FATIGUE ANALYSIS FOR AL-MG-SC TIDAL TURBINE BLADES USING RAINFLOW ALGORITHM.

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Abstract: *The dependency of the tidal turbines array for converting the kinetic energy into a usable electrical power in addition to several economic and environmental benefits. However, the turbine design process aiming to achieve the optimum performance is not so simple, because of the several studies and decisions needed. This research concentrates on understanding accurately the turbine constructing components along with the evaluated environmental effects for the influencing of the turbine output. For assuring the convenient performance from the turbine, performing different techniques of maintenance is fundamental relying on the situation of the turbine. In order to perform the most proper maintenance on the turbine that operates, the understanding of the essential failure origin is needed. Then, this research covers the most common failures. It is founded by the researchers that, the fatigue stress applied, as a result of the blade rotational speed and hydrodynamic force, is the mechanical fractures major reason. So, in order to decrease the mechanism of fatigue stress during the implementation of the turbine's design, the aim of this research is to study these mechanisms. To estimate the lifespan of the blades, a CFD simulation is performed. An alloy of aluminum of a 0.4% scandium was concerned in the study for the differentiation of the given resistivity versus the material fatigue stress. The variation of the thickness of the blade is meant for helping the designers in the selection of the most proper thickness and material depending on the application. The variation of the rotational speed of the blade and the average thrust force is for allowing the numerical inspection of the impact of them on the lifespan of the blade. The provided comparison of the service life is for the exact inspection of the material that will be used in the fabrication of the blades according to the service life.*

Method: *modelling analysis will be performed for the turbine blades with the applied forces that causes fatigue using ANSYS. While the forces will be plotted using MATLAB software.*

Results: *Increasing the applied force decreases the expected life of Aluminum blade. while increasing the blade thickness increases the blade rotational speed and consequently increases the gap of the lifespan.*

Conclusion: *the selected Al-Sc alloy is a proper selection for manufacturing the turbine blade to resist the high erosion of the marine environment.*

BACKGROUND

Environmental pollution is a multifaceted problem that poses a great threat to the health and life of mankind. The peak of environmental pollution is in the more advanced industrial countries with high population density [1]. Air pollution is a type of environmental pollution and it is defined as the case of introducing new components into the air, making it harms the life of all organisms. Air pollution is harmful to the health of humans and other organisms on earth [2]. The main cause of air pollution is due to the combustion (burning) of fossil fuel in different fields such as industry, transportation and households [3]. Sustainable energy sources have become one the most desirable power sources recently after the fossil fuel as it comes second ever since the scarcity of the oil production in late 2014. The study of the renewable energy field has grown since it was more needed and desired by the society than before due to it was environmentally friendly and was also running with low cost back then. Generally, renewable power sources have different types such as the hydropower which became very valuable nowadays because of the great applications it serves [4, 5]. Mentioning the tidal power as one of the hydropower types which transforms the mechanical energy from sea waves to electricity and considered one of the greatest electric power sources of energy. Unlike wind and solar energy, the tidal power source is less fluctuating. The high initial cost and the few suitable tides flow sites are enough reasons not to be widely used; even so, serious improvements are taken into consideration to reduce the cost and make it more available through many sites. The main theory for the tidal plant is letting the incoming seawater to be stored in a tank by the help of an elevated gate attached to a dame, and then it starts to operate whenever the seawater level gets low [6].

Nowadays, many of the tidal power plants are depending on the same dame principle which could possibly be established beside a river, and then there are the turbines that work in both directions and the pumps that might be useful in the energy-saving process. Another way to operate the turbine is by taking advantage of the incoming synchronous mechanical energy rather than the normal tides disparity operation [7].

Blade martials is one of the key design factors considered to improve the life service of turbine, so in this research the life service of turbine blades was investigated by suggesting an improved aluminum alloy by scandium, then a Rainflow algorithm was used to evaluate the life service for the proposed alloy.

The light metal scandium (SC), which characterized of 3,000 kg/m^3 in density and 1450 °C melting temperate. Accordingly, the alloys of Scandium-based become a proper selection for light weight and high temperature applications even though this metal has no commercial exploitation and also low global require. Several studies assured that the interesting in the usage of the scandium is increased as a component of the aluminum alloy even though the extraction of the scandium is difficult that lead to increase its cost. The addition of scandium to the alloys of the aluminum directly influence the structure grain and refine [8].

The alloys of Scandium-reinforced aluminum are considered a progressed version of the high-performance alloys, which provide enormous benefits on the alloys of high-strength aluminum. The alloys of Scandium-reinforced are sturdier than the rest of the alloys of high-strength, display considerable refinement of the grain, support welds and remove the welds hot cracking. They also display a high resistivity to erosion. in addition to their microstructural, erosion and mechanical characteristics represent that the alloys of scandium-reinforced can be helpfully involved in the applications of the marine environment and the fabrication of the tidal turbine in particular [9].

Additionally, the alloys of Al-Mg-Sc got great attention for the applications of engineering that revolve around its perfect composition of the properties of mechanical and physical. However, the performance of these alloys in an erosive environment needs more studies [9].

All countries are moving towards renewable sources of energy to meet their needs of power [10]. The main way to reach the sustainable future of marine energy is to create a relevant industrial area that depends on the development of technology. Tidal power is an environmentally friendly source of energy, has many great potentials. This alternative energy source is expected to be highly efficient if some economic and technical problems that hinder its use are overcome. Although power plants differ in terms of tidal altitude and the process of converting tidal energy into electrical energy, the theory of tidal power generation is generally similar to that traditionally used in hydroelectric power plants [11, 12].

II. OVERVIEW OF THE TIDAL POWER GENERATION PROCESS

III. Tidal power generation devices

The tides have three types: diurnal, semi-daily and the last is a combination of the two previous types. Different devices are used to generate the tidal energy:

The tidal barrage (dam): It stores the tidal flow and then drains the forced water through the turbine, generating energy.

The tidal fence: Prevent the movement of the energy in one or both directions of the tidal flow, it can be used in open basins.

Tidal turbines: Turbines-like in their design underwater windmills, but rotating motors are driven by fast, constant-current currents [13], [11].There are two different types of tidal range turbines existing used, which are [13];

Bulb turbine: The water enters the turbine and acts on the blades to move it to the optimal position for generating power, used for The La Rance tidal plant.

Straflo (rim) turbine: is an axial turbine, it does not work well in pumping and is not easy to control its performance, used for Annapolis Royal tidal plant.

IV. TIDAL POWER GENERATION METHODS

Tidal range methods use one of the following operating cycles. Each of them relies on the concept of filling the basin to achieve the required difference in the head and then use the turbine to generate electricity with the choice of an appropriate pumping method.

V. FATIGUE LIFE FOR TIDAL TURBINE BLADES

The tidal turbine is a device that uses a rotor to utilize the kinetic energy of tidal currents and convert them into electrical energy. This is very similar to the theory of the operation of wind turbines to convert wind energy into electrical energy. However, there are some differences that must be taken into account while designing tidal turbine blades, those are; the difference between air and water density (The water density is 800 times the air density), which increases acting forces on blades of the tidal turbine. In addition to waves' impact and vertical velocity profile which makes the distribution of load irregular along the blade [14]. The tidal turbine blades are designed with a shorter length compared to equivalent wind turbine blades, but they should be stiffer and stronger due to the density difference between water and air [15]. Usually, tidal turbine blades are exposed to cyclic (fatigue) loading on a regular basis condition which may cause failure. Therefore, it is expected that the fatigue strength will be the main considerable parameter during the design stage [16]. As per ISO 12107:2012, fatigue life was defined as the number of cyclic loads that can be applied to the structure until it reaches the failure criterion [17]. It is important to study the efficiency of materials used in the design of tidal power devices in the marine environment, in order to maximize the fatigue life of these devices. Designers should study the efficiency of materials used in tidal power devices in the marine environment, in order to maximize the fatigue life of these devices. Suitable materials for such applications have a high cost [18].

Optimizing the balance between fatigue resistance, manufacturing costs and turbine efficiency was discussed. since Blade and structural malfunctions due to design or manufacturing defects that cannot withstand extreme underwater conditions. Then, Marine environments need durable mechanisms to withstand these difficulties and dynamic conditions [13]. The nature of the ocean current is random and variable which increases its intensity. as well as the change in the speed profile with the depth of the ocean, which causes the shear load on the turbine blade. This is in addition to fatigue loading on the blade due to repeated stresses and most of it is the reason for the random shear of the ocean current. Several studies investigated the impact of these two types of loading in order to provide methodologies to predict fatigue life. ANSYS software usually used to design the turbine blades [19].

Static analysis was conducted and resulted in the failure initiated in the core due to shear stress [19]. Algorithms to improve the fatigue design of the tidal turbine blades contain several separate models, which combine to facilitate the identification of the required hydrodynamic and structural data. It the first model of the fatigue design methodology, the tidal current velocity is predicted at any time and used for the hydrodynamic model [18]. A paper studied the design optimization of the tide turbine blade design, focusing on dynamic loads as it is the main cause of blade failure. Researchers investigated the possibility of applying the blade elemental momentum theory (BEMT) to the tidal turbine to determine forces on the proposed blade during exposure to regular waves from several heights and periods, with a view to classifying criteria of importance and introducing fatigue analysis. Optimizing the balance between fatigue resistance, manufacturing costs and turbine efficiency was discussed. Blade and structural malfunctions due to design or manufacturing defects that cannot withstand extreme underwater conditions. Marine environments need durable mechanisms to withstand these difficulties and dynamic conditions. Blade performance and fatigue life can be improved by taking into account certain material properties, such as the corrosion-resistant in a wet environment, stiffness, strength and weight, during the material selection step [20, 16].

VI. FATIGUE LIFE CALCULATION USING RAINFLOW CYCLE COUNTING ALGORITHM

Predicting the fatigue life of a structure with variable loads with respect to time is a very complicated mission. For that reason, researches have proposed different methodologies to facilitate this process. One such method is called rainflow counting cycle algorithm [21]. The term “Rainflow” derives from the similarity of this method with the rain falling on the edges of the surface. Several algorithms have been proposed to calculate the cycle of this rainflow [22].

The stress-strain curve of a loaded structure forms a closed-loop so-called hysteresis loop, which is related to energy dissipation and fatigue failure. The uniaxial fatigue failure (constant loading) usually based on these hysteresis loops, considering each closed loop as one cycle. The algorithm that calculating the rain flow determines these cycles within the log of load time, stress or strain, [22, 21]. In the case of fatigue failure, the value of loading is a more powerful effect than the speed of applying cyclic load. Hence, hysteresis loops are very important [28].

The following steps summarize the algorithm of rainflow cycle counting;

Rotate the load log plot 90 degrees clockwise in order to make the load log horizontal to represent the surface and the time axis vertical and downward to represent the falling raindrops.

Suppose the rain flow starts at each consecutive peak point.

Each rainflow will continue dripping till falling below the surface or integrated with the prior rainflow path [21], [22].

There are two cycle count methodologies for determining a complex multi-axial loading time history, used to predict fatigue failure of a structure.

The critical plane method: The size of the material is specified in selected planes. The uniaxial cycle counting method is used for each plane and fatigue failure should be determined. The critical plane is the one that has the greatest failure, the structure fatigue life is then estimated based on this value.

The equivalent stress or strain amplitude method: This method can be computed depending on fatigue failure taking into account the specific cycles from the history of the complex equivalent loading [22].

Despite the rainflow counting algorithm was studied for the first time for metals, it has been founded to be applicable for composite materials [23].

VII. FATIGUE LIFE PREDICTION OF THE TIDAL BLADE USING RAINFLOW CYCLE COUNTING ALGORITHM

When designing a cost-effective hydro-turbine system, emphasis should be placed on studying the fatigue life of the tidal turbine blade. Since the blade is the most effective and costly element in the tidal turbine, it should, therefore, have an operating life of about 20 years. there are different factors that affect the operating life of the blade such as; the stochastic hydrodynamic load of streams, corrosion due to water and mud, the impact of floaters and fish in addition to the possibility of vibration occurrence because of rotating and the difficulty of underwater maintenance [24]

Thus, a study aimed to investigate predicting the fatigue life of the composite blade of an ocean current turbine. The tested blade was deployed in the gulf of South Florida, under a depth of 25 m with a mean current speed of 1.6 m/s.

AeroDyn was used to calculate and analyze the ocean current loads. The blade was proposed to be made of Carbon/Epoxy and S2-Glass. To fulfill the strength and fatigue requirements, the cross-section of the designed blade was very large compared to its length. Thus, the designer recommends considering glass-fiber reinforced material in further research [25].

To study the fatigue lifetime, DOE/MSU composite material fatigue database and rainflow counting methodology according to calculations of miner's rule were used. The proposed composite blade predicted to have a lifetime of more than 20 years [25].

Another study developed the fatigue life algorithm based on the reliability of a medium scale tidal turbine blade FEA and the theory of blade element momentum BEM was used to determine and adapted the stress response on the turbine blade, based on the MSU/ DOE fatigue database,

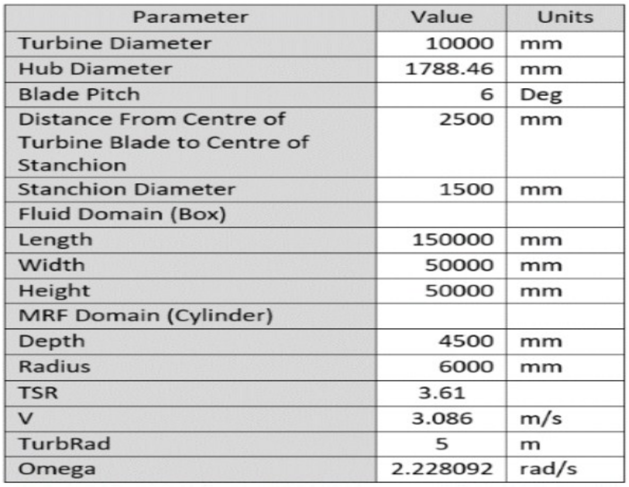
The blade fatigue behavior in critical stress areas was investigated. The simulation stress response model was also constructed at some determined points. The rainflow counting algorithm was used and constant life diagrams were created.The investigation approved that the working lifetime for the studied blade is more than 20 years [26].

VIII. METHOD AND MODELLING

IX. Turbine modeling

Practically, the variation is the main reason of the difficulty in the simulation of the thrust force that applied on turbine blades (Three bladed Horizontal Blades Turbine) with respect to operation time resulting from the predicted high instability of the applied force. Then, for the understanding of the behavior of the hydro force, the available method is to record the magnitude of the applied force during the time of operation. The following Table 1 shows the examined parameters of the turbine according to the supervisor in accordance of the simulation of the CFD.

Table 1: Characteristics of the examined turbine.



Parameter	Value	Units
Turbine Diameter	10000	mm
Hub Diameter	1788.46	mm
Blade Pitch	6	Deg
Distance From Centre of Turbine Blade to Centre of Stanchion	2500	mm
Stanchion Diameter	1500	mm
Fluid Domain (Box)		
Length	150000	mm
Width	50000	mm
Height	50000	mm
MRF Domain (Cylinder)		
Depth	4500	mm
Radius	6000	mm
TSR	3.61	
V	3.086	m/s
TurbRad	5	m
Omega	2.228092	rad/s

This simulated turbine composed of six blades in addition to two circular bases, Figure 2. Represents the simulation model of the tidal turbine. The model of the six blades is according to the feature of circular pattern in SolidWorks.

The performance of the tidal turbine has been simulated by the aid of ANSYS, which needs to specify the dimensions of the CFD to be suitable for the dimensions of the test rig utilized in the experiment. Therefore, the rectangular length domain must be proper for investigated. Figure 3 represents the proposed dimensions that will be used for enclosing the domain of the fluid. Moreover, there is a recommendation to follow reliable sources like [12] for the accurate specification of the dimensions of the CFD fluid based on the length required. Figure 4 represents the specified domain of computational fluid in ANSYS.

Figure 1: The six-blades-modelled tidal turbine.

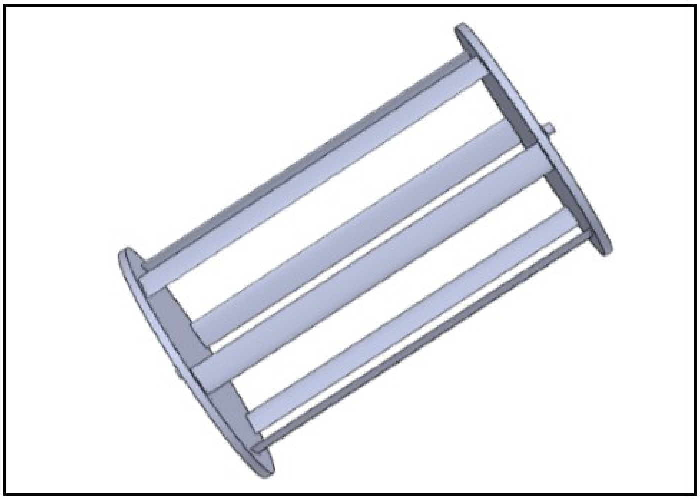


Figure 2: Standardized computational fluid domain [12].

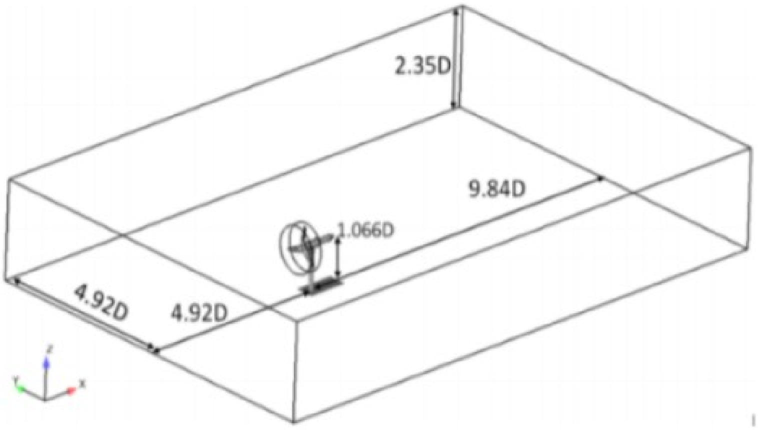
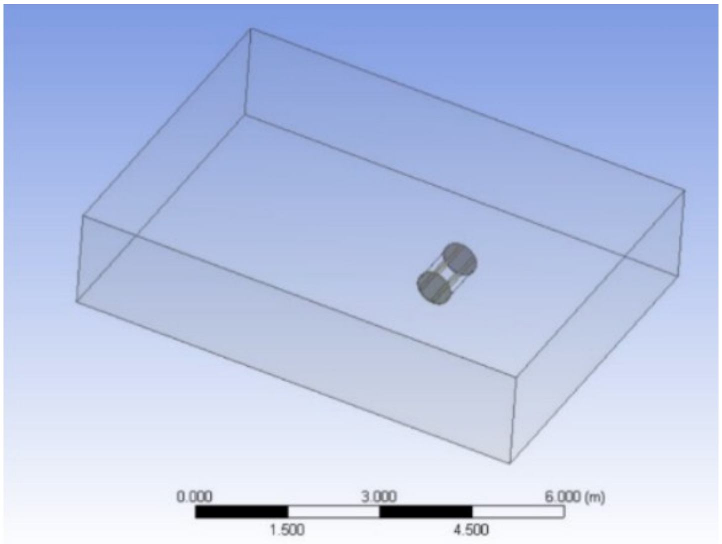


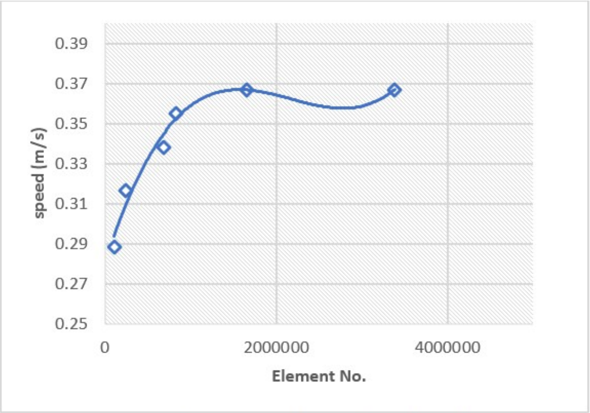
Figure 3: ANSYS model for CFD.



In the purpose of having the best accuracy in addition to proper economy of the simulation, the definition of the domain of the computational fluid is found by the aid of fine mesh, the number of elements and nodes is calculated by ANSYS.

The analysis of the independence grid will be aided in the solution of the equations of the study of the simulation. The characteristics calculations are estimated to be more exact that will let to understand the effecting parameters impact the mechanical output. Figure 5 shows the elements number (size of the mesh) and the velocity resulting. The solutions of the velocity and the Froude number (0.9) are related. The magnitude of the velocity level is accepted regarded the stability when the elements number is 2,000 x 10^3 or greater that shows the low rate of the error at the magnitude.

Figure 4: Velocity magnitude according to the mesh size.

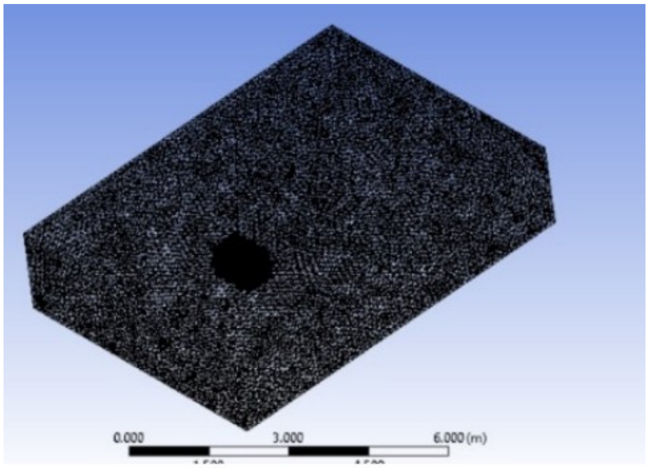


The elements and nodes number that aided in the definition of the domain of the computational fluid is counted in Table2. Exact results are estimated to be obtained when the type of fine mesh will be used. Fig5 reviews the shape of the resulting mesh. After the accurate assumption of the Froude Number, the previously mentioned equations will be solved.

Table 2: Mesh description.

Statistics	
Nodes	728,791
Elements	3,385,770

Figure 5: The generated mesh.



In accordance of the literature [13], the examination of the Froude Number ranged between 0.09 and 0.22. The simulation study took in 4 assumptions for allowing the accurate performance inspection of the tidal turbine. Also, the simulation study cannot take a single assumption for the results accuracy check when comparing them with the results in [13].

X. FATIGUE MODELLING

The cyclic loading is responsible for the generation of the fatigue stress, which can be aided in the calculations of the design life cycle according to the analysis of the fatigue failure. The research predicted that the blade of the tidal turbine life cycle is exposed to current flow thrust loading. The considerable factor impacting the turbine life cycle is the type of the material used in fabricating the blades of the turbine. There are different materials used in fabricating the blade of the turbine as steel, aluminum and composite materials. Therefore, the cyclic loading modelling exactly is very hard based on the mechanical engineering [27].

The inspection of the fatigue life is in accordance of the cyclic loading applied and the designed section examined till the appearance of the fatigue failure. The fatigue of the blade experimental inspecting is expensive mostly for the blades of heavy duty. Different simulations inspections were used in different researches for the life span estimation of the blade of the turbine. The life cycle was identified in this research according to applied thrust force on the blades linked to the turbine till pre-identified period. MATLAB solved a problem included the input parameters that depended on the previous measurements [27].

For the measuring of applied hydro-force on the blade, the understanding of its major source is important. Generally, the stored kinematic energy in the flow current is transformed to mechanical power via the blade hydrodynamic profile. The thrust force applied on the blade consists of a composition of the lift and drag forces. The conditions of the environmental operating under the level of the sea are not stabilized. Therefore, the lift and drag forces constantly oscillate during the year. Then, the generation of the thrust power expression is from the existed hydropower in seawater, this expression must be considered as a function of time.

Figure 6 and 7 explain the blade thrust force applied along with the average thrust force. MATLAB software was used to plot the forces. The sinusoidal behavior of the thrust forces is due to the blades rotational motion. The graphical expression of the forces is in the relation between the time ranges (between 0 and 27 sec.) along with the rotational angles of (0 to 3300). Data will be aided in the generation of the algorithm of the rainflow with a reason of counting the number of the cycles for every loading cycle.

Figure 6: The mean thrust force over the time.

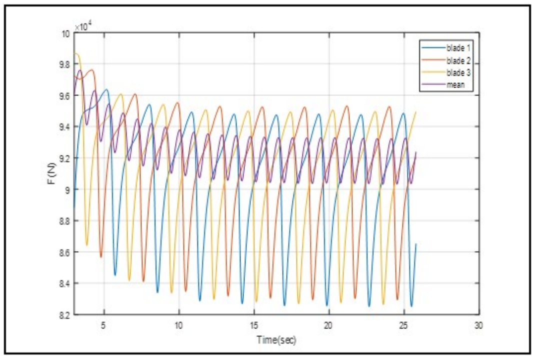
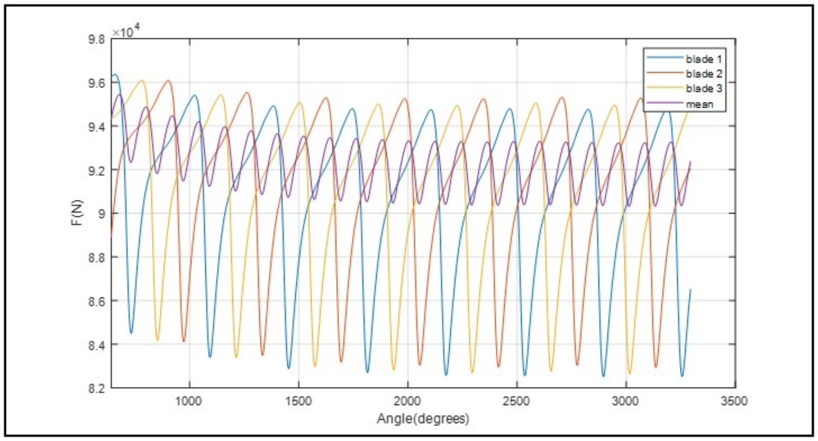


Figure 7: The mean thrust force over the rotational angle.

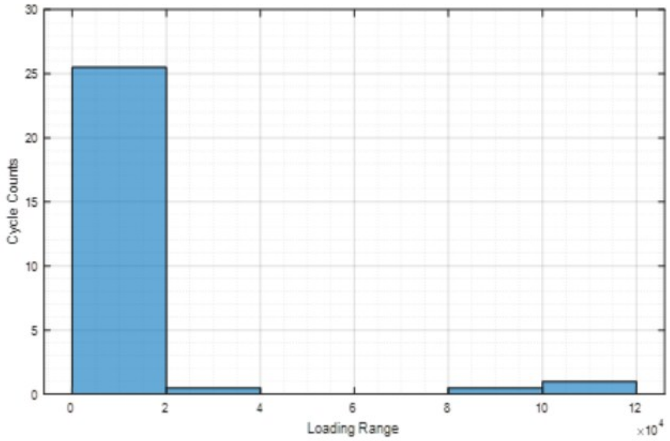


For the modelling of the blade fatigue stress, MATLAB software was used. The procedures of the modelling implemented by the author described briefly in these steps;

The thrust force values were inserted into the MATLAB software: In this step, each blade thrust force, rotational angles, time and average thrust force are the essential variables were identified in the code of the MATLAB.

Counting of the cyclic loading by the rainflow algorithm: it is a mathematical technique, which used for the counting of the cycle via rearranging the peaks of the cycle. Figure 8 represents the cycle number counting by the aid of the command algorithm that affects in giving the histogram, which clarifies the counted number of the cycle of the loading range. The previous data was considered as input data in the following step that the number of the cycles of the range of the loading will be considered as an input in the code of the MATLAB.

Figure 8: Cycle number according to the loading range.



For the estimation of the damage equivalent load (D.E.L), Eq. 1 was expressed as follows [28];

$$D.E.L = \left(\sum_i (l_i^m x n_i) / t\right)^{\frac{1}{m}}$$

The relation between the range of the cycle (l), history of period time, the negative inverse S-N diagram slop (varies based on the material of the manufacturing used in the fabrication of the blades) and number of the cycles (n_i). MATLAB solved the empirical correlation at various thicknesses of the blade, (i) is the number of tries decided to be 20. The rainflow algorithm automatically combined the history of time and the range of loading. Also, m Is the decided material, the variation of the materials of the fabrication in the study is due to including the steel, aluminum and Composite. The negative inverse S-N diagram slope is represented by (m), each material has its (m) value. For the D.E.L determination, the industrial material of the blade specifies the values of constant (m). Its value is 5 for steel, 7 for aluminum and 10 for composite [28].

The calculations of the equivalent damage fatigue stress are depending on both D.E.L and the projected area. (Rectangular is the assumption of the projected area A).

$$\mathrm{S.E.L_i} = \mathrm{D.E.L}/\mathrm{A}$$

The blade expected life time calculations is according to the equation inputting [28];

$$\text{lifetim } e_i = \left(\frac{\mathrm{S.E.L_i}}{S_f}\right)^{-m}$$

Where, (S_f) is the final fatigue stress, it must be identified for every material from the software of CES Edu Pack. The final fatigue stress is 208×10^3 kPa forsteel and 63×10^3 kPa for aluminum.

The impact of the rotational speed and the thrust force variation checks included the following:

a) Analysis to be repeated at the thrust force triple magnitude.

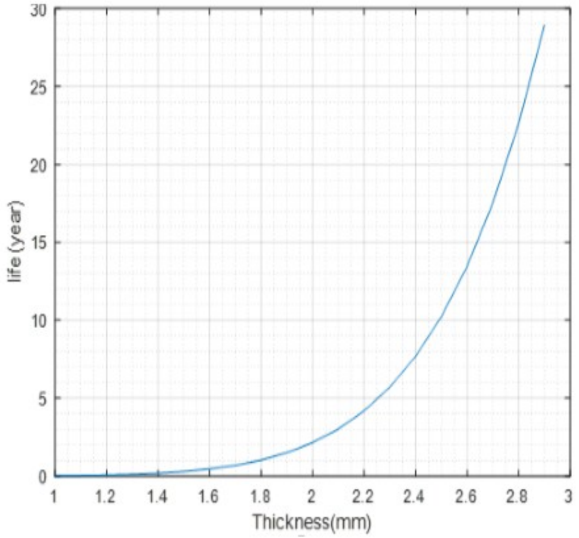
b) Analysis to be repeated at the speed of double rotation.

XI. RESULTS

The code of the MATLAB consequences represents the relation of the lifetime expected of the blade and the thickness of the blade for each material. The following figures represents each material life cycle provided according to only fatigue despite any mechanical effect.

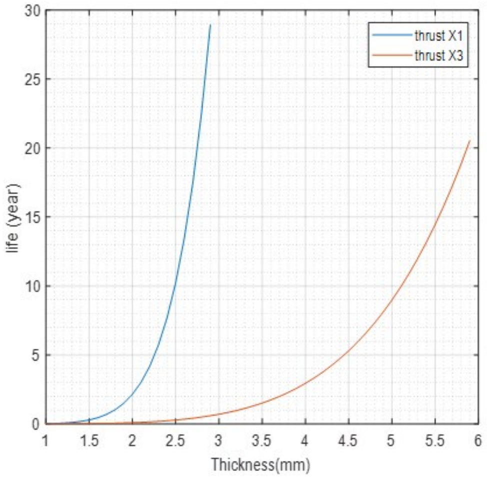
The blade lifetime calculations are depending on the variation of the thickness of the blade, average thrust force applied, and the rotational speed of the blade which represented by graph. Figure 9 showed that, the longer life of service is a result of the increasing of thickness of the blade. In fact, the consequences will allow the proper selection of the blade thickness based on the turbine lifespan demanded.

Figure 9: Aluminum blade's lifetime according to thickness.



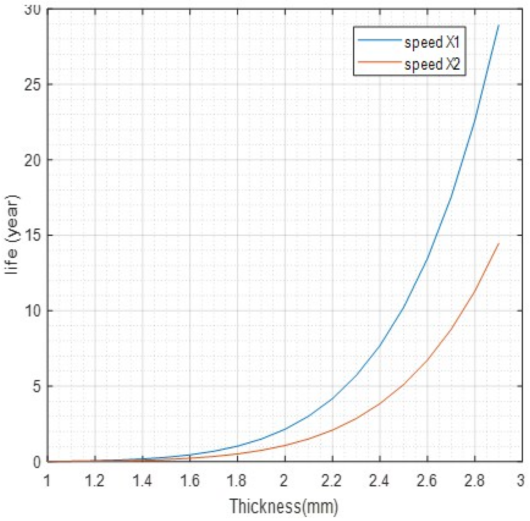
Practically, the mean trust force is varying over the operating life. Therefore, it is important to study the blade life taking into consideration the variation of the hydro force. Figure 10 presents the estimating Aluminum blade's life considering the trust force. It has been resulted that increasing the thrust force has a great impact on decreasing the expected life of Aluminum blade.

Figure 10: Predicted life according to the applied trust and the blade thickness.



Increasing the blade rotational speed will impact the study predicted blade lifetime. Then, the study of the RPM varying with the thickness of the blade of the Aluminum provides an accurate determination of the blade average lifetime. Figure 10 represents that; the increasing of the thickness will automatically increase the gap of the lifespan as a consequence of the increasing of the blade rotational speed.

Figure 11: Predicted life according to the rotational speed and the blade thickness.



DISCUSSION AND CONCLUSION

The discrimination of Aluminum is due to its accuracy, lightweight, obtainability, ability to be manufactured, and being highly resistive against the conditions of erosive operating predicted under sea level. Moreover, it is lowly resistive against large effects expected from the conditions of harsh environment. Generally, the usage of Aluminum in the manufacturing of complicated contours (like blades) is highly recommended because of its domesticity in the part of the industry. Generally, the usage of Aluminum in the erosive conditions is preferable as in the turbines under sea level. The steel features are great strength and several mechanical features which are (the high resistance to the effects and also the provided shore for the processes of the manufacturing steel).

Looking for obtaining renewable energy from the natural world is considered a sign in the 21st century as a result of the lack the sources of fossil fuel in addition to a large amount of the released toxic emissions as a result of the ordinary methods used to generate the electricity. In order to harness an array of a marine turbine in littoral countries got high concentration in the past decades because of the enormous quantity of energy stockpiled in the waves of the ocean. It is fundamental to keep the operation of the turbine and prevent any potential break or fracture because of the large initial costs and the performed effort in its construction. The research aims to perceive the design in all ways, the proper selection and manufacturing the marine turbine for applying the proper techniques of maintenance. A huge domain of the types of the turbine is provided by suppliers for covering the demand of the whole global market.

The exploitation of the actuators and the sensors in the marine turbine is due to the accurate measurement of the detected error in the turbine resulted from (vibrating, erosion rate and biofouling). The most efficient factors on marine turbines are both the environmental effects and the changes in the climate. The erosion can raise the blade's surface roughness that results in losses in the output of the energy. Also, the ocean water turbulences can cause vibration and fatigue loads. These problems solution is studying the types, materials and components of the marine turbines. Also, consider the proper maintenance techniques to perform based on the data collected.

The resulted conclusion from the applied fatigue stress on the turbine with six blades modeling is as follows: The model implementation depended on the records of the blades thrust forces measured by accurate examination. These results aided the code of MATLAB for the construction of the algorithm of the rainflow by rearranging the blades' average thrust force applied. The previously mentioned steps lead to counting the cycles applied for each range of loading. Hence, the damage equivalent load resulted from the fatigue stress applied is calculated numerically for the determination of the stress equivalent load. Then, the estimation of the lifespan of the blade was reached with regard to the thickness of the blade. In addition, the increasing of the blade average thrust force and rotational speed impact was studied. Consequences show that the time of the service is decreased as the increase of the average thrust force and the rotational speed. MATLAB provided a comparison based upon the thickness of the blade. The selection of the aluminum that will be used in the blade manufacturing in accordance with the conditions of the environmental erosive where it's expected to the blade to be operating. In addition, the resistivity provided by the aluminum against the effects that are unexpected, which occurs due to the seawater wildlife and items.

Renewable energy resources found great interest to use as an alternative to the fossil fuel in producing the required energy. Among these renewable resources, tidal power is considered as a promising source to generate electrical energy. Tidal turbines are used to convert the kinetic energy of tides into a usable form of power. Therefore, several researches aimed to study the design parameters of such tidal turbines in order to optimize the amount of generated energy. Turbine blade is the most critical part that can affect the performance of the turbine. It has been stated that the marine environment has a great influence on the operating life of the turbine, therefore, it should be taken into consideration during the design phase.

This research investigated the operating life-time of the turbine blades that made of the high-performance alloy consisting of Aluminum and 0.4% Scandium, taking not account the dynamic load because it is the major cause of the blades failure. The Rainflow algorithm was used for estimating the operating life-time of the turbine blades. CFD simulation has been performed for different thicknesses for the turbine blades, in order to select the optimum thickness that can increase the rotational speed and therefore increase the generated amount of electricity, at the same time increasing the expected service life of the turbine blades.

It has been concluded that the selected alloy of aluminum and scandium is a proper selection for manufacturing the turbine blade according to the high erosion of the marine environment. As well as, the resistance that aluminum provides is against unexpected impacts, which are caused by the surrounding wildlife and marine environment.

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