Validation of Vertical Flow Water Turbine to Analyze Drag Forces and Velocity of Hydrofoil by using Finite Volume Method

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Abstract

Present analysis is on fluent 15.0. It was carried out on considering hydrofoil of structural steel material with different angle of attack. The study was conducted by using the Finite volume method. Drag forces and wall shear stresses, has been analyzed by ANSYS 15.0. A simplified and idealized finite volume model by using symmetry assumption and a non-simplified finite volume model of process have been used in the analyses. The major study was done on water turbine blade of hydrofoil shaped by using different angle of attack and inlet pressure.

In our analysis, ANSYS is used and the model is developed on UNIGRAPHICS 8.0 and also analysed for FLUENT 15.0. The analysis results show that 45.6 degree of angle of attack and 6bar of inlet pressure gives absolute convergence on pressure and drag forces as well as wall fluxes, Validation and optimization is done to determine the effect of drag forces, velocity, pressure distribution of different inlet pressure working condition. The natural frequency is analyzed in Reaction turbine blade of Vertical flow, thus 3rd mode of natural frequency shows optimum convergence at 45.6 degree of stagnation point with 6 bar of inlet pressure for enhancement of RPM

Keywords— *Angle of attack, Reaction turbine, Drag force, velocity, Wall shear stress, natural frequency, Hydrofoil.*

I INTRODUCTION

A water turbine is a device that converts the kinetic strength of the water into mechanical electricity. Today's water turbines are massive as compared to those of even a decade in the past, and the trend is towards manufacturing still large machines. Although it is able to now not appear so, water generators are complex machines to control, specifically if high performance and excellent efficiency are wished. The secure and excessive overall performance of these machines is feasible best thru technological development in control structures, electronics, communications, and the like, and their integration with the legal guidelines of mechanics that govern the conduct of such machines. Understanding the guidelines of nature and the behavior of a water turbine, and the methods its operation may be regulated as favored, is referred to as "water turbine generation." This is a subject that requires a number of forms of specialized know-how, which one desires to realize which will understand how water generators operate, to work on them, and to carry out in addition research and development on their capability. The cloth associated with water generators is ample. During the beyond 30 years a variety of work has been accomplished on the associated subjects, all of which cannot be included in a monograph. As expected, but, each e-book is written with a selected intention in thoughts and addresses a positive class of readers. This mechanical electricity can be used for precise duties (which include grinding grain or pumping water) or for using a generator that converts the mechanical energy into electricity that is supplied to the energy grid or person users.

The water is an unfastened, easy, and exhaustible power supply. It has served mankind nicely for lots centuries through propelling ships and riding water generators to grind grain and pump water. Interest in water energy lagged, however, whilst cheap and considerable petroleum products have become to be had after World War II. The excessive capital costs and the uncertainty of the water placed water strength at an economic disadvantage. Then in 1973, the Arab countries located an embargo on petroleum. The days of reasonably-priced and abundant petroleum had been drawing to an quit. People started to comprehend that the arena's oil components might now not ultimate all the time and that final resources must be conserved for the petrochemical industry. The use of oil as a boiler gas, as an instance, might have to be removed. Other strength assets except oil and natural fuel should be developed.

The two power sources except petroleum that have been assumed able to supply the long term strength wishes of america are coal and nuclear strength. Many humans suppose there is enough coal for several centuries at present quotes of consumption, and likewise for nuclear electricity after the breeder reactor is absolutely advanced. These are verified assets inside the sense that the technology is noticeably evolved, and large coal and nuclear powered electric generating vegetation are in operation and are delivering sizable blocks of electricity to the patron. Coal requires big scale mining operations, leaving land this is hard or impossible to repwater to usefulness in many instances. The combustion of coal might also disappointed the planet’s heat stability. The production of carbon dioxide and sulfur dioxide can also have an effect on the surroundings and the potential of the planet to supply food for its people. Coal is also a precious petrochemical feedstock and plenty of remember the burning of it as a boiler gas to be silly.

Nuclear power has several advantages over coal in that no carbon dioxide or sulfur dioxide are produced, mining operations are smaller scale, and it has no different foremost use besides providing warmness. The essential issue is the hassle of waste disposal, which, because of the fears of many, will possibly by no means have a definitely pleasant answer. Because of these problems, water energy and different kinds of solar power are being strongly encouraged. Water power may end up a prime supply of electricity regardless of slightly higher charges than coal or nuclear electricity due to the basically non-economic or political problems of coal and nuclear energy. This is not to say that water energy will continually be greater pricey than coal or nuclear energy, because large progress is being made in making water electricity less high priced. But even without a clean value gain, water power might also grow to be really vital inside the global electricity picture.

II TYPES OF WATER TURBINE

Horizontal axis- Large 3-bladed horizontal-axis water mills (HAWT), with the blades up water of the runner produce the overwhelming majority of waterpower within the world nowadays. These generators have the primary rotor shaft and electrical generator at the pinnacle of a runner, and must be pointed into the water. Small generators are pointed by using a simple water vane, while huge generators normally use a water sensor coupled with a yaw system. Most have a gearbox, which turns the sluggish rotation of the blades right into a quicker rotation that is extra suitable to force an electrical generator.[24] Some turbines use a unique type of generator perfect to slower rotational speed input. These do not want a gearbox, and are known as direct-force, meaning they couple the rotor without delay to the generator without a gearbox in among. While everlasting magnet direct-power turbines can be greater high-priced because of the rare earth materials required, these gearless turbines are occasionally preferred over gearbox turbines because they "take away the gear-pace increaser, that's prone to huge amassed fatigue torque loading, related reliability issues, and preservation fees. Most horizontal axis turbines have their rotors upwater of its assisting runner. Downwater machines had been constructed, due to the fact they don't need a further mechanism for preserving them consistent with the water. In high waters, the blades can also be allowed to bend which reduces their swept region and for that reason their water resistance. Despite these benefits, upwater designs are preferred, due to the fact the change in loading from the water as each blade passes at the back of the helping runner can motive damage to the turbine. Turbines utilized in water farms for commercial production of electrical energy are normally three-bladed. These have low torque ripple, which contributes to desirable reliability. The blades are typically colored white for daylight visibility by using plane and range in duration from 20 to 80 meters (66 to 262 ft). The length and peak of generators increase yr via 12 months. Offshore water generators are built as much as 8MW nowadays and feature a blade period up to eighty meters (260 toes). Usual tubular metal runners of multi megawatt generators have a height of 70 m to a hundred and twenty m and in extremes as much as 160 m.

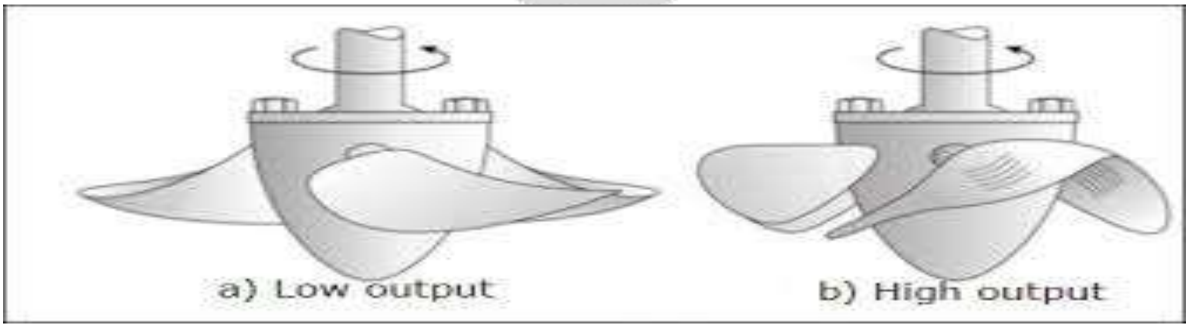

Figure 2.1 Horizontal axis water turbines

Vertical Axis-Vertical-axis water turbines (or VAWTs) have the main rotor shaft organized vertically. One gain of this arrangement is that the turbine does now not need to be pointed into the water to be effective, which is an advantage on a domain where the water direction is water variable. It is also a bonus whilst the turbine is integrated into a building because it is inherently less steerable. Also, the generator and gearbox may be located close to the ground, the usage of an immediate drive from the rotor meeting to the ground-based totally gearbox, improving accessibility for upkeep. However, these designs produce plenty less strength averaged over the years, which is a first-rate drawback. The key hazards consist of the exceptionally low rotational velocity with the consequential higher torque and hence higher cost of the pressure educate, the inherently decrease strength coefficient, the 360-degree rotation of the aero foil within the water flow at some point of every cycle and for this reason the rather dynamic loading at the blade, the pulsating torque generated via a few rotor designs at the force train, and the difficulty of modeling the water waft appropriately and therefore the challenges of analyzing and designing the rotor prior to fabricating a prototype.

When a turbine is installed on a rooftop the building generally redirects water over the roof and this can double the water speed at the turbine. If the peak of a rooftop established turbine runner is approximately 50% of the building height it is close to the top-rated for max water power and minimum water turbulence. While water speeds inside the built surroundings are commonly a good deal decrease than at exposed rural web sites, noise can be a concern and an existing structure may not correctly resist the extra stress.

Subtypes of the Vertical design include:

Darrieus water turbine- Eggbeater" mills, or Darrieus generators, have been named after the French inventor, Georges Darrieus.[30] They have desirable efficiency, however produce big torque ripple and cyclical stress at the runner, which contributes to bad reliability. They also usually require some outside electricity supply, or an additional Savonius rotor to begin turning, because the starting torque is very low. The torque ripple is decreased with the aid of the usage of 3 or more blades which results in extra solidity of the rotor. Solidity is measured by means of blade place divided through the rotor location. Newer Darrieus kind turbines are not held up by way of guy-wires however have an outside superstructure related to the pinnacle bearing.

Giromill- A subtype of Darrieus turbine with directly, in place of curved, blades. The cycloturbine variety has variable pitch to lessen the torque pulsation and is self-beginning.[32] The benefits of variable pitch are: high beginning torque; a extensive, highly flat torque curve; a higher coefficient of overall performance; more efficient operation in turbulent waters; and a lower blade speed ratio which lowers blade bending stresses. Straight, V, or curved blades may be used.

Savonius water turbine- These are drag-type devices with (or extra) scoops which are utilized in anemometers, Flettner vents (typically seen on bus and van roofs), and in a few high-reliability low-performance energy generators. They are always self-starting if there are at the least 3 scoops. Twisted Savonius is a modified savonius, with lengthy helical scoops to offer smooth torque. This is often used as a rooftop water turbine and has even been adapted for ships.

Parallel- The parallel turbine is similar to the crossflow fan or centrifugal fan. It uses the ground effect. Vertical generators of this type have been tried for many years: a unit generating 10 kW become built with the aid of Israeli water pioneer Bruce Brill within the 1980s.

III MAINTENANCE

Turbines are designed to run for many years with very little upkeep of the main elements; overhaul intervals are on the order of numerous years. Maintenance of the runners and parts exposed to water encompass elimination, inspection, and restore of worn elements. Normal wear and tear includes pitting corrosion from cavitation, fatigue cracking, and abrasion from suspended solids inside the water. Steel factors are repaired through welding, commonly with stainless steel rods. Damaged regions are reduce or floor out, then welded lower back up to their unique or an stepped forward profile. Old turbine runners may have a widespread quantity of stainless steel delivered this manner via the quit of their lifetime. Elaborate welding tactics can be used to attain the highest high-quality maintenance.

IV LITERATURE REVIEW

Keke Gao et al. [1] - the studies with Partial admission turbine plays an essential role in power manage, which strengthens the unsteady go with the flow. The outcomes of rotor solidity at partial admission condition may be more complicated, and leakage flow deeply strengthens the unsteadiness. Hence, the investigations of rotor solidity and leakage float at the unsteady flow are of extraordinary importance for turbine designs. Turbines including five kinds of solidity at complete and partial admissions are modeled primarily based on 3D viscous compressible NS equation. In addition, the leakage glide model inclusive of tip leakage, inlet and outlet hollow space is investigated. The results show that the solidity consequences on partial admission turbine are not exactly the same as that on full admission turbine. The differences are identified, in particular the Vertical unsteady aerodynamic pressure. Moreover, the attack attitude tends to be terrible with rotor solidity growing; in the meantime, the low stress region varies with solidity because of drift separation or throat region reduction. Leakage flow model is more capable to show the unsteady glide, and the comparative evaluation of float phenomenon below the mixed results of leakage float and partial admission float is carried out. The exchange of rotor inlet parameters is smoothed down for leakage model and the Vertical thrilling pressure is relative lower.

Amin Najafi et al. [2]- Many research have validated tUsing hydrofoils among hulls of catamarans, hydrofoil supported catamaran (HYSUCAT), is oneof the nice manner to improve the hydrodynamic traits of this vessels. In the prevailing take a look at, thehydrodynamic performance of three special hydrofoils of NACA sixteen, EPPLER 874 and Gottingen 11kare evaluated initially and experimentally through version exams. Afterward, the hydrodynamic performance ofthese hydrofoils is anticipated by using appropriate synthetic neural networks (ANNs). For this purpose, thetotal resistance, powerful energy, sinkage and trim of HYSUCAT is anticipated underneath special Froude range(Fr) and hydrofoil type. According to the results carried out from the version exams, a extensive decrease intotal resistance and trim is observed the use of hydrofoils within the considered catamaran, where Gottingen 11kshows extra outcomes on hydrodynamic overall performance of HYSUCAT in comparison to the other hydrofoils. Inaddition, maximum suggest rectangular mistakes (MSE) of ANNs output in prediction of general resistance, effectivepower, sinkage and trim is carried out 0.000683, zero.000155, 0.000454 and zero.00688, respectively. Moreover,an equation is proposed to are expecting the hydrodynamic overall performance of the HYSUCAT the usage of ANNs weights and bias.

Derrick Custodio et al. [3] - the studies Cavitation traits and hydrodynamic forces of hydrofoils with bioinspired, wavy main edges had been tested experimentally in a water tunnel. Force measurements have been executed the usage of a water-proof load cell, and cavitation styles were recorded by way of immediately imaging the hydrofoil floor. All semi-span hydrofoils had an underlying NACA 634-021 profile with either a square or swept leading part planform. The sinusoidal leading facet geometries were described by way of 3 amplitudes of 2.5%, 5%, and 12% and two wavelengths of 25% and 50% of the imply chord period. Results revealed that cavitation on the changed hydrofoils with the two larger amplitudes changed into in large part restrained to the areas without delay at the back of the protuberance troughs, whereas a baseline with flat main side and the smaller amplitude hydrofoils exhibited sheet cavitation over the whole span. Additionally, cavitation on the changed hydrofoils regarded at continually decrease angles of attack than on the baseline model. Lift coefficient for the baseline version changed into commonly comparable to or greater than that of the modified hydrofoils on the angles of attack considered. Except for the most important amplitude hydrofoils, drag for the modified hydrofoils became equal to the baseline model for nearly the complete angle of assault range.

Andrea Meroni et al. [4] - the research organic rankine cycle electricity structures constitute a possible and efficient answer for the exploitation of medium-to low temperature warmth sources. Despite the huge variety of commissioned devices, there is constrained literature at the design and optimization of organic Rankine cycle electricity systems thinking about multistage turbine design. This paintings offers a initial design technique and working fluid choice for organic Rankine cycle gadgets featuring multistage Vertical turbines. The approach is then implemented to the case of waste warmness recovery from a big marine diesel engine. A multistage Vertical turbine model is offered and demonstrated with the fine available records from literature. The method allows the identity of the maximum appropriate operating fluid considering the trade-off between cycle and multistage turbine designs. The effects of the optimization of cycle and turbine propose that the fluid n-butane yields the excellent compromise in phrases of cycle net power output, turbine fee and efficiency for the considered case examine. When a conservative layout approach is adopted, the turbine functions a two-degree configuration with supersonic converging nozzles and publish-expansion. Conversely, a unmarried-stage turbine proposing a supersonic converging-diverging nozzle and Mach variety up to 2 is the resulting best preference while a more superior design technique is implemented.

Jean-Baptiste Marchand et al. [5] - this studies an experimental research of a hydrofoil in reversed glide configuration in the context of marine modern-day turbine improvement. Experiments consist in hydrodynamic pressure measurements and PIV float observations on a NACA 0015 hydrofoil, at 5 × 105 Reynolds number. The hydrofoil in reversed float produces a better lift than inside the classical forward drift for very low angles of assault and proved to be highly efficient for an angle of assault decrease than 10°, notwithstanding a far higher drag than the same foil in direct go with the flow. Moreover, the elevate coefficient shows a discontinuity with an hysteresis effect while the attitude of assault is various up and down round 0-diploma. It is proven that the pointy main side generates an early Leading Edge Separation Bubble on one facet (suction aspect) even for vanishing angles of attack. This separation bubble triggers the transition to turbulence of the boundary layer at the suction aspect whilst the stress facet boundary layer remains laminar. As a outcome, separation on the rounded trailing edge occurs farther downstream on the (turbulent) suction facet as compared to the (laminar) stress aspect. The Leading Edge Separation Bubble and the inherent up–down asymmetry inside the boundary layer regime are accountable for the raise singularity.

Daegyoum Kim et al. [6] - this studies energy harvesting overall performance and resulting glide systems of a hydrofoil oscillating in pitch and heave are studied experimentally in a water flume. The form of a hydrofoil move phase is proven to have negligible have an impact on at the electricity generation for the geometries examined. It is discovered that contribution to performance from heaving movement will increase with decreased frequency at best pitching amplitude. However, contribution to performance from pitching motion decreases with decreased frequency due to the fact the development of a leading-facet vortex at some point of the stroke is behind schedule on the high decreased frequency. Increasing the element ratio of the hydrofoil results in a better contribution to efficiency from heaving over the range of thing ratios taken into consideration on this take a look at. However, the impact of the component ratio on efficiency from pitching is negligible. When stop plates are hooked up at both ends of the hydrofoil, heaving power complements. However, the enhancement of heaving electricity becomes smaller with growing thing ratio. Meanwhile, pitching electricity improves uniformly with the addition of quit plates for all three element ratios. Our study suggests that the dependence of energy harvesting performance on factor ratio is due to the not on time boom of the leading-aspect vortex near the ends of the hydrofoil.

Keke Gao et al. [7] - The unsteady go with the flow in turbine is extremely complicated and the wake similarly strengthens the unsteadiness. The critical outcomes of stator blade camber and floor viscosity on unsteady drift in Vertical turbine are found out, aiming to improve aerodynamic performance. Single-degree fashions with instantly stator, negative-bowed stator and high quality-bowed stator are constructed. Then, viscous version and non-viscous model on stator blade surfaces are adopted respectively. The waft phenomenon consisting of stator wakes and passage vortex are offered in the view of space and time. Moreover, time-averaged force and pulsating pressure changes are analyzed through time domain and frequency domain approach. The effects display that efficiency of turbine with non-viscosity stator floor is higher because of the weakening wakes and tremendous-bowed stator can reduce the cease wall losses. Notably, the stator camber can lessen the aerodynamic thrilling force thru the wake shape exchange, and the aerodynamic thrilling pressure for the investigated low hole turbine with stator surface viscosity is tremendously decrease because the wake caused by way of viscosity improves the capability waft area uniformity. The paper offers reference for performance improvement and aerodynamic interesting force discount through wake manipulate.

Adel Ghenaiet and Kaddour Touil [8] -the characterization of both the steady and unsteady flows and the analysis of stator/rotor interactions of a -level Vertical turbine. The expected aerodynamic performances display great differences while simulating the turbine degrees concurrently or one after the other. By considering the multi-blade according to row and the scaling method, the Computational fluid dynamics (CFD) produced higher effects regarding the effect of pitchwise positions among vanes and blades. The recorded strain fluctuations exhibit a excessive unsteadiness characterised via a area–time periodicity described by using a double Fourier decomposition. The Fast Fourier Transform FFT analysis of the static strain fluctuations recorded at exclusive interfaces exhibits the life of principal harmonics and their multiples, and every lobed structure of stress wave corresponds to the range of vane/blade matter. The capacity effect is visible to propagate each upstream and downstream of every blade row and will become accentuated at low mass flow rates. Between vanes and blades, the capacity effect is visible to dominate the quasi totality of blade span, even as downstream the blades this impact seems to dominate from hub to mid span. Near the shroud the winning impact is instead linked to the blade tip glide structure.

E. Koç et al. [9] - this investigation the hydro dynamic performance of a dual-blade hydrofoil has been numerically and experimentally investigated in 3 dimensions for tip pace ratio ranging between 1.5 and five.5. The most fulfilling geometric and flow parameters main to the maximum fee of the CL/CD ratio, that's the Major design parameter of the wind and hydro kinetic turbines, were decided. At a design float velocity of 2m/s the maximum energy coefficient of 0.457 was received at the tip speed.

Shengbing Zhou [10] - The research on rotating detonation turbine engine is attracting a good deal interest in recent years. In this observe, experiments were achieved on a structure combining a rotating detonation combustor and an Vertical-waft turbine to analyze the propagation characteristics of the hydrogen-air rotating detonation wave. The stable rotating detonation wave is efficiently initiated using the spark plug and pre-detonator, and there may be nevertheless a speed deficit of approximately 20% relative to the Chapmane-Jouguet price. There is a formation procedure for the strong detonation wave, and the formation time for the pre-detonator is far much less than the spark plug, however the very last country is independent on the ignition tool. The rotating detonation wave successively seems the two-wave country with a equal route, the 2-peak wave country, and the country of robust–vulnerable alternation at some stage in the formation method. Finally, only one strong detonation wave is fashioned within the chamber and propagates until the operation off.

V MODELING AND ANALYSIS

The procedure for solving the problem is

- Modeling of the geometry.
- Meshing of the domain.
- Defining the input parameters.
- Simulation of domain.

Finite element and volume analysis of hydrofoil (water turbine).

Analysis Type - Fluent and Modal.

Preprocessing

Preprocessing include CAD model, meshing and defining boundary conditions.

Table :*5.1 Dimension of hydrofoil shaped water turbine blade*

Angle of attack	30.80, 45.60, 60.90
Length of Hydrofoil	1000mm
Thickness of Hydrofoil	200 mm

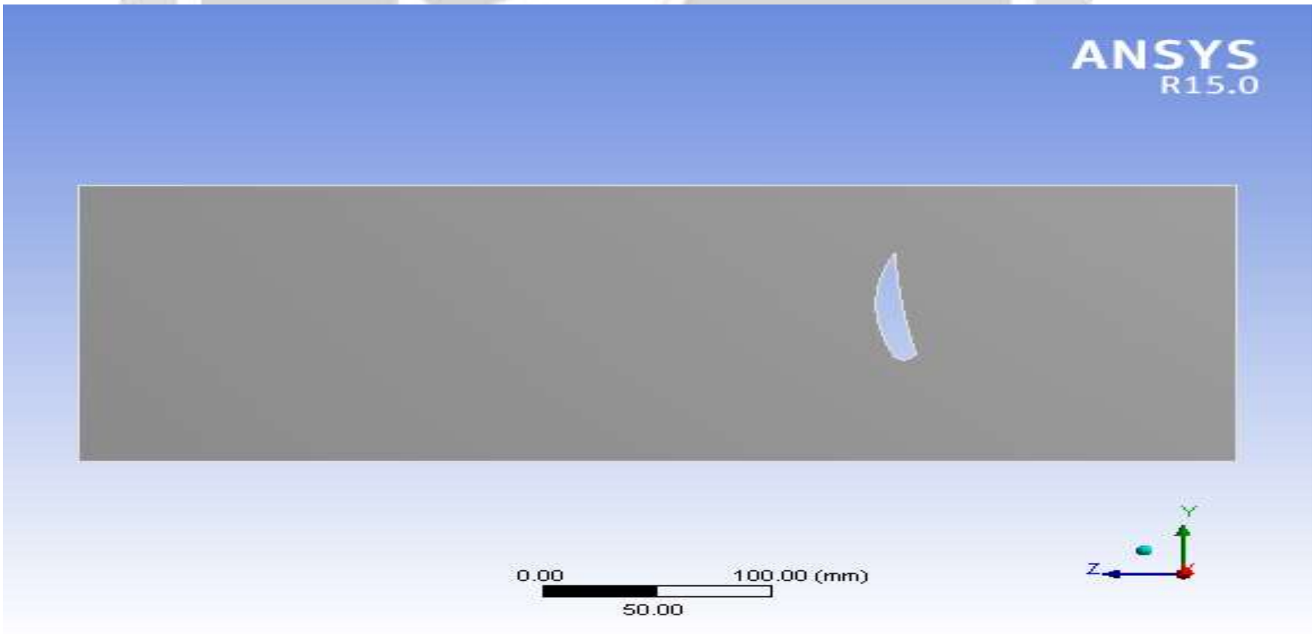

Figure*: 5.1 CAD Model of Hydrofoil with 30^0angle of attack.*

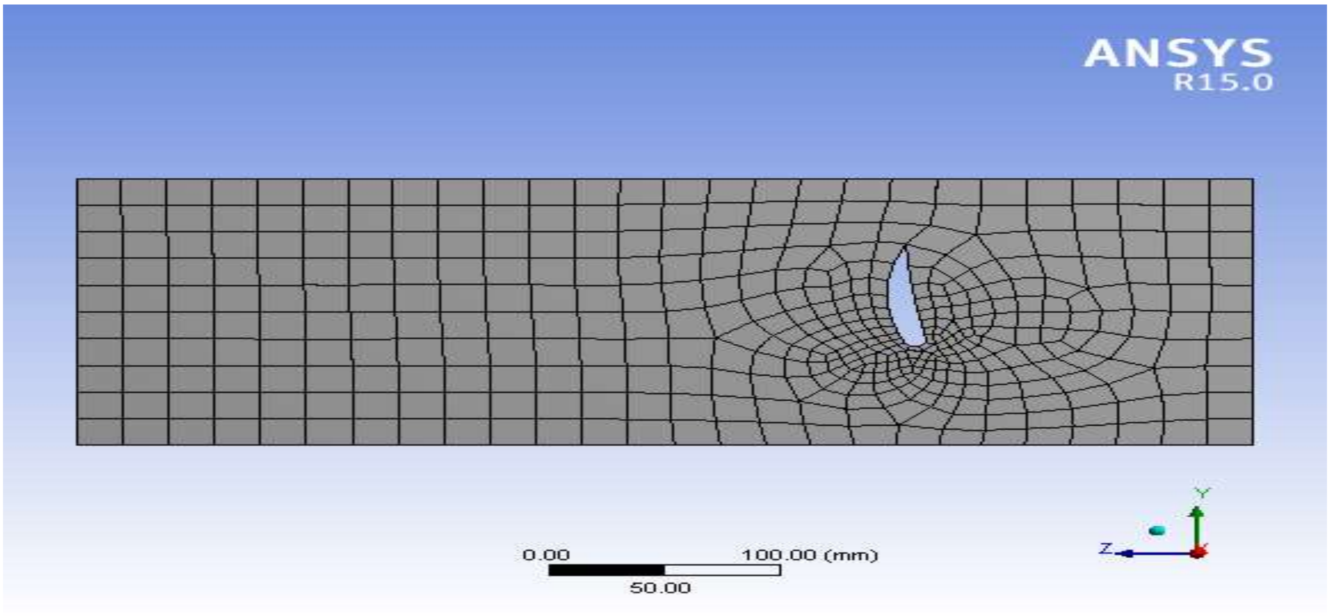

Figure 5.2 Mesh domain of Hydrofoil with 30.80angle of attack.

Table 5.1 Properties of different material**.**

Material Properties	**Structural steel**
Thermal Conductivity	-
Young’s Modulus	2e11 Pa
Poisson's Ratio	0.3
Density	7850Kg/m^3

COMPUTATIONAL FLUID DYNAMICS (CFD)

Computation Fluid Dynamics (CFD) is the branch of fluid science which deals with a variation occurs on fluid flow, basically computational fluid dynamics opt an finite volume method as methodology and for base equation it follows the Eulerian equation, i.e.

Fluent Solver

Computation Fluid Dynamics consists of several domains to solve fluid flow problem like CFX, fluent (poly flow), fluent (blow moulding), fluent, fluent solver works under computational fluid dynamics, it obeys the three governing equation with respect to base equation (Eulerian equation) i.e.

energy equation, momentum equation and continuity equation by applying or solving through this algorithm, the further results were obtained and variation could be determine.

Boundary condition for solving problem on fluent solver: In a finite volume method with respect to governing equation, boundary conditions were applied to simulate to present model, “inlet” this boundary conditions indicate the inlet of fluid with a desire velocity on a model, “outlet” this definition of fluid indicates that the outlet flow of fluid, further heat flux, radiation, convection, mixed (conduction + convection) were applied on present model for simulation.

VI RESULT AND DISCUSSION

The effects of pressure and velocity on hydrofoil of water turbine with natural frequency effects is proceeded for present analysis the natural frequency and pressure distribution on drag surface of hydrofoil is determined for enhancement of converged hydrofoil for pure rotation of reaction turbine blades. The results have been compared with Numerical values of same parameter and also compare with present experimental model with different angle of attack on hydrofoil for operating under similar operating conditions to discuss the enhancement in pressure distribution and velocity effect as well as wall shear stresses on account of hydrofoil shaped.

6.1 CHARACTERISTICS OF PRESSURE DISTRIBUTION

Table 6.1 Validation results of static pressure distribution with numerical simulation and experimental values

Static Pressure for hydrofoil shaped turbine blade			
Inlet Pressure	**30.8 degree**	**45.6 degree**	**60.9 degree**

4 bar	392042.7	390252.4	350123.8
6 bar	588286.5	585321.7	532768.3
10 bar	980695.6	975442	948652.6
12 bar	1176905	1170521	1091423.4

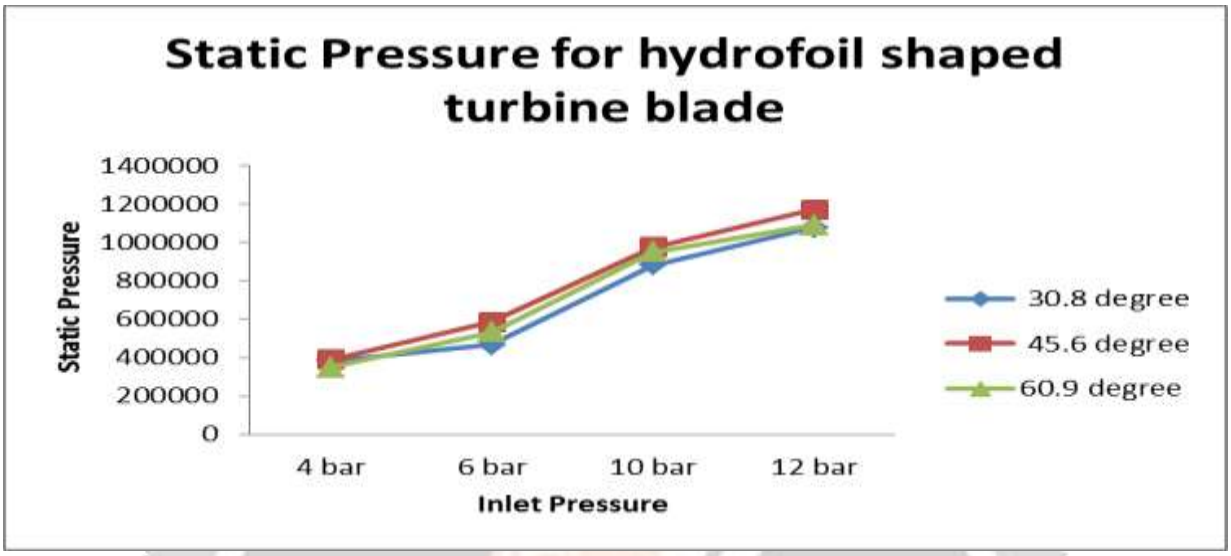

Figure: 6.1 Comparison of static pressure distribution of different inlet pressure with different angle of attack of hydrofoil shaped turbine blade.

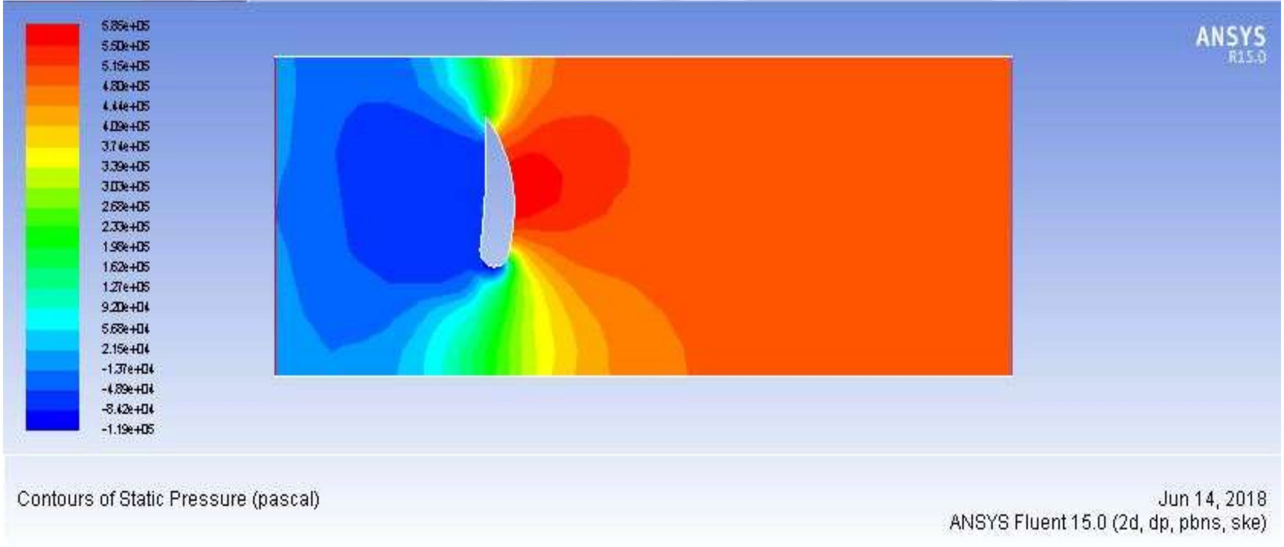

Figure 6.2 Contour plots of static pressure of hydrofoil with 45.60angle of attack with 6 bar.

6.2 Characteristics of drag force

Table 6.2 Validation results of drag force with numerical simulation and experimental values.

Drag Forces for hydrofoil shaped turbine blade			
inlet Pressure	**30.8 degree**	**45.6 degree**	**60.9 degree**
4 bar	2.7466054	3.5485821	7.4945275
6 bar	4.8040868	6.9554677	9.7892123
10 bar	8.4553245	9.5763047	11.921345
12 bar	10.128053	11.8247432	13.629461

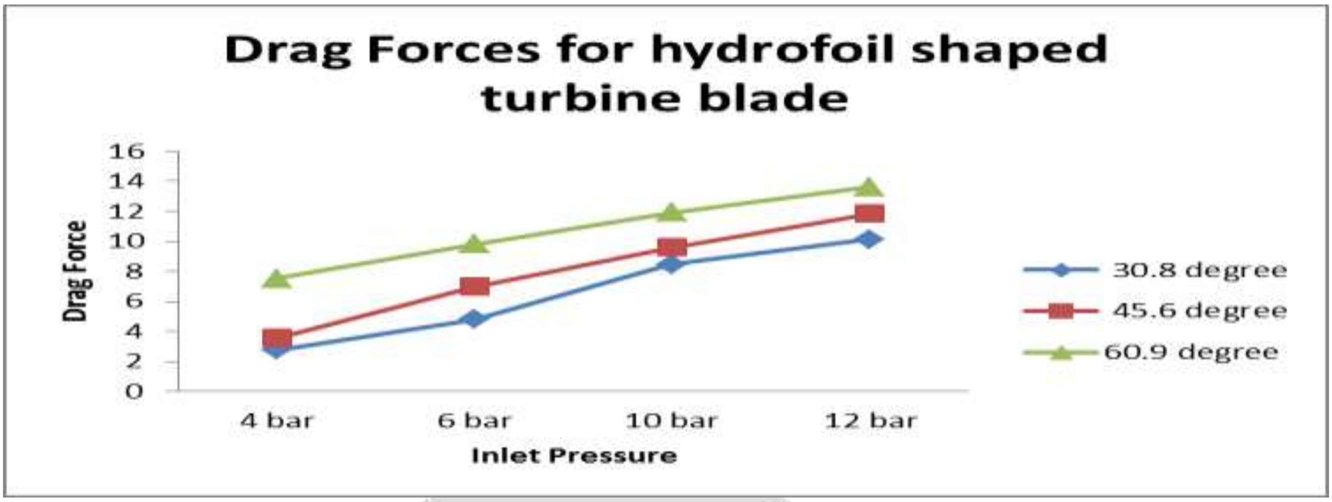

Figure: 6.3 Comparison of drag force of different inlet pressure with different angle of attack of hydrofoil shaped turbine blade.

Table6.3 Validation results of velocity with numerical simulation and experimental values

Velocity for hydrofoil shaped turbine blade			
Inlet Pressure	**30.8 degree**	**45.6 degree**	**60.9 degree**
4 bar	25.37941	28.56417	26.64231
6 bar	30.74536	34.9823	32.32163
10 bar	42.27564	45.16217	43.98179
12 bar	44.98322	49.47283	46.89153

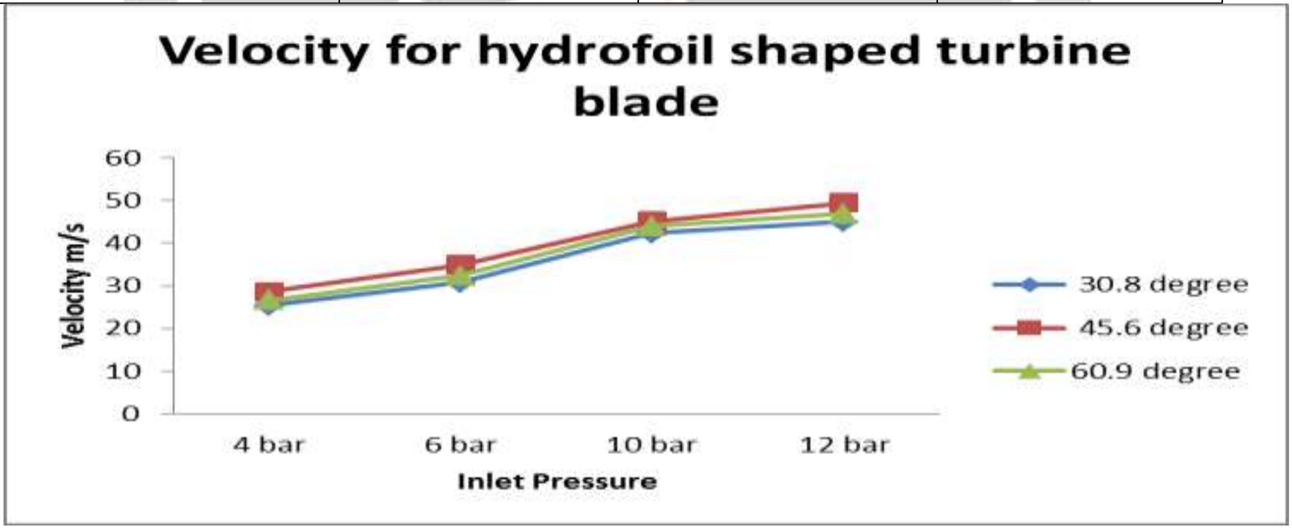

Figure 6.4 Comparison of velocity of different inlet pressure with different angle of attack of hydrofoil shaped turbine blade.

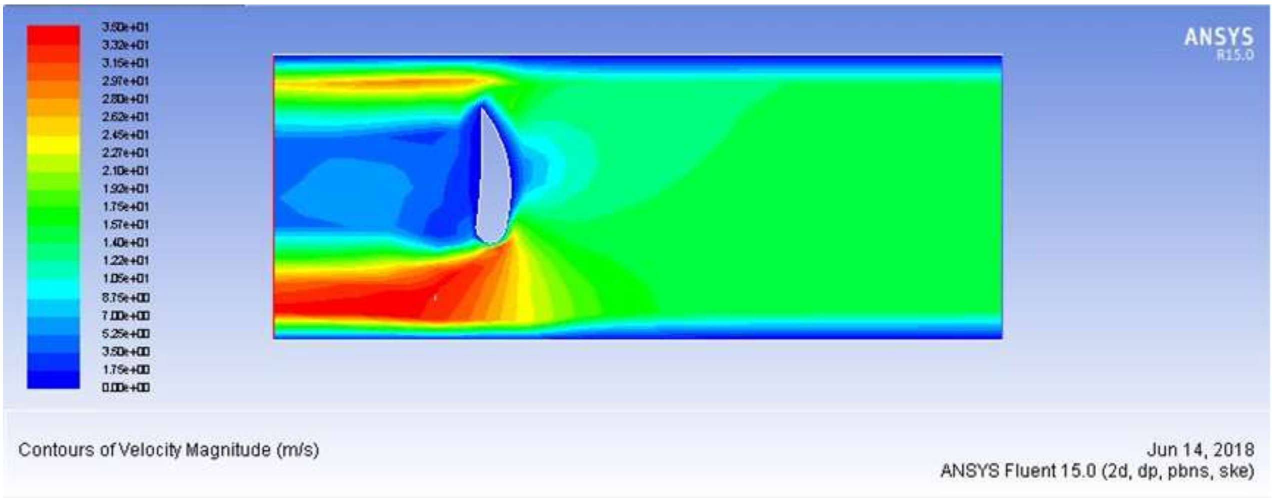

Figure 6.5 Contour plots of velocity of hydrofoil with 45.6^{0}angle of attack with 6bar.

Table 6.4 Validation results of wall fluxes with numerical simulation and experimental values

wall fluxes for hydrofoil shaped turbine blade			
Inlet Pressure	**30.8 degree**	**45.6 degree**	**60.9 degree**
4 bar	690.7061	1023.464	1310.549
6 bar	945.271	1443.032	1924.011
10 bar	1432.957	1997.149	3105.179
12 bar	1669.2	2565.971	3675.177

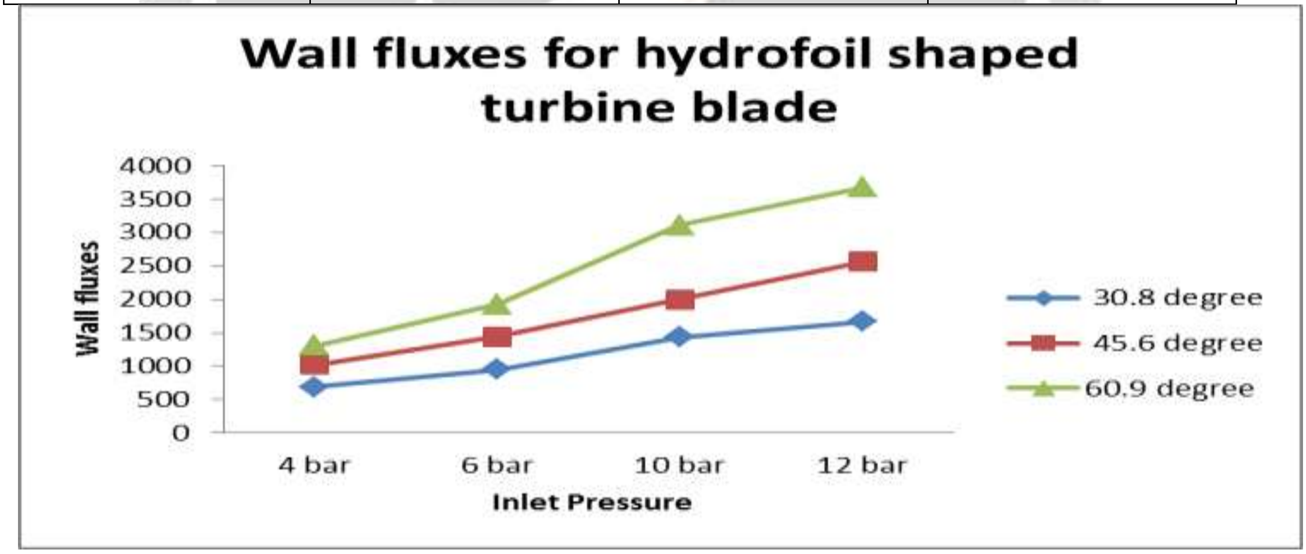

Figure 6.6 Comparison of wall fluxes of different inlet pressure with different angle of attack of hydrofoil shaped turbine blade.

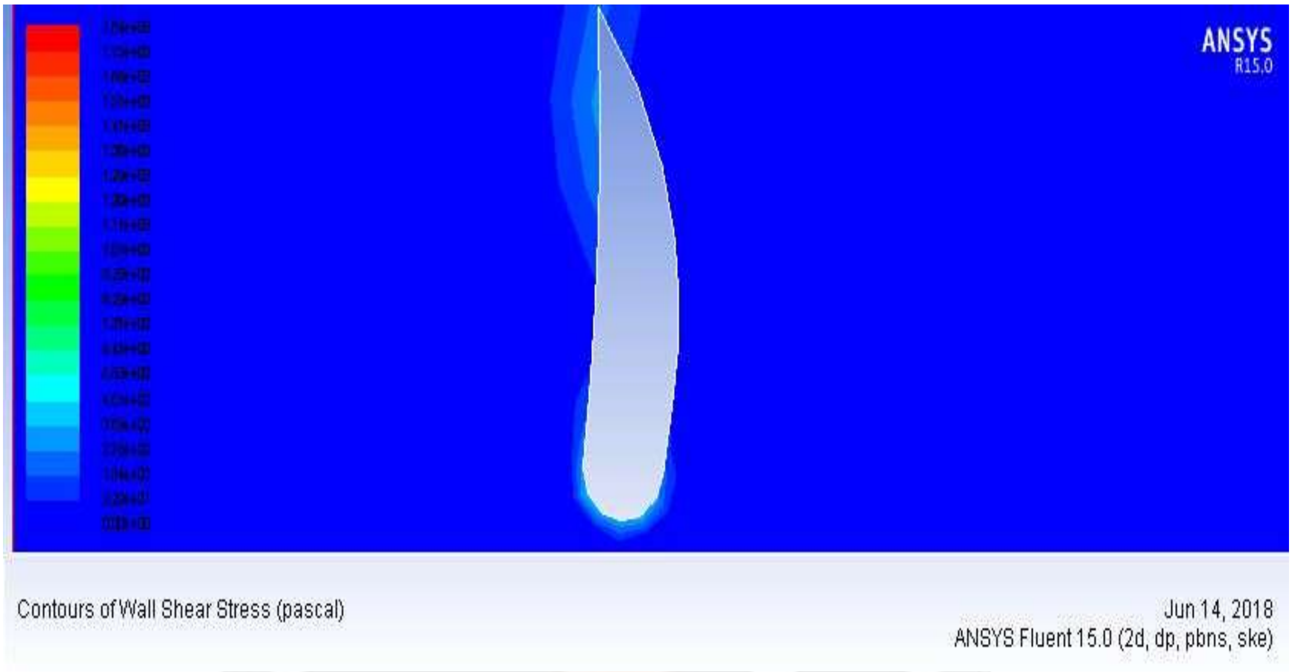

Figure 6.7 Contour plots of wall fluxes of hydrofoil with 45.60angle of attack with 6bar.

Table 6.5 Results of natural frequency with numerical simulation

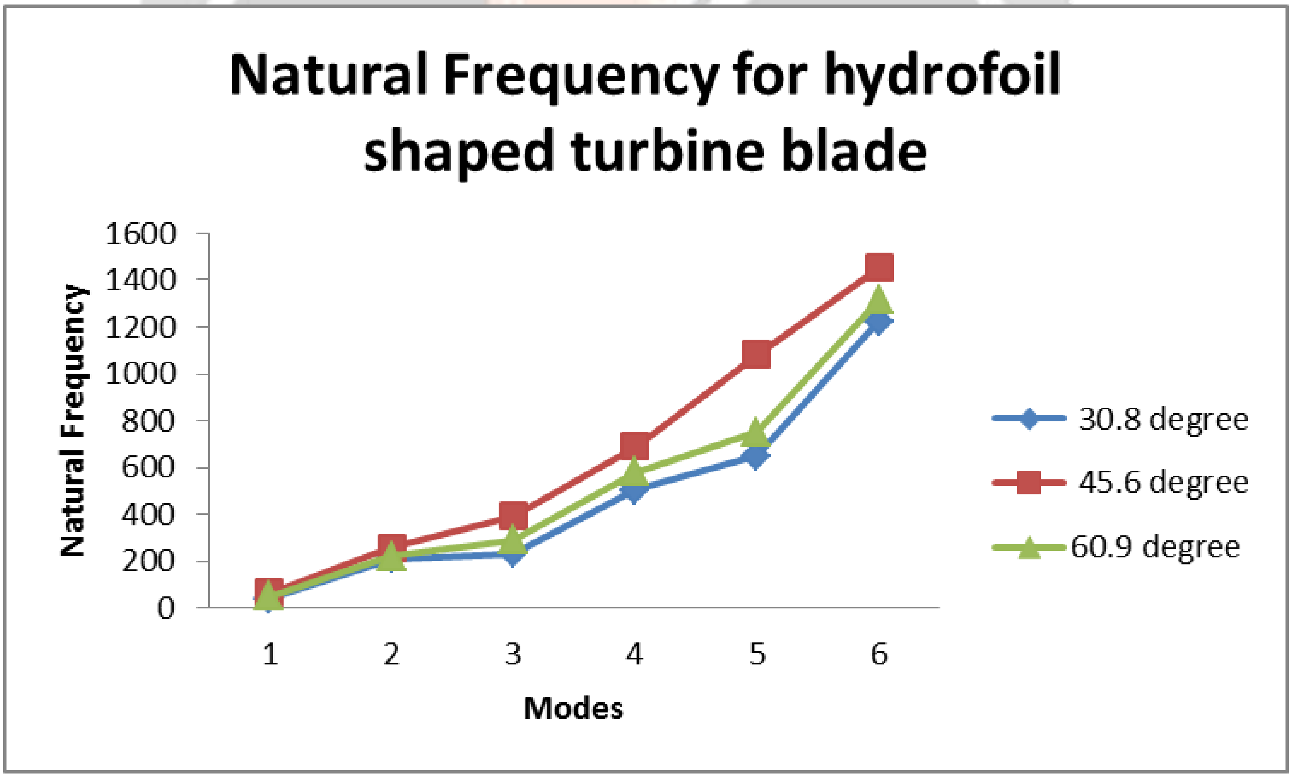

Figure 6.8 Comparison of natural frequency of different inlet pressure with different angle of attack of hydrofoil shaped turbine blade.

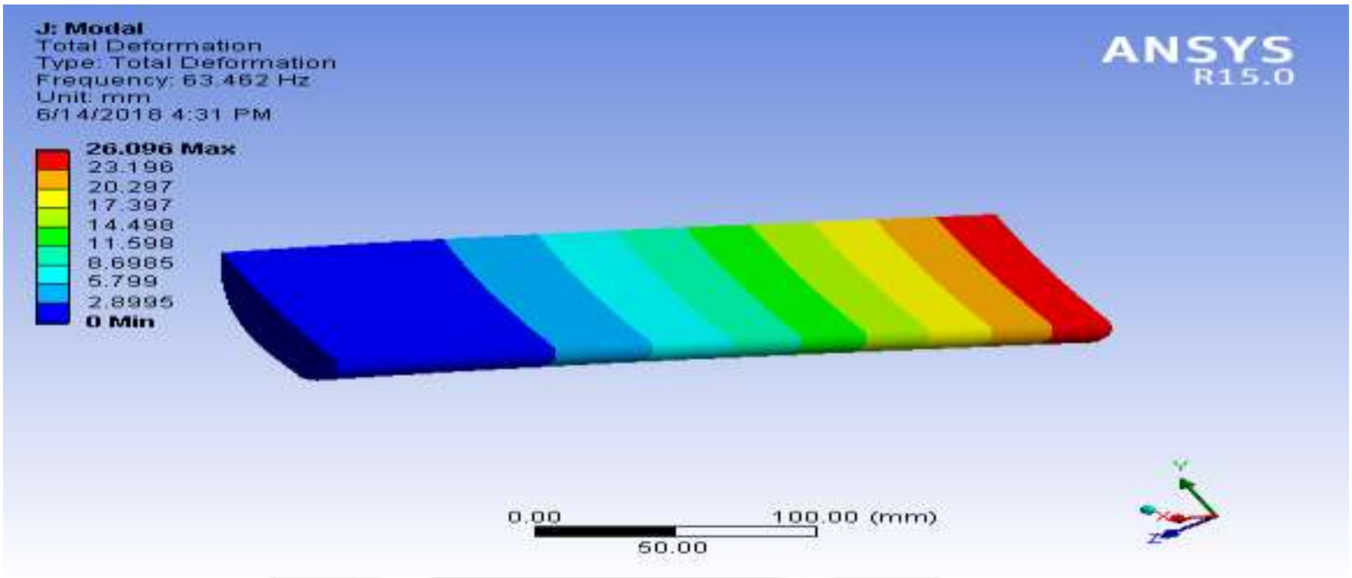

Figure 6.9 Contour plots of natural frequency of hydrofoil with 45.60angle of attack with first mode.

VII CONCLUSION

- Average deviation of result obtained from ANSYS and FLUENT in analysis of hydrofoil water turbine blade with different angle of attack, for base model the pressure, velocity, wall shear stresses, drag forces lies within the range, pressure is deviate 3.76% for simulation model and drag forces effect is deviate 3.91% as compared to experimental study on Andritz Hydro.
- Average deviation of results obtained for different angle of attack with different inlet pressure from CFD (FLUENT) in velocity is deviated by 17.01 % i.e., velocity increases for 6 bar inlet pressure and angle of attack for 45.6 degree from stagnation point.
- Average deviation of result obtained for different inlet pressure on hydrofoil with different modes from CFD in natural frequency is deviated by 8.15% i.e., natural frequency optimum for 45.6 degree angle of attack on its 3rd mode.

Drag forces is optimum for 45.6 degree of stagnation point on stagnation stream line for different inlet pressure, the average variation is analyze by 6.7% and for velocity w.r.t. it is increased by 16. 97% respectively for different angle of attack.

This CFD and ANSYS analysis clearly indicates that hydrofoil of 45.6 degree angle of attack decreases the drag forces and increases velocity with different inlet pressure and different modes of natural frequency which shows optimal frequency on third mode with angle of attack on stagnation point of 45.6 degree due to this effect RPM of turbine increases.

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