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LOW PRESSURE STEAM TURBINE USING CFD : DESIGN

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***Abstract*—** A commercial organization, where the goods are prepared they need to transport their goods from one place or one station to anher. For this purpose, they use hand trolley or also known as hand k on which the load is handled manually from one place to another. Sometimes, it is difficult with this equipment to transport or carry the load manually. In this paper, some design and modification is practically done on the modelled hand truck. Further, it is been motorized which make it simplier for the use instead of manual operation. Design of the model is done in modelling software called Creo Parametric 2.0 and considering several factors, the analysis will be done in analysis software called Ansys 14.0.

Key words: Hand truck, trolley, motored wheel, ANSYS, CREO-PARAMETRIC 2.0.

INTRODUCTION

A steam turbine is a mechanical tool that converts thermal strength in pressurized steam into beneficial mechanical work. The steam turbine derives lots of its higher thermodynamic performance due to the usage of a couple of levels withinside the enlargement of the steam. This outcomes in a 32closer technique to the perfect reversible process. Steam mills are made in a number of sizes starting from small 0.seventy five kw devices used as mechanical drives for pumps, compressors and different shaft pushed equipment, to one hundred fifty mw mills used to generate electricity. Steam mills are broadly used for marine programs for vessel propulsion systems. In latest instances fueloline mills, as advanced for aerospace programs, are getting used increasingly withinside the area of strength technology as soon as ruled with the aid of using steam mills.

Turbine Blades

Blades are the coronary heart of a turbine, as they're the most important factors that convert the strength of running fluid into kinetic strength. The performance and reliability of a turbine rely upon the right layout of the blades. It is consequently important for all engineers worried withinside the mills engineering to have a top level view of the significance and the simple layout components of the steam turbine blades, Blade layout is a multi-disciplinary task. It includes the thermodynamic, aerodynamic, mechanical and cloth technology disciplines. A general improvement of a brand new blade is consequently feasible simplest while specialists of a majority of these fields come collectively as a team. The variety of turbine levels could have a excellent impact on how the turbine blades are designed for every stage. The variety of levels relies upon upon the burden we've and the amount of strength we required. Too many levels may additionally broaden bending second and excessive torque which in flip the purpose of failure of the whole unit of the plant.

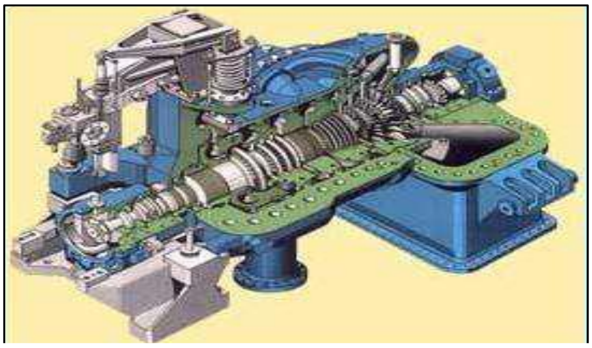


Fig. 1: Half Sectional View of Steam Turbine

Fig. 2: Assembled guide Blades in Inner Casing

LP Blading

Since the axial pace after the closing blade is more often than not associated with the go out area (and now no longer to duration of the closing blade), a homogenous distribution of go out regions has been selected for the Siemens own circle of relatives of LP preferred ranges. For every of the given go out regions, a fixed of 3 preferred ranges has been designed In general, the closing rows of LP transferring blades are designed as free-status blades with curved fir-tree roots for a homogenous pressure distribution. The highly-green 3-dimensional aerofoil layout includes super-sonic tip phase for the massive give up blades. The inlet side is flame or laser hardened, respectively, to save you from droplet erosion. Additional erosion safety measures are relevant to the closing desk bound blades. They are designed as hole blades that both encompass drainage slots to put off moisture from the blade floor or may be heated with steam. An superior 3-dimensional aerofoil layout is implemented so that you can boom degree response on the blade hub and as a result enhance overall performance at low load.

LITERATURE REVIEW

Subramanyam Pavuluri, Dr. A. Siva Kumar concluded that The Experimental investigation on design of high pressure steam turbine blade addresses the issue of steam turbine efficiency. A specific focus on aerofoil profile for high pressure turbine blade, and it evaluates the effectiveness of certain Chromium and Nickel in resisting creep and fracture in turbine blades. The capable of thermal and chemical conditions in blade substrate from to prevent the corrosion when exposed to wet steam. The efficiency of the steam turbine is a key factor in both the environmental and economic impact of any coal-fired power station. To increasing the efficiency of a typical 500MW turbine by 1% reduces emissions of CO2 from the turbine station, with corresponding reductions in NO_x and SO_x. In this connection an attempt is made on steam turbine blade performance is important criterion for retrofit coal fired power plant. Based on the research presented modifications to high pressure high pressure steam turbine blades can be made to increase turbine efficiency of the turbine. The results and conclusions are presented for a study concerning the durability problems experienced with steam turbine blades.

Amit Kumar Gupta , Mohd Rehan Haider, Rohit Pandey conclude Turbine Blades are the main component of any steam power plant and have to withstand in very high temperature. The main aim of this paper is to calculate the creep life of 210MW Reheat Reaction Turbine Blade by changing the different material and suggested the best material for the turbine blade, so the life of the turbine blade is increased to some extent. In this paper the modelling of blade is done in PRO-E and analysis of stress is done in ANSYS 14.5 FEA tool. After structural analysis of the turbine blade Modified Larson Miller Parameter is used to calculate the creep life of the turbine blade then the results are compared and finally some of the results are presented.

A. Sudheer Reddy, MD. Imran Ahmed, T. Sharath Kumar, A. Vamshi Krishna Reddy, V.V Prathibha Bharathi conclude that

Steam turbine is an excellent prime mover to convert heat energy of steam to mechanical energy. Of all heat engines and prime movers the steam turbine is nearest to the ideal and it is widely used in power plants and in all industries where power is needed for process. In power generation mostly steam turbine is used because of its greater thermal efficiency and higher power-to-weight ratio. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator – about 80% of all electricity generation in the world is by use of steam turbines. Rotor is the heart of the steam turbine and it affects the efficiency of the steam turbine. In this project we have mainly discussed about the working process of a steam turbine. The thermal efficiency of a steam turbine is much higher than that of a steam engine.

DEVELOPMENT OF NEW HIGH EFFICIENCY STEAM TURBINE

Mitsubishi Heavy Industries, Ltd. (MHI) has developed new high performance turbine blades (reaction blades, impulse blades, and LP end blades) and high performance seals, as new technologies that remarkably improve the performance of steam turbines. Moreover, MHI has developed a new high efficiency steam turbine, adopting not only these new technologies but also other latest technologies to improve performance and operability. The first unit of new high efficiency steam turbine has started the operation at the “T-point” combined cycle verification power plant in Takasago Machinery Works of MHI, and performance and reliability were verified by special measurements. This article describes the characteristics of the new technologies and the structures that were applied to the newly developed steam turbine and the results of the verification.

What are the Objectives?

1. To increase drag;
2. To increase efficiency;
3. To reduce the losses.

CADD AND CAD MODELLING

Computer aided design and drafting (CADD) is a powerful technique to create the drawings. Traditionally, the components and assemblies are represented in drawings with the help of elevation, plan, and end views and cross sectional views. In the early stages of development of CADD, several software packages were developed to create such drawings using computers.

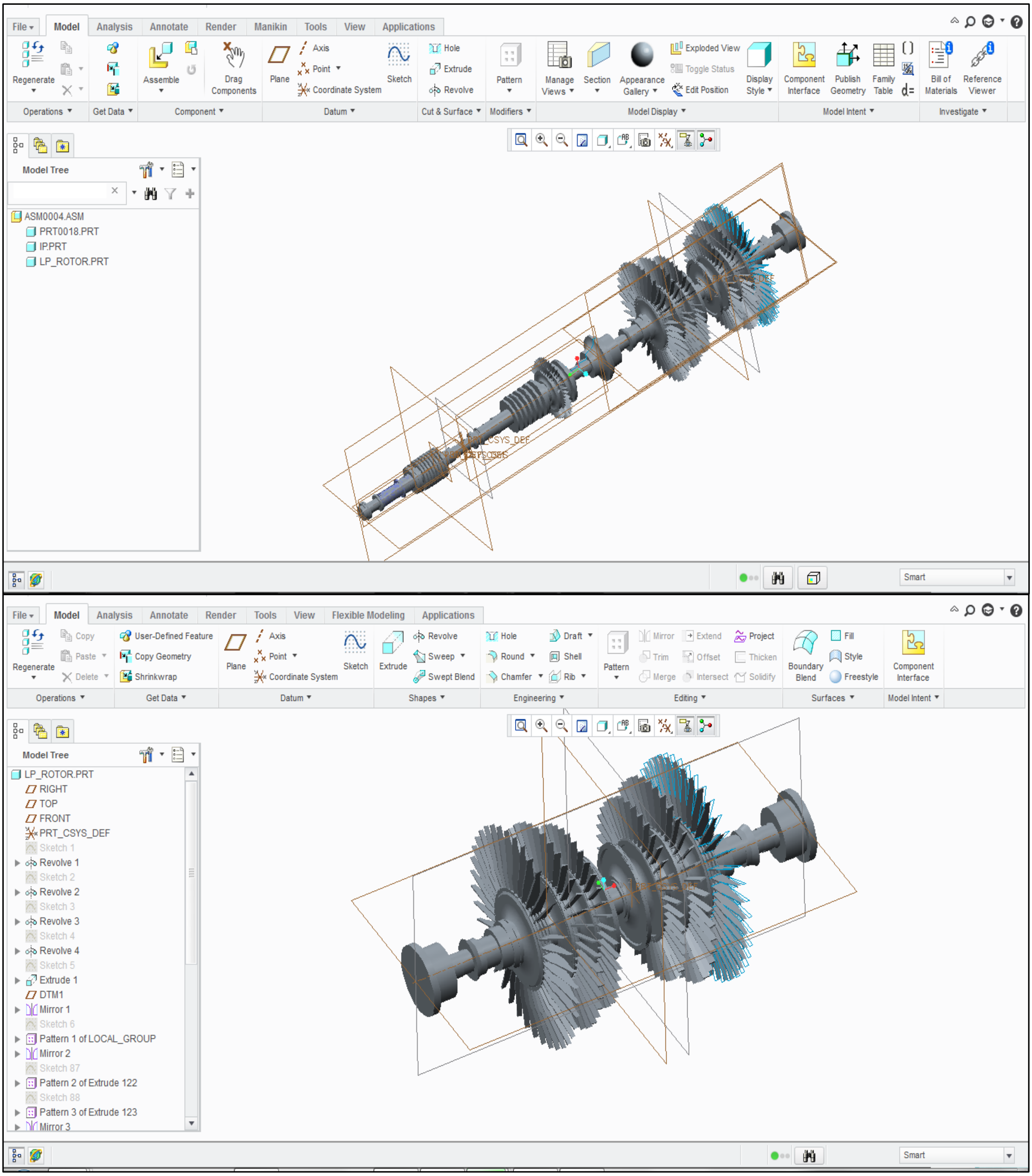
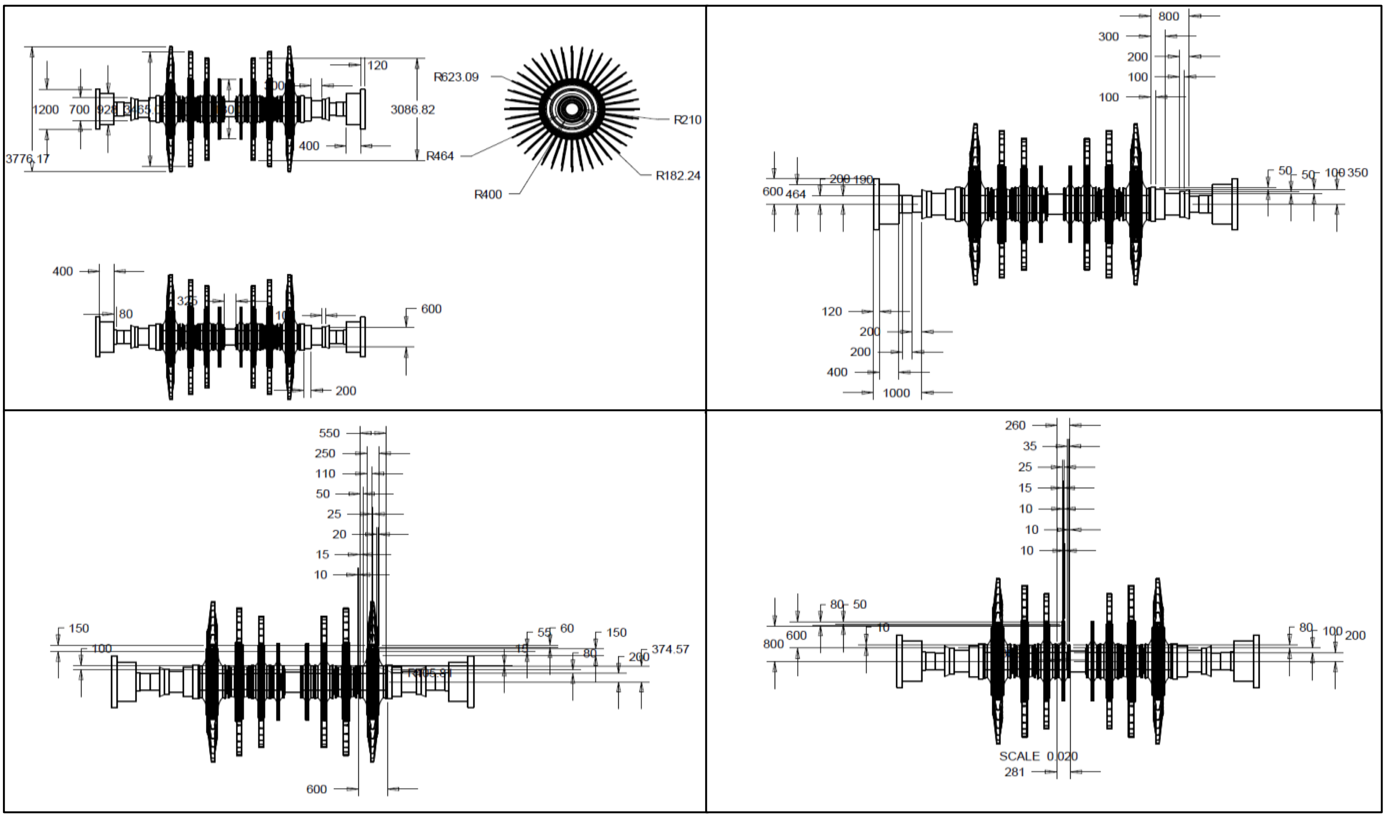


Fig. 3: CAD Modeling of the Rotor Blades



Analytical Method:-

The following operat

Fig. 4: Drafting of the Rotor Blades

Table No 1 Type Of Turbine : Impulse Reaction Turbine

Parameters	Values	Parameters	Values
Turbine Capacity	700 MW	Absolute velocity of steam from the stator blade (V_1)	456.05 m/s
Inlet steam Pressure	76 bar	Tangential velocity of the blade (U)	280.976 m/s
Inlet steam Temperature	501^0 C	Absolute velocity at the outlet of moving blade (V_2)	241.93 m/s
Turbine Speed	3000 RPM	Power developed in the stage (P)	1470.538 kW
Exhaust Steam Pressure	0.1765 bar	Blade efficiency (η_{blade})	81.74%
Outlet Steam Temperature	57.40^0 C	Stage efficiency (η_{stage})	79.245%
Number of Stages	12	Pressure at the exit of the stage	0.176 bar
Working medium : Steam			

What is CFD?

Computational Fluid Dynamics (CFD) is the technological know-how of predicting fluid glide, warmth and mass transfer, chemical reactions, and associated phenomena. To expect those phenomena, CFD solves equations for conservation of mass, momentum, power etc.

CFD can offer precise records at the fluid glide behavior:

- Distribution of pressure, velocity, temperature, etc.
- Forces like Lift, Drag.. (outside flows, Aero, Auto..)
- Distribution of more than one phases (gas-liquid, gas-solid..)
- Species composition (reactions, combustion, pollutants..)
- Much more...

CFD is utilized in all tiers of the engineering process:

- Conceptual research of recent designs
- Detailed product development
- Optimization

- Troubleshooting
- Redesign

Defining Boundary Conditions

- To outline a trouble that effects in a completely unique solution, you have to specify records at the dependent (glide) variables on the area boundaries.

Specify fluxes of mass, momentum, power, etc. into the area

- Poorly described boundary situations may have a sizeable effect to your solution
- Defining boundary situations involves:
- Identifying types (e.g. inlets, walls, symmetry,…)
- Identifying area
- Supplying required information relying on boundary type, area and bodily models

Choice relies upon on:

- Geometry
- Availability of information on the boundary area
- Numerical considerations

<u>CFD Analysis of the Airfoil of Blade</u>

- Importing .iges file into ANSYS Workbench
- Create Meshing file

977	2.8394e-04	3.9282e-06	6.2883e-05	2.7847e-04	1.5211e-06	6.7102e-07	2.3977e-01	8.2953e-03	0:00:06	23
978	3.1049e-04	3.8414e-06	5.9314e-05	3.0456e-04	1.5223e-06	6.4447e-07	2.3977e-01	8.2953e-03	0:00:05	22
979	3.1327e-04	4.0249e-06	5.8543e-05	3.0718e-04	1.5078e-06	6.4524e-07	2.3977e-01	8.2953e-03	0:00:08	21
iter	continuity	x-velocity	y-velocity	energy	k	omega	Cl-1	Cd-1	time/iter	
980	3.0191e-04	3.9490e-06	5.6508e-05	2.9628e-04	1.5142e-06	6.1688e-07	2.3977e-01	8.2953e-03	0:00:06	20
981	3.0846e-04	4.0392e-06	6.0104e-05	3.0266e-04	1.5136e-06	6.0910e-07	2.3977e-01	8.2953e-03	0:00:04	19
982	3.3199e-04	4.0058e-06	5.8134e-05	3.2580e-04	1.5233e-06	5.9163e-07	2.3977e-01	8.2953e-03	0:00:07	18
983	3.0249e-04	3.9500e-06	5.9781e-05	2.9682e-04	1.5138e-06	5.9901e-07	2.3977e-01	8.2953e-03	0:00:05	17
984	2.9289e-04	3.8805e-06	6.0614e-05	2.8739e-04	1.5089e-06	6.2449e-07	2.3977e-01	8.2953e-03	0:00:04	16
985	2.9502e-04	3.7934e-06	6.0169e-05	2.8957e-04	1.4993e-06	6.0193e-07	2.3978e-01	8.2953e-03	0:00:06	15
986	3.1292e-04	4.0427e-06	5.9929e-05	3.0706e-04	1.4961e-06	6.0102e-07	2.3978e-01	8.2954e-03	0:00:04	14
987	3.3585e-04	4.1412e-06	6.0474e-05	3.2945e-04	1.4944e-06	5.8557e-07	2.3978e-01	8.2954e-03	0:00:03	13
988	2.7812e-04	3.7921e-06	5.7055e-05	2.7289e-04	1.5026e-06	6.0252e-07	2.3978e-01	8.2954e-03	0:00:05	12
989	2.8662e-04	3.8303e-06	5.3877e-05	2.8113e-04	1.4950e-06	6.3063e-07	2.3978e-01	8.2954e-03	0:00:04	11
990	3.3222e-04	4.0559e-06	5.7345e-05	3.2596e-04	1.4878e-06	5.7034e-07	2.3978e-01	8.2954e-03	0:00:03	10
iter	continuity	x-velocity	y-velocity	energy	k	omega	Cl-1	Cd-1	time/iter	
991	3.0610e-04	3.9373e-06	5.5625e-05	3.0029e-04	1.4879e-06	5.6732e-07	2.3978e-01	8.2954e-03	0:00:02	9
992	3.2192e-04	3.8331e-06	5.7418e-05	3.1586e-04	1.5027e-06	6.1642e-07	2.3978e-01	8.2954e-03	0:00:03	8
993	3.0559e-04	3.8556e-06	5.7895e-05	2.9974e-04	1.4882e-06	6.2139e-07	2.3978e-01	8.2954e-03	0:00:02	7
994	3.0489e-04	3.9154e-06	5.8462e-05	2.9918e-04	1.4902e-06	5.8080e-07	2.3978e-01	8.2954e-03	0:00:01	6
995	2.9405e-04	3.7245e-06	5.8178e-05	2.8852e-04	1.4855e-06	6.0723e-07	2.3978e-01	8.2954e-03	0:00:02	5
996	2.9715e-04	3.9296e-06	5.5862e-05	2.9158e-04	1.4782e-06	5.8605e-07	2.3978e-01	8.2954e-03	0:00:01	4
997	2.8856e-04	3.7384e-06	5.6528e-05	2.8321e-04	1.4928e-06	6.2677e-07	2.3978e-01	8.2954e-03	0:00:01	3
998	2.7207e-04	3.9117e-06	5.8133e-05	2.6708e-04	1.4772e-06	6.3985e-07	2.3978e-01	8.2954e-03	0:00:01	2
999	3.0979e-04	3.8285e-06	5.6978e-05	3.0391e-04	1.4831e-06	5.7816e-07	2.3978e-01	8.2954e-03	0:00:00	1
1000	3.0549e-04	3.9871e-06	5.9989e-05	2.9976e-04	1.4684e-06	5.8444e-07	2.3978e-01	8.2954e-03	0:00:00	0

- Assign boundary conditions
- Import case file in to solver ANSYS FLUENT
- Give necessary import parameters such as material, model type, pressure inlet and outlet, monitoring values, iterations
- Postprocessor

Post-Processing (Fluent): Compare the predicted C_l and C_d against the experimental values

- From Reference [1], $C_l = 0.241$ and $C_d = 0.0079$
- The CFD solution calculates $C_l = 0.240$ and $C_d = 0.0083$

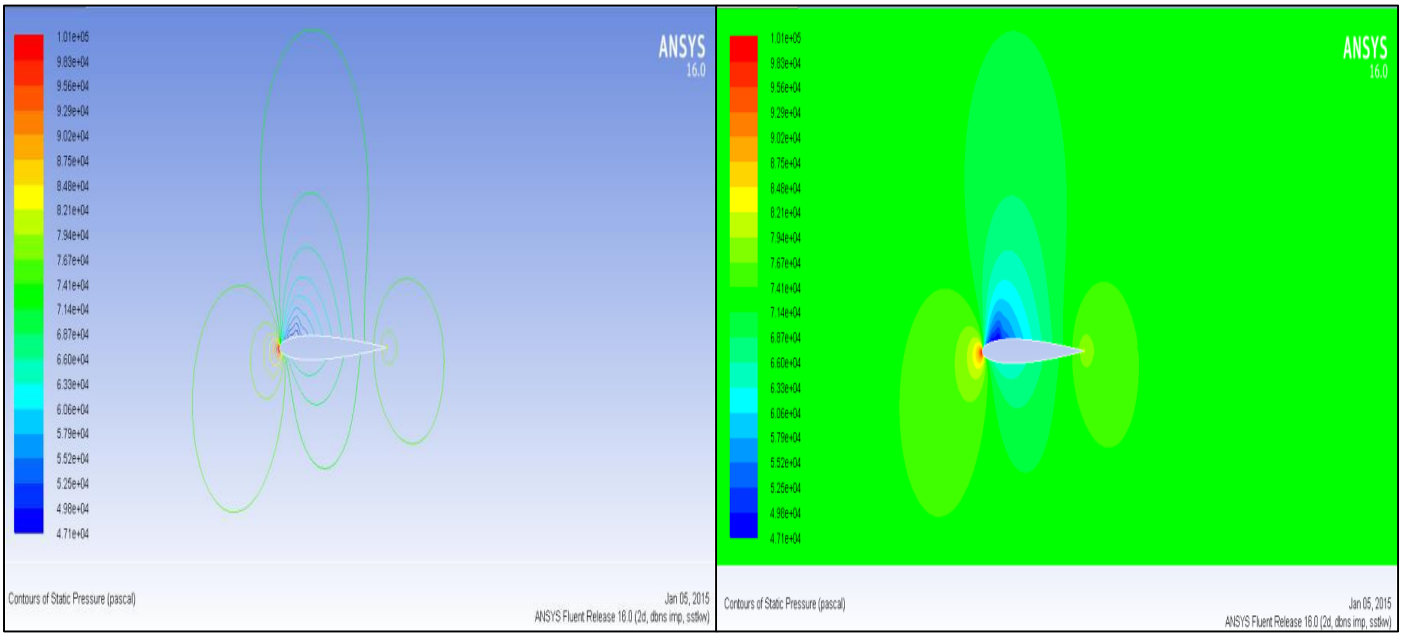
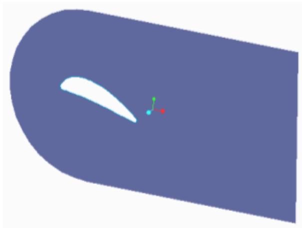
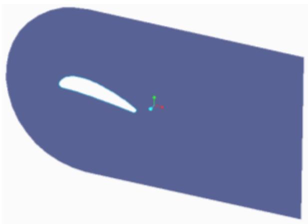
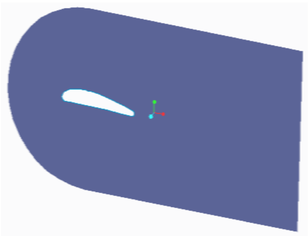
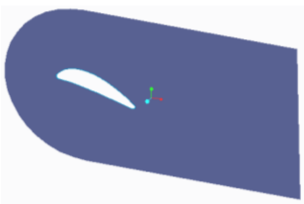
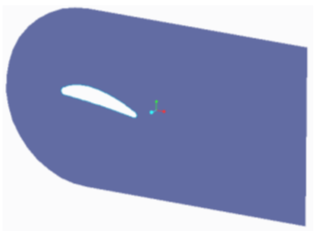
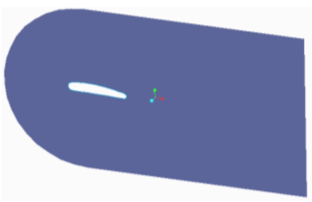


Fig. 5: Post-Processing (Fluent)

Shape		**C_d**
Original Shape		1.224
Modified Shape		1.9233

Figure 6 Comparison Between Original And Modified Shape (3d

SHAPE	**C_l (10^{-3})**	**C_d (10^{-3})**	**C_m (10^{6})**
Original Shape			
1st cross  section	1.499	1.224	-2.4117
2nd cross  section	2.391	2.0863	-6.3442
3rd cross  section	3.6043	3.6219	-1.0722

Modified Shape			
1st cross  section	1.1971	8.129	-1.9203
2nd cross  section	3.0001	3.656	-1.135
3rd cross  section	4.211	3.921	-2.0023

IV. Figure 7 Comparison Between Original And Changed Shaped (2d)RESULT AND DISCUSSION

Table No. 2 Comparison Of Cfd Results With Analytical Values Parameter

Output Parameters	Analytical Value	CFD Value
Power developed in the stage in kW	1470	1386
Blade efficiency in %	81.74	79.8
Stage efficiency in %	79.245	78.2
Pressure at stage outlet in bar	0.1765	0.172
Absolute velocity at the outlet of the moving blade in m/s	241.93	224(average)
Temperature at the outlet of the stage in ^{0}C	57	59.5

Conclusion

Computational Fluid Dynamics is turning into a completely vital device for engineers. Although presently CFD is particularly getting used withinside the layout workplace via way of means of the steam generators producer, it may additionally be hired via way of means of strength plant engineers to expect and enhance the performance of the rapid machines. The facts received from the prediction might also additionally then be used to resource in selection making whether or not to update the blade row with the greater green one. The ordinary performance of turbine changed into expected the usage of CFD method and as compared with the version checking out consequences received from the producer and superb settlement changed into found. It may be concluded that CFD method enhances the alternative approaches, as CFD method enables in discount in fee of version checking out and saving in time which results in fee-powerful layout of the system. CFD method can be beneficial in development of the present performance measuring strategies and assessment of the overall performance of hydro generators to beautify the viability of hydropower development.

References

1. Zamri, M.Y., " An Improved Treatment of Two-Dimensional Two-Phase Flows of Steam by a Runge-Kutta Method", Ph.D. Thesis, Department of Manufacturing and Mechanical Engineering, The University of Birmingham, U.K., 1997.
2. Bakhtar, F., So, K.S., " A Study of Nucleating Flow of Steam in a Cascade of Supersonic Blading by the Time-Marching Method", International Journal oh Heat and Fluid Flow, Vol. 12, pp: 52-64., 1991 .
3. Deckers, M., Simon, V., Scheuerer, G., "The Application of CFD to Advanced Steam Turbine Design", International Journal of Computer Applications Technology, 1997.
4. Bakhtar, F., Shojaee-Fard, M.H., Siraj, M. A., "An Experimental Facility for Studies of Nucleating and Wet Steam Flows in Turbine Blading", IMechE Paper No. C423/003, 1991.
5. Edwin Krämer, Hans Huber and Dr.Brendon Scarlin, ABB Power Generation, Low-pressure steam turbine retrofits.
6. Paul Albert, Steam Turbine Thermal Evaluation and Assessment.