IMPACT ANALYSIS OF NOZZLE DESIGN IN STEAM TURBINES

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Abstract

In the field of energy conversion, Steam turbines play a crucial part. The design and operational procedures of steam turbine is highly advanced and considered as fully fledged technological components. This steam turbine converts heat energy of steam to mechanical energy. Every industry comprises of these turbines for they regarded as a perfect replacement of many heat engines and prime movers and also used in power plants for possessing greater thermal efficiency and high power to weight ratio. Above all, the turbine is an assembly of nozzles which were used to generate high kinetic energy. These nozzles are great devices for understanding the working features of steam turbines. A different kinds of sizes and shapes of nozzles are feasible, among those Convergent Divergent nozzle is frequently used. When steam turbine works the flow loss of steam increases as the disrupt of profile and surface smoothness occurs because of solid particle erosion on nozzle surface.

Key Words: steam turbine nozzle, CATIA, ANSYS FLUENT

INTRODUCTION

Steam turbines are used in all of our major coal fired power stations to drive the generators or alternators, which produce electricity. The turbines themselves are driven by steam generated in 'Boilers 'or 'Steam Generators' as they are sometimes called .Energy in the steam after it leaves the boiler is converted into rotational energy as it passes through the turbine. The turbine normally consists of several stages with each stage consisting of a stationary blade (or nozzle) and a rotating blade. Stationary blades convert the potential energy of the steam (temperature and pressure) into kinetic energy (velocity) and direct the flow onto the rotating blades. The rotating blades convert the kinetic energy into forces, caused by pressure drop, which results in the rotation of the turbine shaft. The turbine shaft is connected to a generator, which produces the electrical energy.

Introduction to steam turbine nozzle

Nozzles are wont to guide the steam to hit the moving blades and to convert the pressure energy into the K.E. within the case of small turbine, the nozzles are located within the lower half the casing. But within the case of the larger turbine, the nozzles are located on the upper half the casing. During this work we mainly focused on nozzles and its types. In a great number of machines the work is performed at the expense of external K.E. of the working fluid. The K.E. of working medium may change during a passage of varying cross-section. If a steam flowing along a passage expands, leading to a decrease in pressure and increase in speed, such a passage or duct is named nozzle. Flow of steam through a nozzle may be a vital aspect of turbine design. The passage of varying cross-section designed to extend the speed of fluid as a results of decrease in pressure is named nozzle. Nozzles are frequently wont to control the speed of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. During a nozzle, the speed of fluid increases at the expense of its pressure energy.

Types of steam nozzles

1. Convergent Nozzle
2. Divergent Nozzle
3. Convergent-Divergent Nozzle

In a convergent nozzle, the cross sectional area decreases continuously from its entrance to exit. it's utilized in a case where the rear pressure is adequate to or greater than the critical pressure ratio. The cross sectional area of divergent nozzle increases continuously from its entrance to exit. It's utilized in a case, where the rear pressure is a smaller amount than the critical pressure ratio. In Convergent Divergent Nozzle, the cross sectional area first decreases from its entrance to throat, then increases from throat to exit. It's widely utilized in many sorts of steam turbines.

Types of convergent divergent nozzles

1. Convergent-divergent nozzle
2. Moore nozzle
3. Moses and stein nozzle

The objective of this work is to form analysis on the above three differing types of nozzles and suggest which one is best. While making the analysis on the nozzle within the present work we also consider the erosion factor on the surface of the nozzle.

Erosion in nozzles

Erosion is a degradation of material surface due to mechanical action, by impinging liquid, abrasion by slurry, Particles suspended in fast flowing fluids, bubbles or droplets. The iron oxide scales exfoliated from the inner wall of the boiler tube and main steam pipe are known to erode the surface of the steam path. The severest erosion may be made in the governing stage nozzles of the steam turbine, which results in a reduction in unit efficiency and an increase in maintenance cost. Although the use of protective coatings and anti solid particle erosion (SPE) steam passage design has improved the erosion resistance of the nozzle, the nozzle life time is still shorter than the overall life of the steam turbine. At present, repairing the eroded nozzle or replacing it with a new nozzle is the most common method to recover the nozzle efficiency to the normal level. As is well known, prolonging the service time of the eroded nozzle will lower the unit efficiency and increase the fuel consumption, whereas shortening the service time of the eroded nozzle will increase maintenance cost. Therefore, a reasonable estimation of the economic lifetime of the eroded nozzle is very critical for reducing the economic losses induced by SPE.

Nozzle Governing:

In nozzle governing the flow rate of steam is regulated by opening and shutting of sets of nozzles rather than regulating its pressure. In this method groups of two, three or more nozzles form a set and each set is controlled by a separate valve. The actuation of individual valve closes 14 the corresponding set of nozzle thereby controlling the flow rate. In actual turbine, nozzle governing is applied only to the first stage whereas the subsequent stages remain unaffected. Since no regulation to the pressure is applied, the advantage of this method lies in the exploitation of full boiler pressure and temperature. Figure shows the mechanism of nozzle governing applied to steam turbines. As shown in the figure the three sets of nozzles are controlled by means of three separate valves.

Introduction to CATIA

CATIA is a robust application that enables you to create rich and complex designs. The goals of the CATIA course are to teach you how to build parts and assemblies in CATIA, and how to make simple drawings of those parts and assemblies. This course focuses on the fundamental skills and concepts that enable you to create a solid foundation for your designs CATIA is mechanical design software. It is a feature- based, parametric solid modeling design tool that takes advantage of the easy-to-learn Windows graphical user interface. You can create fully associative 3-D solid models with or without constraints while utilizing automatic or user-defined relations to capture design intent. To further clarify this definition, the italic terms above will be further defined: Feature-based Like an assembly is made up of a number of individual parts, a CATIA document is made up of individual elements. These elements are called features. When creating a document, you can add features such as pads, pockets, holes, ribs, fillets, chamfers, and drafts. As the features are created, they are applied directly to the work piece.

Sketched-based features are based on a 2D sketch. Generally, the sketch is transformed into a 3D solid by extruding, rotating, sweeping, or lofting. Dress-up features are features that are created directly on the solid model. Fillets and chamfers are examples of this type of feature.

CATIA parametric modules:

Sketcher
Part modeling
Assembly
Drafting

Advantages of CATIA Parametric Software

- Optimized for model-based enterprises
- Increased engineer productivity
- Better enabled concept design
- Increased engineering capabilities
- Increased manufacturing capabilities

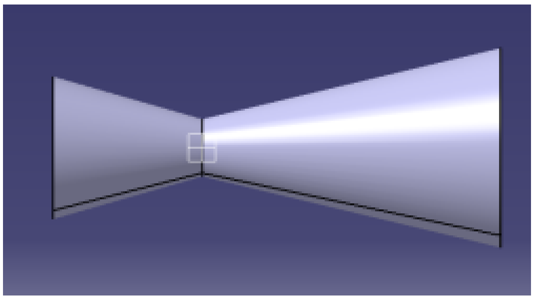

Figure: convergent divergent nozzle

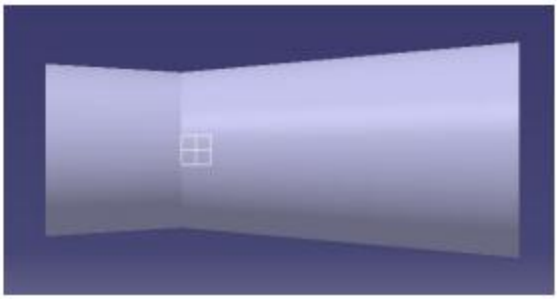

Figure: Moor nozzle

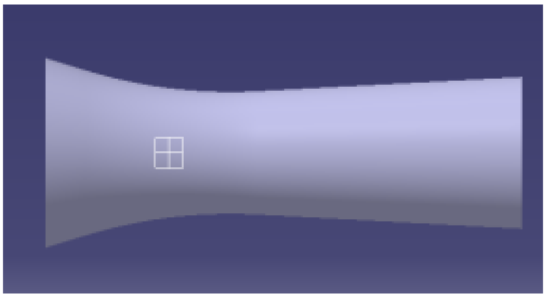

Figure: Moses and stein nozzle

Analysis of nozzles using ANSYS FLUENT

- 3d model of nozzle was imported in to Ansys fluent
- Refine meshing was done.
- Bronze as solid material and steam as fluid material was assigned in material property. Steam with iron oxide impurities was considered for erosion analysis.
- Common inlet conditions were considered for all cases of analysis. Inlet velocity of 5 m/s and pressure of 78000 pas was taken as boundary conditions.

Results and Discussion

With the above stated input conditions the analysis was done and the required parameters were calculated.

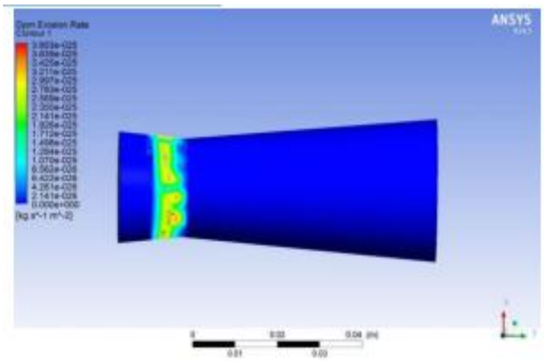

Figure: Dpm Erosion rate in Moore nozzle

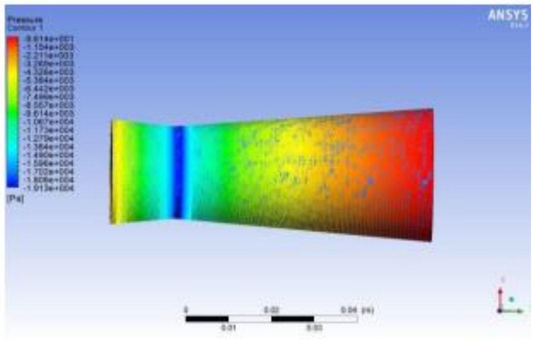

Figure: Pressure distribution in more nozzle

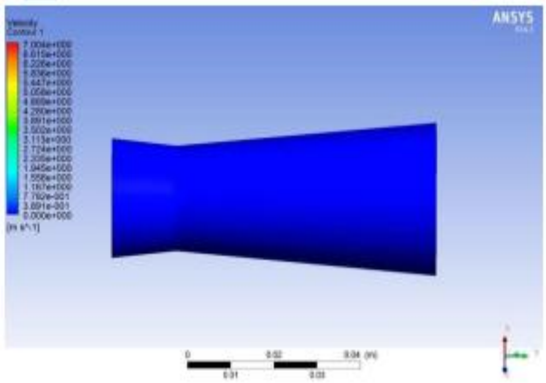

Figure: Velocity distribution in more nozzle

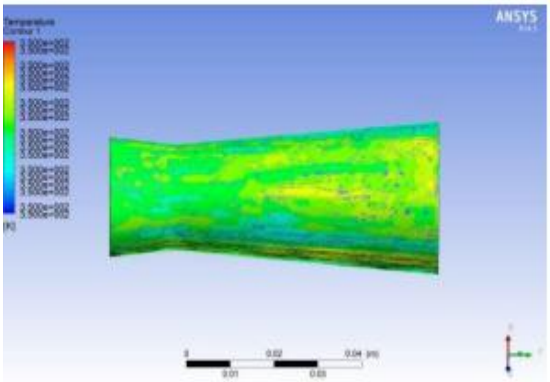

Figure: Temperature distribution in more nozzles

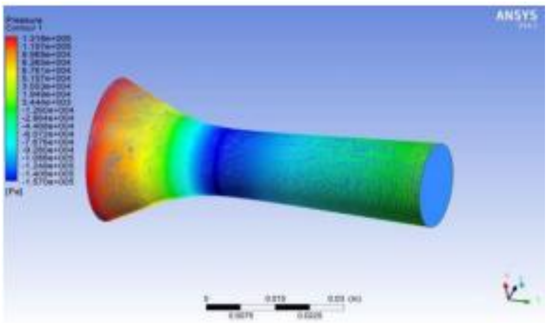

Figure: pressure distribution in moses & stein nozzle

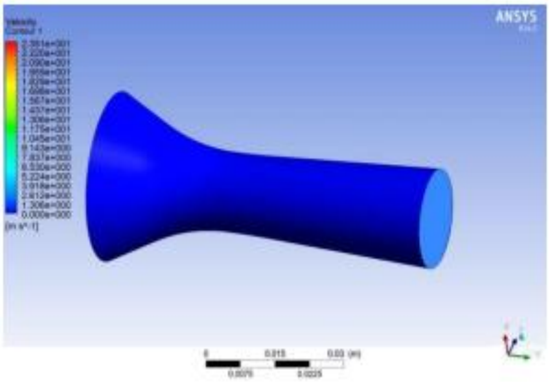

Figure: Velocity distribution in moses & stein nozzle

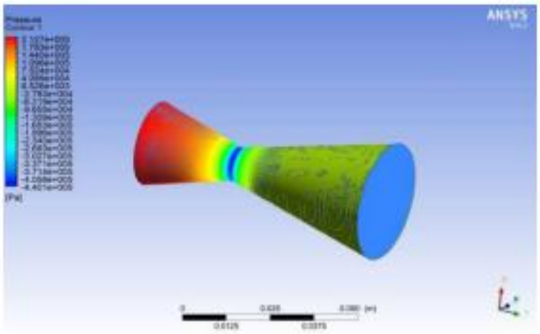

Figure: pressure distribution in convergent divergent nozzle

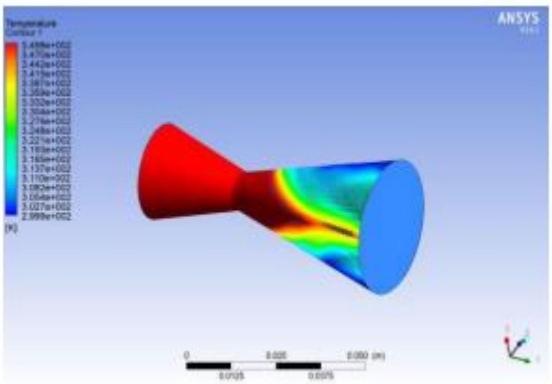

Figure: Temperature distribution in convergent divergent

Conclusion

In the current work, by utilizing ANSYS Familiar stream investigation on steam turbine spout was finished. Speeds, strain, temperatures and Disintegration, not set in stone for three kinds of spouts i.e Moore spout, Moses spout and joined disparate spout. From the acquired outcomes it was tracked down in Moore spout the pace of disintegration 3.85e-25 Kg/m2-s is least, and speed at outlet 7.0 m/s is less when contrasted and different spouts. Outlet Speed 31.95 m/s is greatest in joined unique spout and disintegration rate 1.36e-24 Kg/m2-s is likewise relatively less. Toward the end of this work it was inferred that among the three spouts joined disparate spout will be ideal.

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