STUDY ON TIDAL POWER, STRUCTURE, AND DESIGN OF A TIDAL CURRENT TURBINE BLADE

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ABSTRACT

This paper describes the structural, design of a tidal turbine blade the study consists of measuring energy creation if a mechanism were to be placed in the sea flow below tidal areas. Growing concern over the threat of global climate change has led to be increased interest in research and development of renewable energy technologies. Most tidal current turbine design are focused on middle and large scale for deep sea, less attention was paid in low water level channel, such as the region around the islands, coastal seas and rivers. The ocean provides a vast source of potential energy resources and as renewab le energy. Tidal energy ortidal power is the power achieved by capturing the energy contained in moving water mass due to tides. two types of tidal energy can be extracted kinetic energy of currents between ebbing and surging tides and potential energy from the different in height between high and low tides.through this energy may not be able to be obtained all of the time, only favorable condition will be able to create enough electricity current understanding, tidally induced flow in subsea.

Keywords: Tidal Turbine Blade, Tidal Energy, Tidal Current, Ocean Energy,

I. INTRODUCTION

Tidal stream technology is one of the most recent forms of renewable energy to be developed as it offers predictable and tide is a periodic rise and fall of water level of sea which are carried by the action of sun and moon on the water of the earth tidel energy can furnis a significant portion of all such energies which are renewable in nature. it has been estimated that about a billion KW of tidal power is dissipated by friction and eddies alone. this is lightly less than the economically explotable power potential of all the rivers of the world. it is only indication of the magnitude of the tidal power available; all of it is not economicaly feasible also. the first attempt to utilize of the ocean was in the form of tidal "mills" in the eleventh century in great britain and latter in france and spain. the first tidal power plant was commissioned by general degaulle at La Rance in 1966 which marked a break through the avarage tidal range is 8.4 m(±4.2m), and the maximum is 13.5 m. effective basin surface is 22 km^2 basin valume is 184,000,000 m^3. there are no special problems with this site and it was a verry sensible choice for the world's first tidal power station. it has used a singal basin and submerged reversible propeller type turbine.[1] Tidal stream turbines are being designed to convert energy from tidal flows into electricity. Several prototype turbines have demonstrated the potential of this technology with rated power of around 1 MW. Planning is ongoing for arrays of turbines at various sites including in the Pentland Firth (Scotland), the Skerries (N Wales), the Bay of Fundy (Canada) and near Brittany (France). Most of the turbines in development are superficially similar to wind turbines, typically with a horizontal axis and two or three blades. However rotor diameter is limited by the water depth and tidal turbine blades typically have smaller aspect ratio (chord/blade length) and greater thickness due to high root bending moments. Turbulence in tidal flows is also quite different from that in wind for which an unbounded turbulent boundary layer is applicable.[2] Tidal stream technology is one of the most recent forms of renewable energy to be developed as it offers predictable and regular electrical generation at higher power densities than other renewable energy resources.[3]

Since the rotors are never placed in isolation, but are typica ly housed on a support structure, it is important not only to characterize the performance of the rotor, but also to fully understand the interaction of the support structure on the flow characteristics. However, little work has been published on the direct effect of a support structure on the performance of a TST, especially when the support structure is upstream of the blades, as could be the case for turbines operating in dual-direction tidal flows. Prior work, carried out by Mason-Jones et al.,[4]

Tidal energy can provide clean, reliable power, and emerging turbine designs are making production of electricity from ocean energy technologically and economically feasible Tidal energy projects could be a viable renewable energy source, displacing fossil fuel-based energy resources, providing benefits to the marine environment through the mitigation of carbon dioxide production (which can lead to ocean acidification, climate change) and a reduction in the risk of catastrophic spills associated with fossil fuel extraction and transportation.[5]

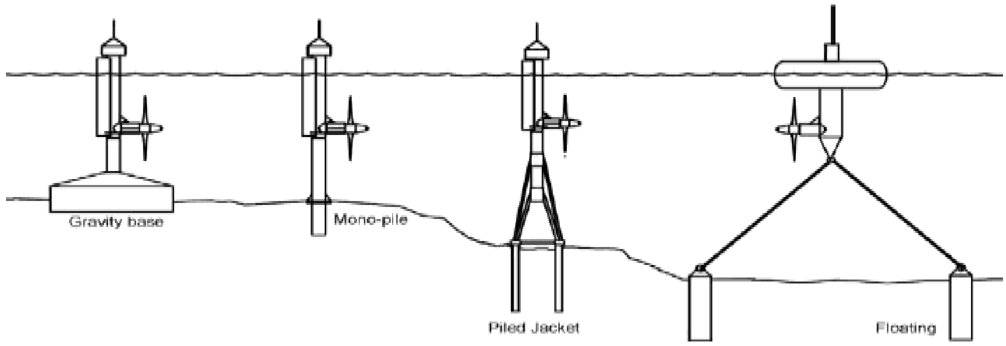


Figure 1. Example of Tidal Current Turbine (Hatt) Configuration.

Table1. Highest Tides (Tide Ranges) of The Global Ocean

Country	**Site**	**Tidal range(m)**
Canada	Bay of fundy	16.2
England	Severn Estuary	14.5
France	Port of Ganville	14.7
France	La Rance	13.5
Argentina	Puerto Rio Gallegos	13.3
Russia	Bay of Mezen (White Sea)	10.0
Russia	Penzhinskaya Guba (Sea of Okhotsk)	13.4

Rising and receding tides along a shoreline area can be explained in the following way. A low height tide wave of hundreds of kilometers in diameter runs on the ocean surface under the moon, following its rotation around the earth, until the wave hits a continental shore. The water mass moved by the moon’s gravitational pull Rlls narrow bays and river estuaries where it has no way to escape and spread over the ocean. This leads to interference of waves and accumulation of water inside these bays and estuaries, resulting in dramatic rises of the water level (tide cycle). The tide starts receding as the moon continues its travel further over the land, away from the ocean, reducing its gravitational inSuence on the ocean waters (ebb cycle).[6]

II. THE RESOURCES OF TIDES

Tidal cycles are calculated using harmonic constants defined by the rhythmic movements of the sun, moon, and earth. The earth is spinning, precessing, and pulsating in concert with its celestial neighbors in an ever-changing and infinite series of movements that causes the oceans to rise and fall. This complex pattern has been closely observed for eons and is now known and mathematically predictable, down to the finest detail across the broadest reaches of time. It is possible, if it strikes one's fancy, to know the precise tidal level at a specific location at a specific moment 100 years or 1000 years in the future. Wind and weather cause changes under extreme conditions ("tidal surges") and these events are not specifically predictable, but the basic harmonic changes in water levels caused by the tides are eminently predictable.
On a global scope, the tides are meters high bulge in the level of the ocean that moves across the globe every 24 hours and 50 minutes. As this bulge nears land, it is changed in amplitude by the decreasing depth and anomalies of the seabed. At the extremes, some tidal ranges are as small as 6 inches and some are as large as 60 feet. Broad-mouthed estuaries create the largest tidal ranges and long straight coastlines tend to have the smalle .The power available (per unit area) in any specific location is a function of the square of the tidal range and thus the largest tidal ranges are the most attractive areas for tidal power generation. The amount of water available in an offshore tidal power generator is a function of the area of seabed impounded. It is most economical to build an impoundment structure in a shallow area, so it follows that the most attractive sites for offshore tidal power generation are those where the tidal range is high and there are broad tidal flats at minimal depth. [7]

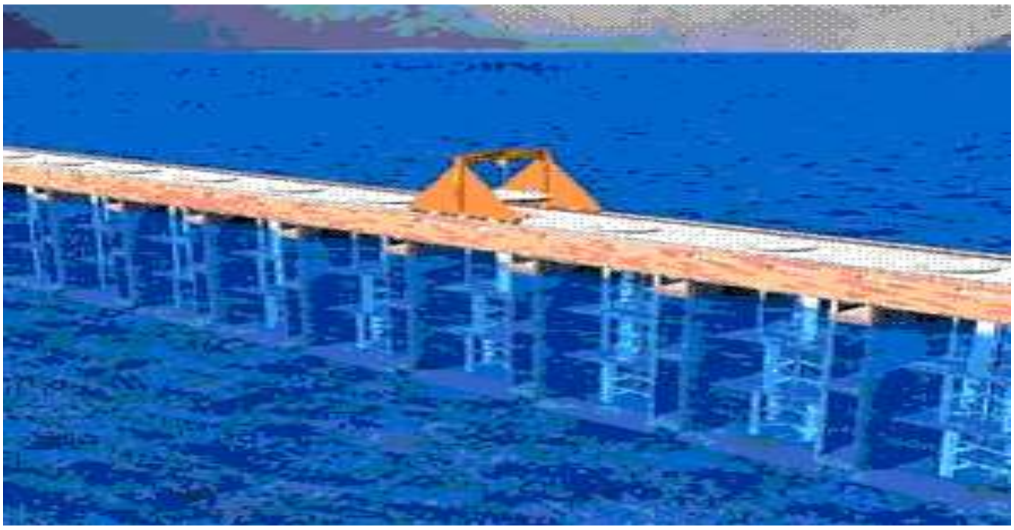


Figure 2.:- Sources of Tidal Energy In Sea

III. METHODOLOGY

3.1 Wave

The method used to identify potential marine resources in Sunda Strait as an electric energy generator is the collection of secondary data through satellite imagery. The parameters identified is the the wave on the year of 2012 starting in January until December through ERDDAP website (Easier access to scientific data) - NOAA Wave Watch III with the coordinates of latitude and longitude 6.183395 ° S 105.172280 ° E. The purpose of the wave data processing is to find the maximum and minimum values of each month of the wave height and period. Then the conversion is to be done by using the equ tion of K. Hulls to obtain generated electrical power. After that, a graphed is to be made to show the relationship between the correlation of the moon with the wave height, the moon with the wave period and the correlation of moo n with potential electric power.

Equation of K. Hulls:

$P = \rho g^2 / 64\pi * H^2 T$

Information:

P = The result of electrical power (watt/meter)

g = 9,8 m/s

□V_0 = 3,14

H = Wave height (meter)

T = Wave period (Second)

3.2 Tidal Wave

The data that are used is the tidal wave in the year of 2012 from January to December by taking the tidal prediction data pattern for 15 days in each monthAfter the secondary data are obtained, then the data are extracting to obtain the average of highest tidal range each month and then inserted into a line graph. Location of the data are located in the coordinate of 5.90720S-105.86890E, the determination is based on the determination of the location that has been done in the other three coordinate points around the Sunda Strait which shows that the location 105.86890E - 5.90720S has the highest of average tidal range per monthly.

3.3 Current

The data of current direction and speed are obtained through satellite imagery from NOAA (National Oceanic and Atmospheric Administration) - Ocean Watch AVISO geostrophic velocities.. After getting satellite data then processed to find the value of the direction and speed of currentParameters obtained from the Ocean watch is the value of the zonal and meridional coordinates of the same point, and with the value of it will get the value of the direction and speed of current. Resultant velocity is obtained by using the Pythagorean rule where the total velocity After getting the values of current direction and speed per montlhy for one year, then the results was made to a graph of from December 2007- November 2008 charts. The current velocity data were taken from December 2007 - November 2008 in the location of 5.356oS 106oE [8]

$$c = \sqrt{v^2 + u^2} \text{ cm/s}$$

IV. HYDRODYNAMIC DESIGN ON TIDAL BLADE

Aerodynamic Characteristics Analysis of Airfoil NACA63-415 is one of NACA series which widely known for its good aerodynamic characteristic. Also, NACA63 series airfoil delay stall and are less sensitive to leading edge roughness than the most other series airfoil . Figure 4 shows the c_l and c_l/c_d of NACA63-415 airfoil at Re 2×10^6. The aerodynamic characteristics data of airfoil were calculated by the open 2D software Xfoil. The range of c_l is from 0.083 to 13.120 with the angle changed from -3 to 15. The attack of airfoil distributes along the blade is focus on 0 to 10, and the value of c_l/c_d is focuses on 70 to 100.

Table2 : Parameter of Blade Design

Design parameter	Values
P_{rated}: Rated power	100 KW
Cp: Estimated power	0.46

Coefficient	
η: Estimated drive train	0.9
efficiency	
V_0: Rated current velocity	2.9 $m.s^{-1}$
ρ: sea water density	1025 kg $.m^{-3}$
D: diameter of the turbine	
N: Blade number	6.2 m
ω: Rated rotational speed	3
λ: Design tip speed ratio	45rpm
	5.8

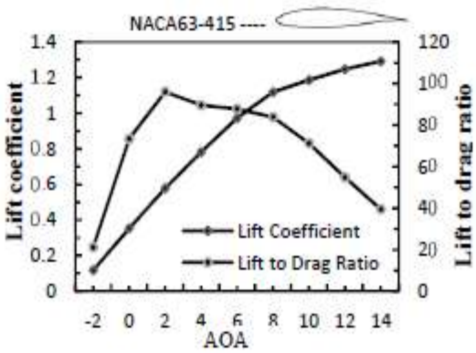
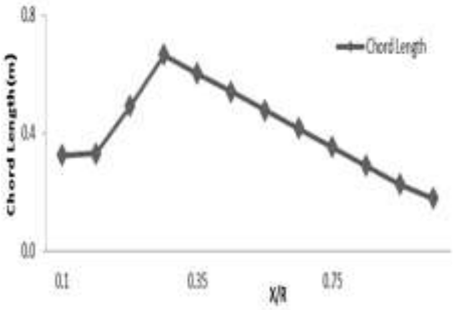


Figure 3. Aerodynamic Characteristics of NACA63-415 At Re=2×106.

V. BLADE DESIGN

The turbine rotor is determined with a 3-piece blade and a 0.15D hub. For a 3-piece blade, the start flow velocity is low compared to a 2-piece blade and ranges from favourable to complex due to the lower effect of the wake . Blade element-moment theory (BEMT) is used for the blade design, which is based on a combination of momentum theory and blade element theory. The chord length and twist angle in Figure 4 are used to define the blade shape. In the main part of blade, NACA63-415 was used as the section. In the root part, a suitable size ellipse was used as the section.[9]



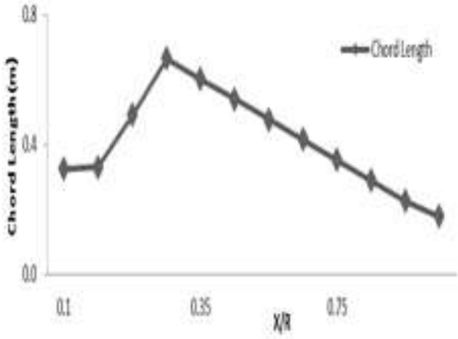
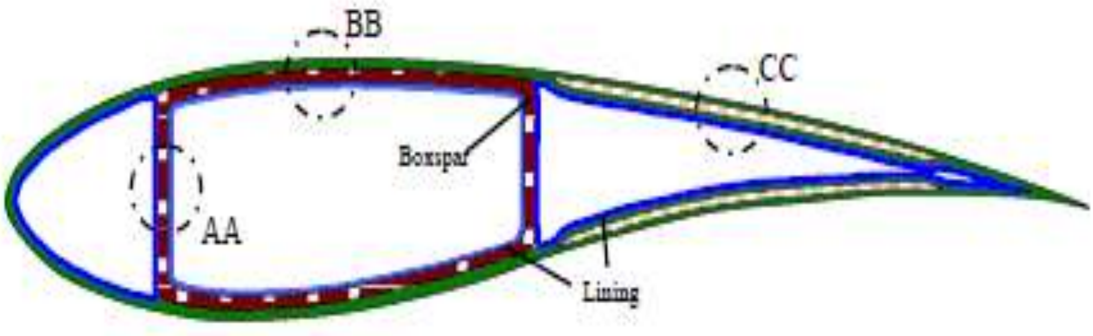


Figure 4. Chord Length and Twist Angle Distribution Along the Blade

VI. STRUCTURE AND DESIGN IN BLADE

For the HATT blade structural design, we use a computerized method that closely follows the one we developed earlier for the preliminary design of composite wind turbine blades [9]. The method allows for arbitrary specification of the chord, twist, and airfoil geometry along the blade and an arbitrary number of shear webs. Given the blade external geometry description and the design load distribution, the code uses ultimate-strength and buckling-resistance criteria to compute the optimal design thickness of load-bearing composite laminates at each blade span location. The code also includes an analysis option to obtain blade properties following blade design. These properties include bending stiffness, torsion stiffness, mass, moments of inertia, elastic-axis offset, and center-of-mass offset along the blade. Nonstructural materials—gelcoat, nexus, and bonding adhesive—are also included for computation of mass. Figure 11 shows the assumed structural layout of composite materials within a typical blade cross section. The figure shows a three-cell blade section with two webs, but the code is applicable to a multi-cell section with an arbitrary number of webs. The outermost skin of a section consists of three layers: a gelcoat layer, a nexus layer, and a double-bias-material composite laminate. In this report, we define a laminate as a stack of plies, where a ply is a planar composite mat. The gelcoat outer layer provides a smooth surface, and although it is not a structural material, it can significantly contribute to the blade mass. Nexus is a soft-material mat that shields the rough surface of the underlying double-bias laminate and provides a relatively smooth but absorbent surface for the gelcoat. At the blade trailing edge, the double-bias laminate splits into two layers to accommodate a core material, such as foam, or honeycomb, as shown in Detail CC below. The core-material laminate augments the buckling strength of the trailing section of the blade.



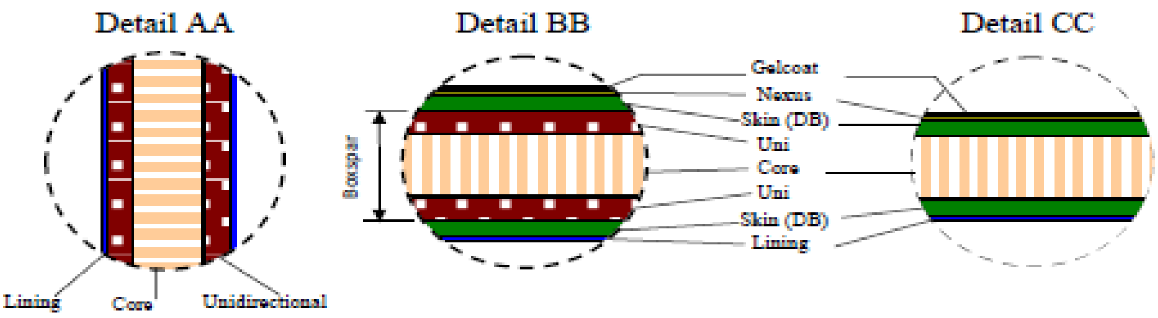


Figure 5. Structural Layup of Composite a Typical Blade Section.

A composite boxspar runs along the midsection of the blade and is attached to the skin double-bias layers at its upper and lower surfaces. The box-spar divides the blade interior into three cells, with the box-spar forming the mid-cell. A lining, typically a double-bias layer, covers the inside surface of each cell. As shown in Detail BB, the box-spar is made of unidirectional composite laminates with an embedded core material. Because of its good axial load-bearing capabilities, the unidirectional laminate provides most of the bending strength. The core material provides the buckling strength to the mid-cell. The two vertical sides of the box-spar serve as webs. Detail AA of Figure 11 shows the sequence of composite layers in each web [10].

VII. CONCLUSION

Tides play a very important role in the formation of global climate as well as the ecosystems for ocean habitants. At the same time, tides are a substantial potential source of clean renewable energy for future human generations. Depleting oil reserves, the emission of greenhouse gases by burning coal, oil and other fossil fuels, as well as the accumulation of nuclear waste from nuclear reactors will inevitably force people t replace most of our traditional energy sources with renewable energy in the future. Tidal energy is one of the best candidates for this approaching revolution. The design approach allows arbitrary twist, chord, and airfoil shape variation along the blade, but allows only a multi-cell boxspar. Though a boxspar design has been the choice by several HATT designers, we plan to extend our design code to accommodate a few more promising layouts. The materials we considered for the HATT design also appear adequate; however, we will critically assess other materials, which may be more suitable for HATT blades.

The radial flow appearance makes the flow on the blade surface irregular, it gives noticeably effect to the aerodynamic characteristic, decreasing the output power and power coefficient. The influence of blade tip chord length is analyzed, the reduction of chord length in the blade tip leads to a decrease in power coefficient. The tidal current recourse review indicates that large energy is contained in the low water level area, which close to the coast. The Uldolmok Strait is a representative and suitable location for tidal current turbine, because of high power density 10 - 25 KW/m^3 and stability flow > 2 $m \cdot s^{-1}$ throughout the year.

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