for the listed numbers in appendices which was selected using CES software. .

$$\sigma_y 1 = 525\ MPa$$

$$\sigma_y 2 = 425\ MPa$$

The force should be apply lifting mechanism of the turbine can be calculated as Norske

F = mg

Where the mass of the tidal turbine was taken as 20 tons

So

F = 20*1000*9.81 = 196.2 KN

Permissible tensile stress for each material is

$\sigma_{prem} 1 = \frac{525}{8} = 65.625$ MPa

$\sigma_{prem} 2 = \frac{425}{8} = 53.125$ MPa

So the cross sectional area for each material is

$$A = \frac{F}{\sigma_{prem}}$$

A1 = $\frac{196200}{65625000} = 2.99 \times 10^{-3}\ m^2$

A2 = $\frac{196200}{65625000} = 3.693 \times 10^{-3}\ m^2$

The diameter of the cable for each cross section can be calculated as

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D= $\sqrt{\frac{4A}{\pi}}$

So

D1 =0.0617 m or 0.062 m

D2 = 0.0686 m or 0.069 m

The first material will be used in this project , where this material has highest mechanical properties which is stainless steel martensitic, the diameter of the cable is 70 mm approximately .The designing of the gripper of the turbines was obtained using the following procedure . where the main parts of the suggested mechanism are

a) the cable joint
b) case
c) hydraulic system
d) levers
e) bearings
f) turbine top joint

The cable joint will be fixed at the top of the case as shown in figure 8. The dimensions of this joint were selected to get factor of safety suitable for designing as will be mentioned later in FEA section.

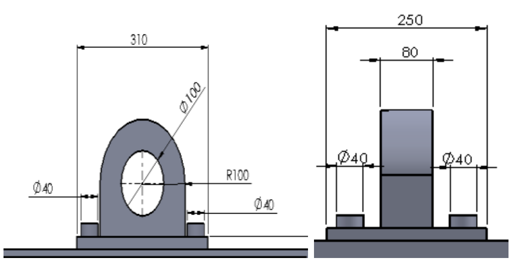

Figure .8: the cable joint dimensions

The case configuration was assumed as shown in figure (9), where the case will be connected with the cable joints and will carry the hydraulic mechanism, levers and should be suitable for turbine joint. The two vertical pipes in the figure are holders included bearings inside.

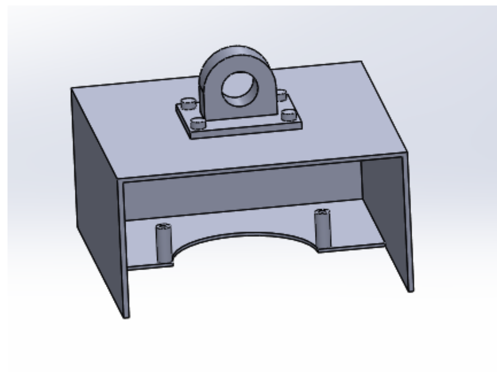

Figure .9: the cable joint dimensions

The lever mechanism was designed as shown in figure (10) which has two rotated arms will be used to be locked on the turbine top joint.

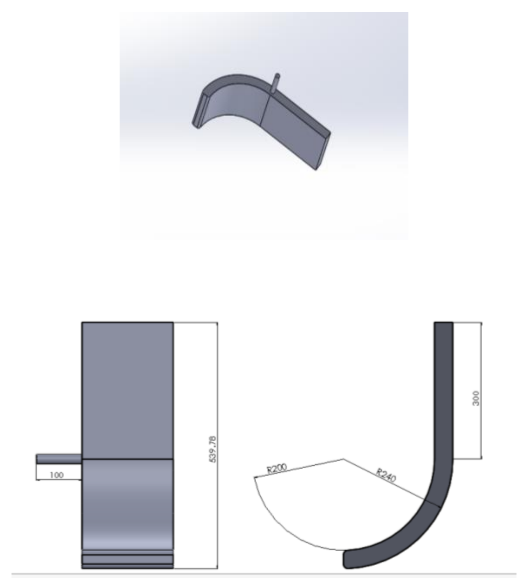

Figure .10: the arm levers

The hydraulic system will involve double acting piston to move the arms as shown in figure (11),

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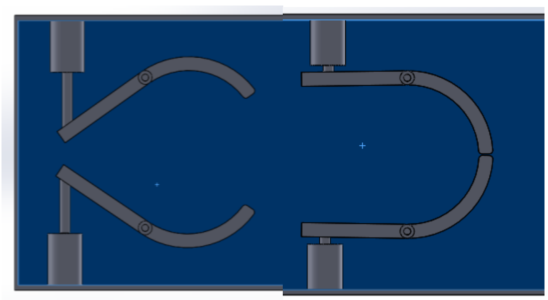
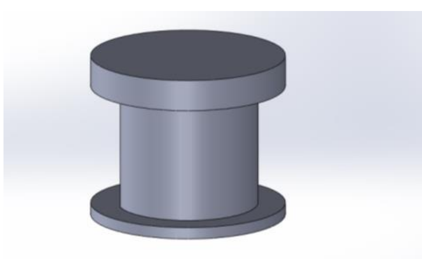


Figure .11: the arm levers movement with the hydraulic system

the moving of the arms should be consider according to the turbine top joint to be locked and loosen easily, so the opening of the arm should be greater than the diameter of the top turbine joint . Where figure (12) shows the design of the turbine top joint , as shown the thickness of the top part is higher than the base where this point was used to minimize the stresses effect on the suggested design, because the turbine weight will effect on that cross section during the lifting .



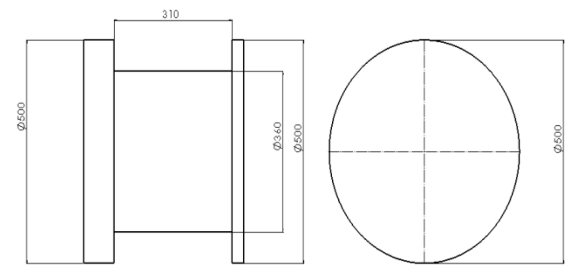


Figure .12: the turbine top joint

Figure 13 shows the opening and the closing when the turbine top joint was added to the design as shown the opening distance of lever arm is 520 mm where the loosen diameter is 360 for turbine top joint as shown in the dimensions (figure 12).

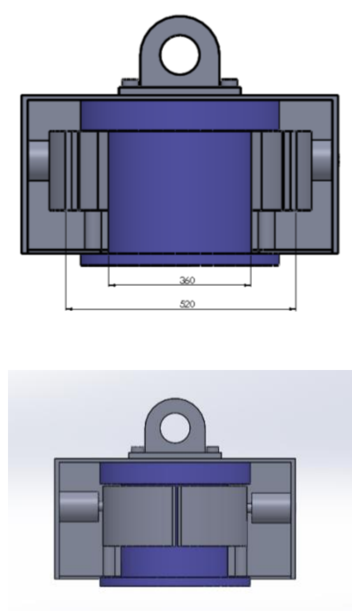


Figure .13: the opening and closing the mechanism.

A finite element analysis was obtained for the , case , arms and the cable joint as shown in the following table

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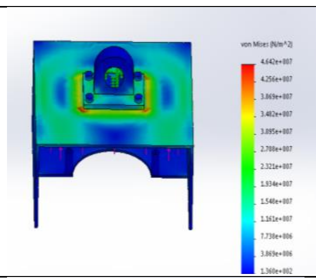
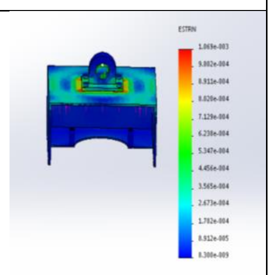
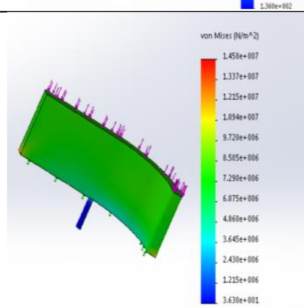
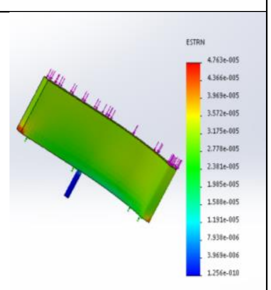
under applying load 20 ton, which was applied as tension force. Where the elements are included in the analysis 28231 for Case and cable joint and 13251 for arm.

Table .3 : the FEA of the suggested design.

Part	Stress	Strain
Case and cable joint		
Arm		

The factor of safety can be evaluated for the materials can be calculated according to the maximum stress will be generated by the input force, where the factor of safety for the case and cable joint is shown in figure 14m which is about 13. The value of factor of safety is high but this factor of safety under tension only .

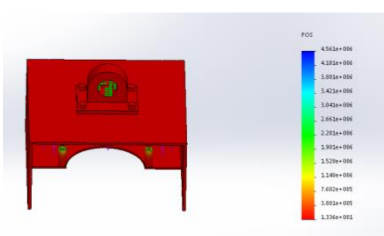


Figure .14: factor of safety for cable joint and case

For the arm the factor of safety was about 42 under tension effect as shown in figure.

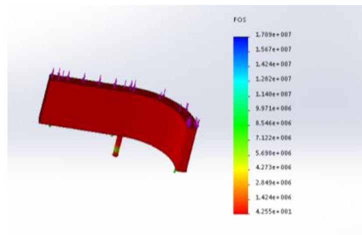


Figure .15: factor of safety for cable joint and case.

IV. Conclusion

The tidal turbines are used to generate electrical power from the waves motion, these devices have different challenges during the installing and the operation, where controlling the installing process required a lot of effort because its under water. In this research mechanisms of lifting the tidal turbines are reviewed, then a new design was suggested where the gripper of the turbine was designed, this device is locked on the turbine to ensure the design is stable according the lifting of installing. The suggested design has different parts where these parts were modelled and tested in solidworks. The suitable material for manufacturing was obtained using CES software, therefore, the operation conditions was considered, so the alternative material was selected to be suitable for under water applications

REFERENCES

[1] REN21 (2010). Renewables 2010 Global Status Report p. 15. And REN21 (2016). Renewables 2010 Global Status Report.

[2] Ocean Energy Council. (2011) Tidal Energy. [Online] Available from: http://www.oceanenergycouncil.com/ocean-energy/tidal-energy/ (Accessed: November 7, 2016)

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[3] Tethys (2016) Tidal - Capturing tidal fluctuations with turbines, reciprocating devices, kites, screws, barrages, or lagoons. [Online] Available from: https://tethys.pnnl.gov/technology-type/tidal (Accessed: November 7, 2016)

[4] Marine Current Turbines. (2016). Tidal Energy. [Online] Available from: http://www.marineturbines.com/Tidal-Energy (Accessed: November 7, 2016)

[5] Sleight, K. (2012) How Do Underwater Turbines Work? [Online] Available from: http://www.ecopedia.com/energy/how-do-underwater-turbines-work/ (Accessed: November 7, 2016)

[6] Li, Y. and Florig, H.K. (2006) Modeling the Operation and Maintenance Costs of a Large Scale Tidal Current Turbine Farm, OCEANS 2006, DOI: 10.1109/OCEANS.2006.306794.

[7] Armstrong, J. (2010) Briefing: 10 MW Triton – a breakthrough in tidal stream power, *Proc. of the Institution of Civil Engineers – Energy, Volume 163, Issue 1.* DOI: http://dx.doi.org/10.1680/ener.2010.163.1.3

[8] RenewableEnergyFocus (2010) Tidal turbine design eases maintenance. [Online] Available from: http://www.renewableenergyfocus.com/view/8901/tidal-turbine-design-eases-maintenance/ (Accessed: November 7, 2016)

[9] VEX. (2016) Design of Lifting Mechanisms, Unit 10, 10.6. [Online] Available from: http://curriculum.vexrobotics.com/curriculum/lifting-mechanisms/design-of-lift-mechanisms (Accessed: November 7, 2016)

[10] ICF Marbek (2012) Review of Selected Tidal Power Technologies, Final Report, Submitted to: Jupiter Hydro Inc., September 20.

[11] Maksoud, J. (2002) Lifting tool combines capacity with safety, September 1st, More Subsea News, Offshore Magazine, PennWell Corp.

[12] Keyvnor Morlift Ltd. (2012) Marine Heavy Lift. [Online] Available from: http://www.keynvormorlift.co.uk/case-studies/marine-heavy-lift (Accessed: November 7, 2016)

[13] Det Norske Veritas. (2014) Lifting appliances used in subsea operations, November, DNV-RP-H201.

[14] Cowie, M. (2015) Ambient Lifting Transforms Traditional Subsea Heavy Lifting, Wednesday, May 6th & 7th, All-Energy 2015, Glasgow.

[15] Baltec Ltd. (2016) Lifting Solutions. [Online] Available from: http://www.balltec.com/solutions/balltec-lifting-solutions-tools (Accessed: November 7, 2016)

[16] Ilfrey, W.T., Heilhecker, J.K., Maus, L.D. (1979) Riser set-aside system, US4147221 A.

[17] Rosman, A.H. (1988) Hydraulic elevator mechanism, US 4761953A.

[18] Grayson, B.H. and Beak, R.J. (1993) Apparatus for attaching a lifting mechanism to a load, US 5244243 A.

[19] Rytlewski, G.L., Meijer, J.R. and Patel, D.R. (2001) Self-aligning subsea latch mechanism, US 6231265 B1.

[20]Ontwerp, material indices, available at http://mech.vub.ac.be/teaching/info/Ontwerpmethodologie/Appendix%20les%203%20Materiaal%20Indices.pdf

[21] bridon, factor of safety avaliable at http://www.bridon.com/china/x/downloads/steel_technical.pdf

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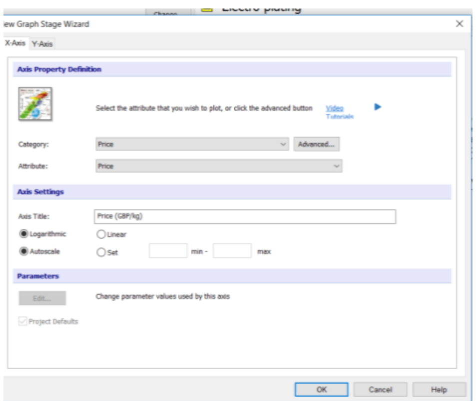
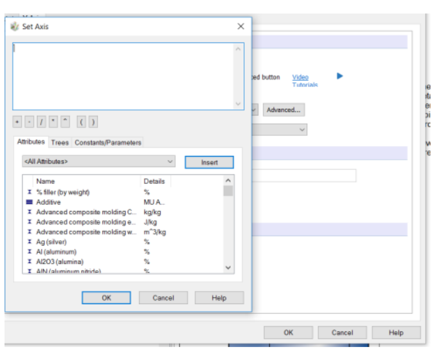
Appendix A materials selection

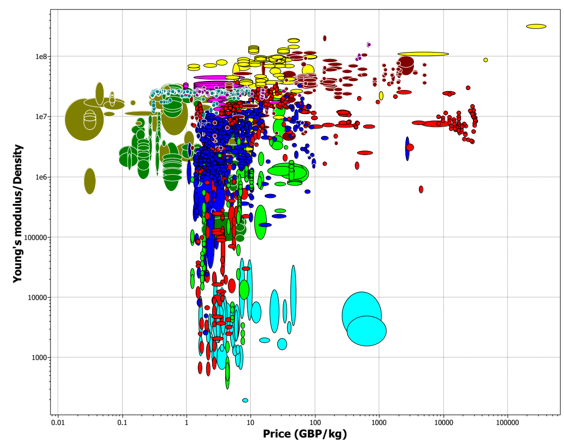
The material was selected using CES software to be suitable for the underwater applications, where the materials were selected using materials indices [20] for tensile stress. the materials will be selected also based on the price as shown in the following figures. For the x-axis the price was selected for materials selection criteria



For y-axis the advanced selection option was selected where the ratio of young modules to density was selected



The following figure shows the relation between the price vs. young modules to density



The slope of material indix was taken as unity based on the following

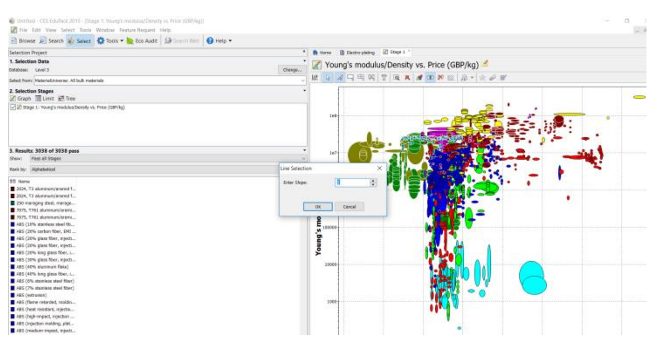
$$M = \frac{E}{\rho}$$

By takin the lograthmic log

Log M = log E –log ρ

Or

log E = Log M + log ρ



The results of applying the slope are shown in the following figure.

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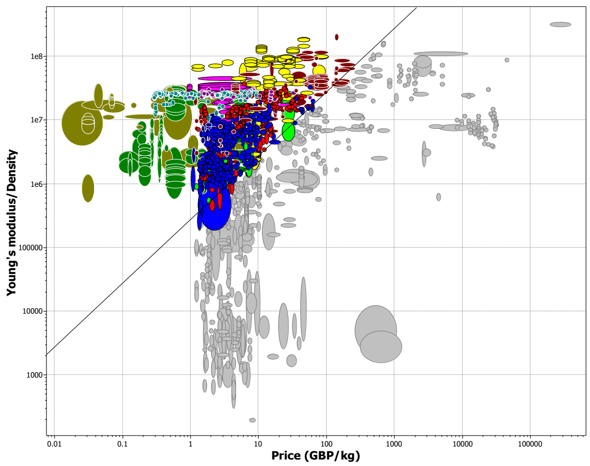

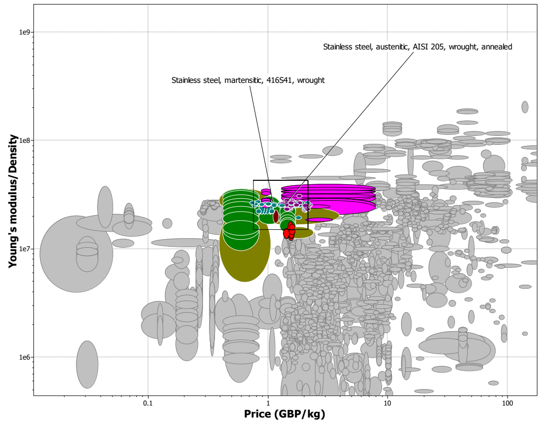

Two materials from the alternatives can be used for the underwater applications which are labled in the following figure , where the materials prperties are shown in the following based on CES software.

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Stainless steel, martensitic, 416S41, wrought

General information

Designation

416S41

Condition	Annealed
UNS number	S41623
US name	416S41

Typical uses

Processing of potentially corrosive liquids, e.g. chemicals, oil, beverages, sewage; Structural uses in corrosive environments, e.g. nuclear plants, ships, offshore oil installations, underwater cables and pipes;

Composition overview

Compositional summary

Fe82-88 / Cr12-14 / Se0.15-0.35 / C0.09-0.15 (impurities: Mn<1.5, Ni<1, Si<1, Mo<0.6, P<0.06, S<0.06)

Material family	Metal (ferrous)
Base material	Fe (Iron)

Composition detail (metals, ceramics and glasses)

C (carbon)	0.09	-	0.15	%	
Cr (chromium)	11.5	-	13.5	%	
Fe (iron)	* 81.8	-	88.3	%	
Mn (manganese)	0	-	1.5	%	
Mo (molybdenum)	0	-	0.6	%	
Ni (nickel)	0	-	1	%	
P (phosphorus)	0	-	0.06	%	
S (sulfur)	0	-	0.06	%	
Se (selenium)	0.15	-	0.35	%	
Si (silicon)	0	-	1	%	

Price

Price	* 1.06	-	1.17	GBP/kg

Physical properties

Density	7.7e3	-	7.9e3	kg/m^3

Mechanical properties

Young's modulus	1.9e11	-	2.05e11	Pa
Yield strength (elastic limit)	4.95e8	-	5.55e8	Pa
Tensile strength	7e8	-	9.25e8	Pa
Elongation	0.28	-	0.32	strain
Compressive strength	* 4.95e8	-	5.55e8	Pa
Flexural modulus	* 1.9e11	-	2.05e11	Pa
Flexural strength (modulus of rupture)	4.95e8	-	5.55e8	Pa
Shear modulus	* 7.3e10	-	8.3e10	Pa
Bulk modulus	* 1.56e11	-	1.64e11	Pa
Poisson's ratio	0.275	-	0.285	
Shape factor	44			
Hardness - Vickers	* 1.57e9	-	1.88e9	Pa
Hardness - Rockwell B	77	-	87	
Hardness - Rockwell C	* 0	-	10	
Hardness - Brinell	1.77e8	-	1.97e8	Pa
Fatigue strength at 10^7 cycles	2.62e8	-	2.9e8	Pa
Fatigue strength model (stress range)	1.64e8	-	2.54e8	Pa

Parameters: Stress Ratio = 0, Number of Cycles = 1e7cycles

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Stainless steel, austenitic, AISI 205, wrought, annealed

General information

Designation

AISI 205

Condition	Solution annealed
UNS number	S20500
US name	ASTM S20500

Typical uses

Processing of potentially corrosive liquids, e.g. chemicals, oil, beverages, sewage; Structural uses in corrosive environments, e.g. nuclear plants, ships, offshore oil installations, underwater cables and pipes;

Composition overview

Compositional summary

Fe63-68 / Cr16-18 / Mn14-16 / Ni1-1.8 / N0.32-0.4 / C0.12-0.25 (impurities: Si<1, P<0.06, S<0.03)

Material family	Metal (ferrous)
Base material	Fe (Iron)

Composition detail (metals, ceramics and glasses)

C (carbon)		0.12	-	0.25	%
Cr (chromium)		16.5	-	18	%
Fe (iron)	*	63	-	68.1	%
Mn (manganese)		14	-	15.5	%
N (nitrogen)		0.32	-	0.4	%
Ni (nickel)		1	-	1.75	%
P (phosphorus)		0	-	0.06	%
S (sulfur)		0	-	0.03	%
Si (silicon)		0	-	1	%

Price

Price	*	1.25 GBP/kg	-	1.38	

Physical properties

Density	*	7.7e3 kg/m^3	-	7.9e3	

Mechanical properties

Young's modulus		1.93e11	-	2.01e11	Pa
Yield strength (elastic limit)		4.25e8	-	5.25e8	Pa
Tensile strength		7.45e8	-	9.25e8	Pa
Elongation		0.4	-	0.7	strain
Compressive strength	*	4.25e8	-	5.25e8	Pa
Flexural modulus	*	1.93e11	-	2.01e11	Pa
Flexural strength (modulus of rupture)		4.25e8	-	5.25e8	Pa
Shear modulus		7.5e10	-	8e10	Pa
Bulk modulus		1.36e11	-	1.49e11	Pa
Poisson's ratio		0.265	-	0.275	
Shape factor		47			
Hardness - Vickers		1.91e9	-	2.4e9	Pa
Hardness - Rockwell B		93	-	103	
Hardness - Rockwell C	*	10	-	22	
Hardness - Brinell	*	1.9e8	-	2.28e8	Pa
Fatigue strength at 10^7 cycles	*	3.48e8	-	4.06e8	Pa
Fatigue strength model (stress range)	*	2.18e8	-	3.05e8	Pa

Parameters: Stress Ratio = 0, Number of Cycles = 1e7cycles

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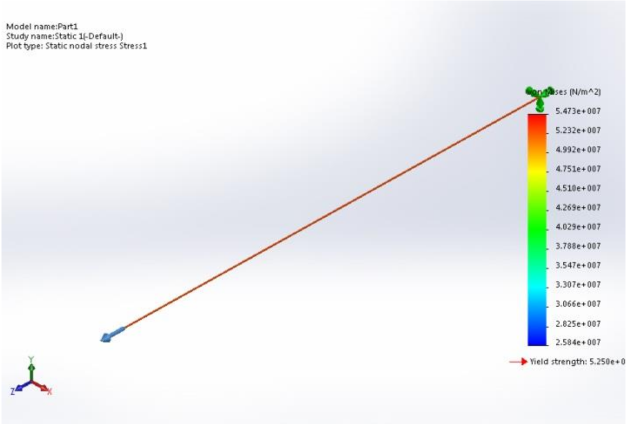
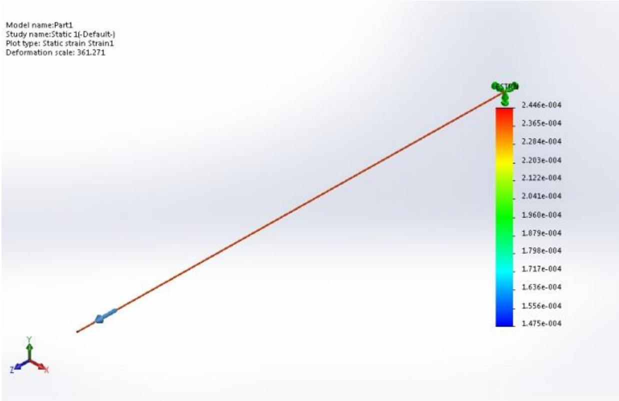
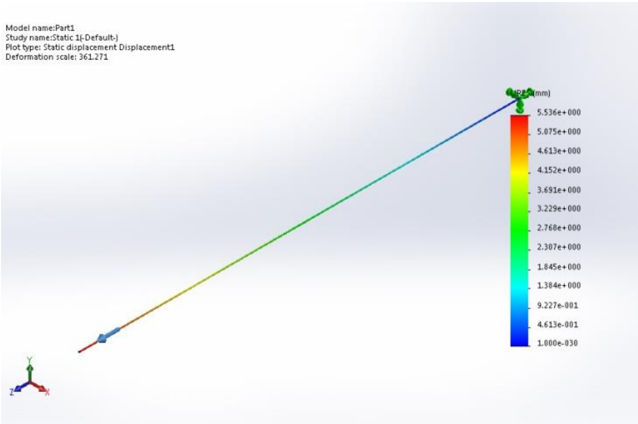
APPENDIX B SIMULATION FOR MATERIALS

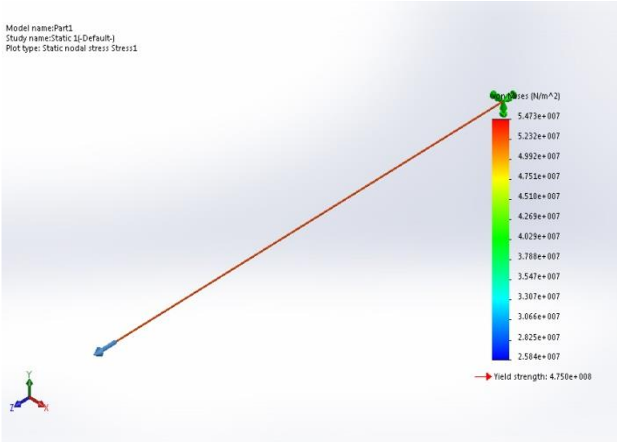


Stress distribution using first material



Strain distribution using first material





Stress distribution using second material

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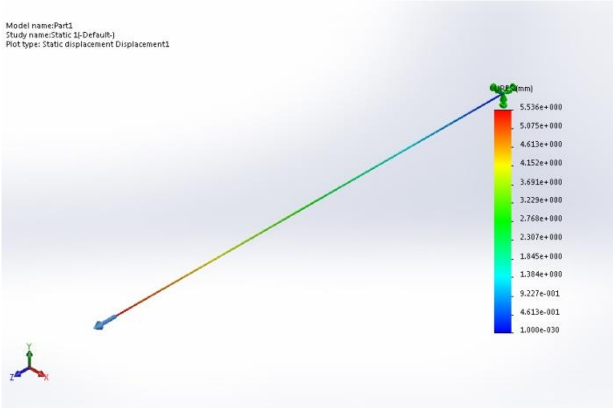
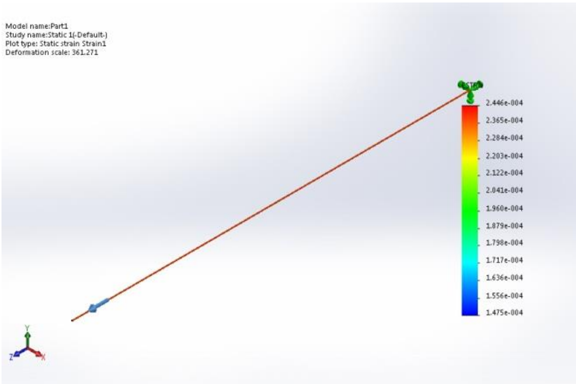


aterial

Displacement distribution using second material



Strain distribution using second material