DESIGN AND FLOW ANALYSIS OF WELLS TURBINE IN TIDEL POWER PLANT

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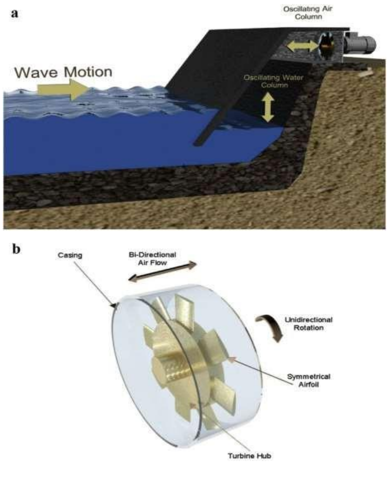
Abstract: **Wells turbine is a self-rectifying air turbine which is widely used in oscillating water column energy converter. The Wells turbine will always rotates in the same direction irrespective of the direction of the oscillating airflow. Moreover the Wells turbine has a simple configuration and structure. This is why the Wells turbine is very commonly used for conversion of wave energy. In this thesis concentrates on the blade profile used is NACA0021 and the speed range of 1000rpm to 5000rpm. First static analysis is performed for the blade of materials selection of ALUMINIUM, INCONEL and SS 310. And then perform CFx analysis the effect of different mass flow rate on the performance of wells turbine then calculate the torque and efficiency.**

Index Terms – NACA0021, Blade Profile, CFx analysis, Mass Flow Rate.

1. INTRODUCTION

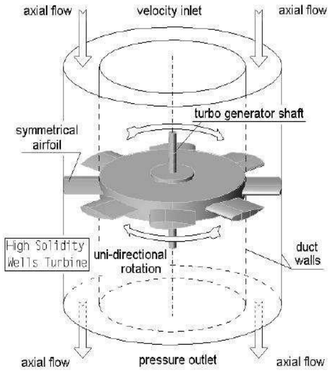
The kinetic energy of moving waves can be used to power a turbine. In this simple Example the wave rises into a chamber. The rising water forces pressurized air the air out of the chamber. The moving air spins a turbine which can turn a generator. When the wave drops, this creates a vacuum in the chamber, causing air to flow in the opposite direction Energy can be harnessed from the tides in two ways: using the change in height of the tides (potential); and using the flow of the water (kinetic).Tidal power is very sensitive to speed. The power output varies as the cube of the speed. In other words, if the water flows twice as fast, it makes eight times the power. Also, tidal turbines do not have to spin as fast as windmills to generate power, because water is round about 800 times denser than air.



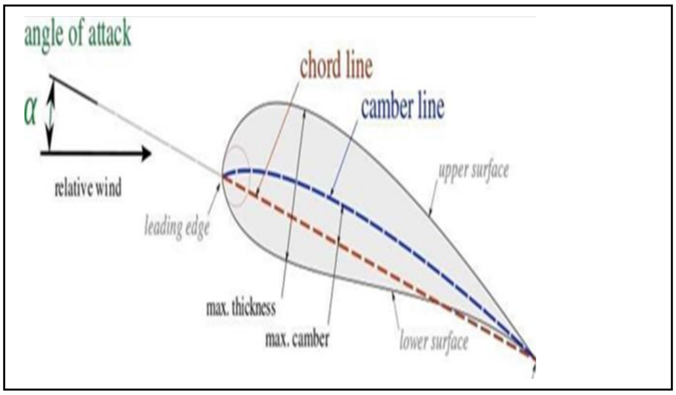
Oscillating water column (OWC)

WELLS TURBINE

The Wells turbine is a low pressure air turbine that rotates continuously in one direction independent of the direction of the air flow. It is a self-rectifying axial flow air turbine. Its blades feature a symmetrical airfoil with its plane of symmetry in the plane of rotation and perpendicular to the air stream. Self-rectifying air turbines are used to extract mechanical shift power. Wells turbine has main disadvantages is lower efficiency, poor starting, and higher noise level in comparison to conventional turbines. In the monoplane Wells turbine, efficiency increases with flow co-efficient up to a certain value, and then it decreases, because angle of attack becomes Greater and boundary layers on the aero foil blades tend to separate. Consequently, the drag force Increases while the lift force reduces. Stall condition occurs at blade tip rather than at hub as the Flow rate increases, so relative velocity distribution at blades leading edge from hub to tip is one of the most important parameters affecting the efficiency of the turbine.



Wells Turbine Layout



Wing Nomenclatures

2. SATATIC STRUCTURE ANALYSIS

	DENSITY	YOUNG MODULES	COST	CORROSION RESISTANT
ALUMINUM	2.7 g/cm³	69 Gpa	0.135 Rs per gram	YES
SS310	8.0. g/cm^3	204Gpa	0.345 Rs per gram	YES
INCONEL	8.44 g/cm^3	204 Gpa	0.6 Rs per gram	YES
GOLD	19.03g/cm^3	69 Gpa	4241 Rs per kg	YES
NICKEL	8.9 g/cm^3	200 GPa	895 Rs per kg	YES
TITANIUM	4.506 g/cm³	120 GPa	1422 Rs per kg	YES
SILVER	10.49 g/cm^3	69 Gpa	50.47 Rs per gram	YES

GEOMETRY

Software Used: - CREO 3.0

Dimensions of Turbine Rotor:

Blade Profile =NACA0021

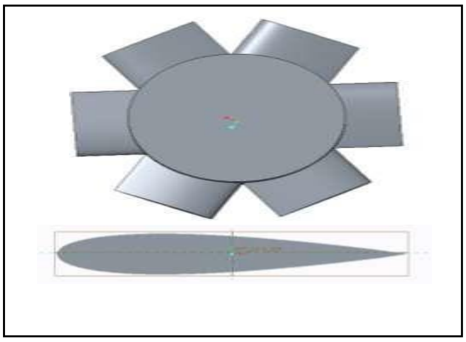
Hub to tip ratio h= 0.7 Blade

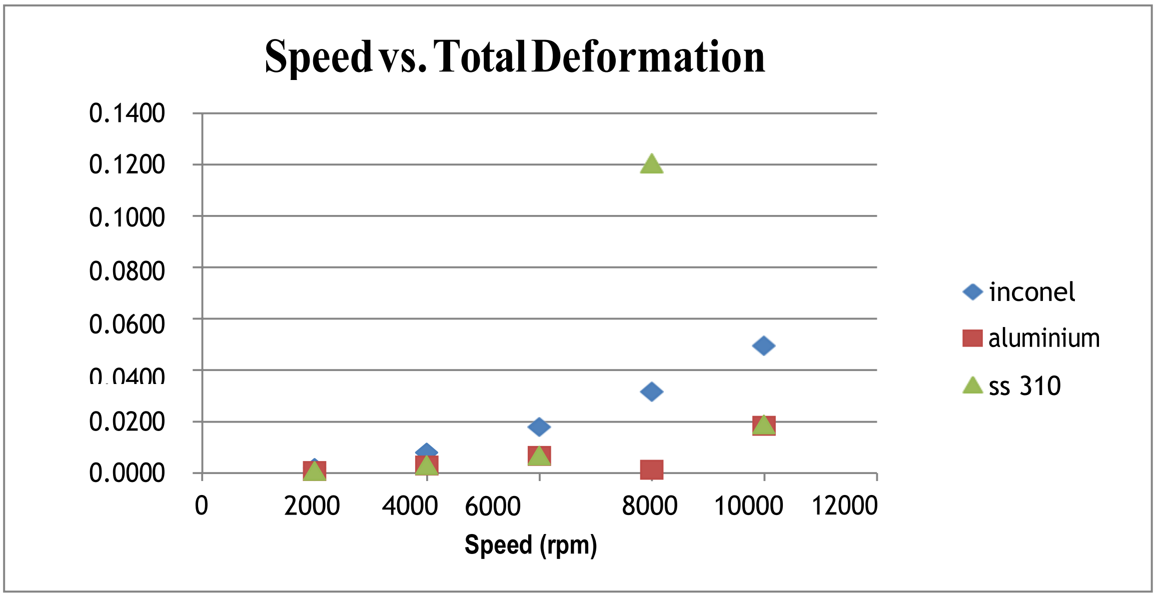
aspect ratio = 0.6 Max.

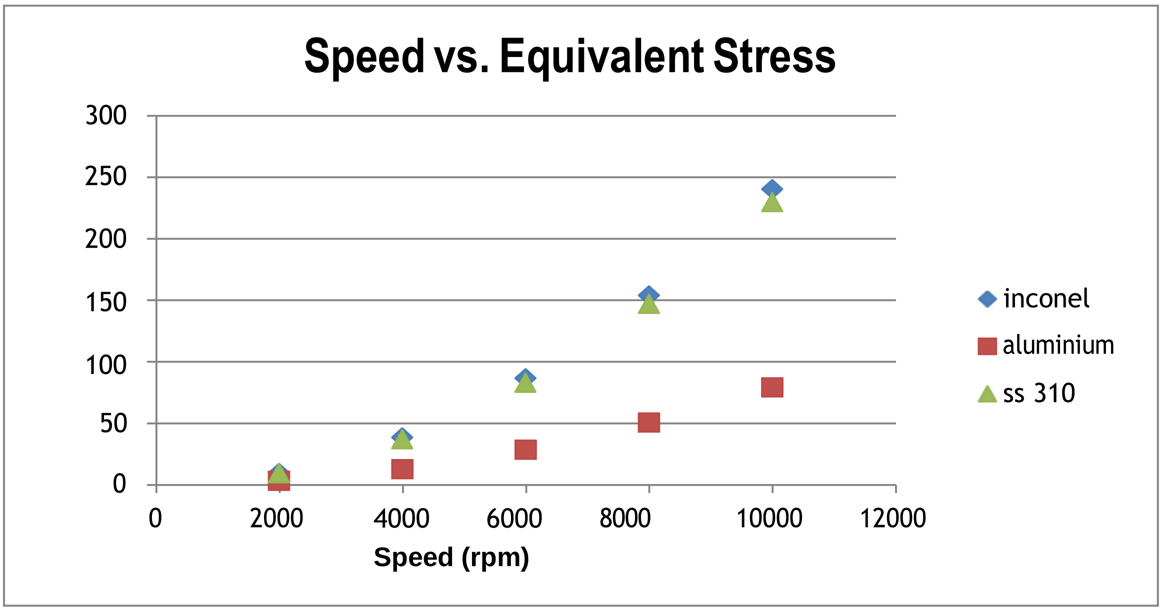
Chamber: 0%

Tip Diameter d_{tip} =153 mm Tip

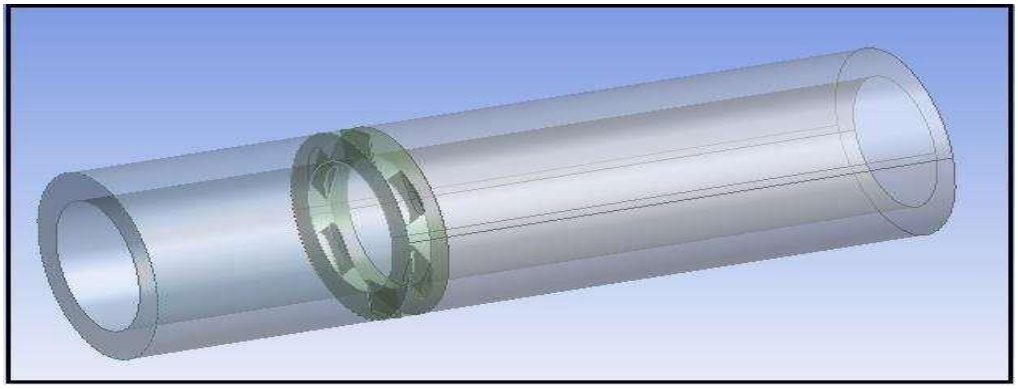
clearance = 2 mm







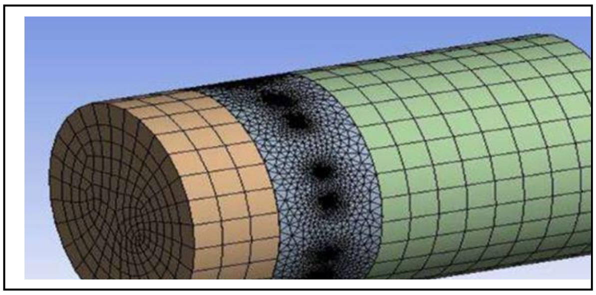
3. CFx ANALYSIS



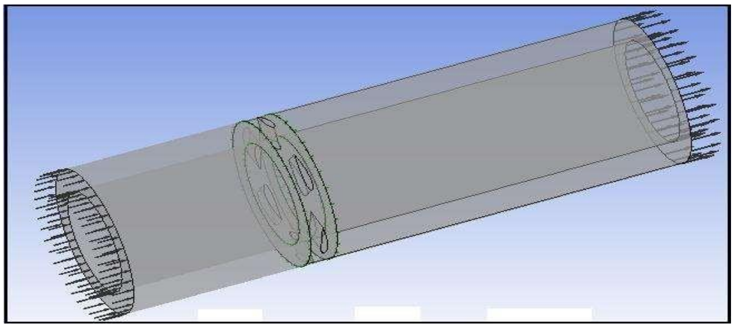
3D MODEL OF GEOMETRY

Meshing:-

- Sizing:
- Relevance center: Medium
- Span angle center: fine
- Smoothening: high
- Transition: Slow
- Nodes: 40695
- Elements: 199560



BOUNDARY CONDITION



Effect change in mass flow rate with speed of 1000RPM

MASS FLOW RATE (kg/s)	MAXIMUM PRESSURE(Pa)	MAXIMUM VELOCITY(m/s)	TORQUE(N*m)	POWER (w)	EFFICENCY (η)
0.10	119.878	16.1213	0.00022510	0.02350	9.8
0.20	194.166	18.7597	0.00029493	0.03880	34.47
0.50	504.818	35.1810	0.00490902	0.51407	16.38
1.00	1819.080	69.4616	0.00558698	0.58500	6.63
1.50	4040.099	104.8630	0.00052317	0.05478	2.30

Effect change in mass flow rate with speed of 1500RPM

MASS FLOW RATE (kg/s)	MAXIMUM PRESSURE(Pa)	MAXIMUM VELOCITY(m/s)	TORQUE(N*m)	POWER (w)	EFFICENCY (η)
0.10	242.171	29.2687	0.00012721	0.02660	10.09
0.20	483.618	32.3206	0.00092819	0.13440	47.991
0.50	889.528	40.3609	0.00180029	0.37705	21.991
1.00	2007.100	71.1670	0.01717450	3.59700	13.982
1.50	4145.660	104.5150	0.00923307	1.93370	8.07

Effect change in mass flow rate with speed of 3000RPM

MASS FLOW RATE (kg/s)	MAXIMUM PRESSURE(Pa)	MAXIMUM VELOCITY(m/s)	TORQUE(N*m)	POWER (w)	EFFICENCY (η)
0.10	361.770	41.3757	0.00155564	0.48887	11.08
0.20	748.262	45.8220	0.00163700	0.51428	32.09
0.50	1569.750	54.4331	0.00204202	0.64152	22.20
1.00	2555.950	74.7023	0.03148270	9.89058	13.20
1.50	4501.710	107.3930	0.03965040	12.45846	4.07

Effect change in mass flow rate with speed of 3000RPM

MASS FLOW RATE (kg/s)	MAXIMUM PRESSURE (Pa)	MAXIMUM VELOCITY (m/s)	TORQUE (N*m)	POWER (w)	EFFICENCY (η)
0.10	516.802	51.9210	0.00391546	1.64010	11.66
0.20	981.912	58.7941	0.00036472	0.15297	37.50
0.50	2314.770	67.2110	0.00348526	1.45990	17.96
1.00	3550.920	80.9260	0.00708219	2.96658	6.09
1.50	5256.600	109.3430	0.01117700	4.68181	2.08

4. CONCLUSION

- Wells turbine can be operated impressively in the range of 1000 rpm to 5000 rpm. From the static structural analysis of the materials Aluminum, Inconel and SS 310 it is concluded that the maximum total deformation & Equivalent stress of Aluminum is less as compare to Inconel and SS 310 in operating range of 1000 rpm to 5000 rpm. So its obtain Efficiency at the range of 2.30% to 47.91%.

- Maximum Efficiency achieve at the speed of 1500 RPM & 0.20 mass flow rate.

- When the Flow Coefficient increase with speed of wells Turbine Blade Then Efficiency also increases at certain speed then efficiency will be sudden drop.

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