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Structural design and FEM analysis of bleeder in steam turbine casing

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Abstract - *Bleed is amount of steam output from turbine through pipe and exit from final stage of turbine. This bleed enters to feed water heater (low and high) and deaerator to increase unit efficiency. The bleed steam is actually the steam which has already performed work on turbine blades. Now we are left with the option either to condense that steam in condenser or to use it to heat feed water. Design and analysis of bleed and more particularly to a device for carrying a store such as a steam, and provided with means for positively ejecting the store from the bleed pocket. The need for a casing and release device which will positively eject a store has become increasingly critical. When the steam is released from a modern high-performance turbine the static and thermal loads on this store may cause it to violently strike the bleed pocket structure before dropping away from the pocket.*

***Key Words*: Steam turbine casing, Turbine bleed, Bleed Diameter, CAD model, Structural Analysis.**

1.INTRODUCTION

Design and analysis of bleed and more particularly to a device for carrying a store such as a steam, and provided with means for positively ejecting the store from the bleed pocket. The need for a casing and release device which will positively eject a store has become increasingly critical. When the steam is released from a modern high performance turbine the static and thermal loads on this store may cause it to violently strike the bleed pocket structure before dropping away from the pocket. A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. Its modern manifestation was invented by Sir Charles Parsons in 1884. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator – about 90% of all electricity generation in the United States (1996) is by use of steam turbines. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency from the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible expansion process. Steam turbine works on Rankine.

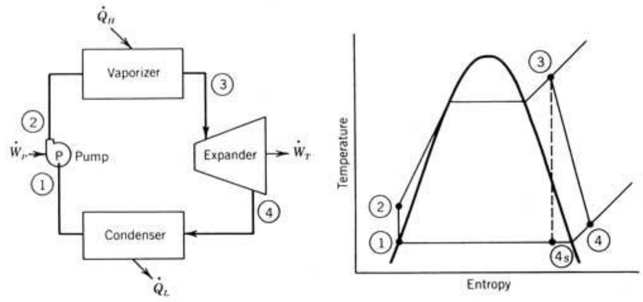

Fig -1: Working of Steam Power plant and its cycle

1.1 Steam turbine casing.

These arrangements include single casing, tandem compound and cross compound turbines. Single casing units are the most basic style where a single casing and shaft are coupled to a generator. Tandem compounds are used where two or more casings are directly coupled together to drive a single generator. A cross compound turbine arrangement features two or more shafts not in line driving two or more generators that often operate at different speeds. A cross compound turbine is typically used for many large applications.

Fig –2: Steam turbine casing

2. Calculation For Bleeder Diameter

For 30 MW steam turbine casing extraction at last stage exhaust stage
Flow = 10TPH (tones per hour)
= 10/3.6kg/sec
Specific volume =0.26570 m^3/kg

Velocity = 40m/sec
Area X velocity = flow X specific volume
Area= flow X specific volume / velocity

$$= \frac{\left(\frac{10}{36}\right) X\ 0.26570}{40} = 18451\ mm^2$$

$$d^2 = \frac{4x18451}{\pi} \quad (2)$$

d(diameter) = 193.311mm = 7.63 inch

NOTE: 7-inch pipe flanges and flanged fittings to be used as per ASME standard 16.5 class 300

3.Geometric Model of casing with bleed

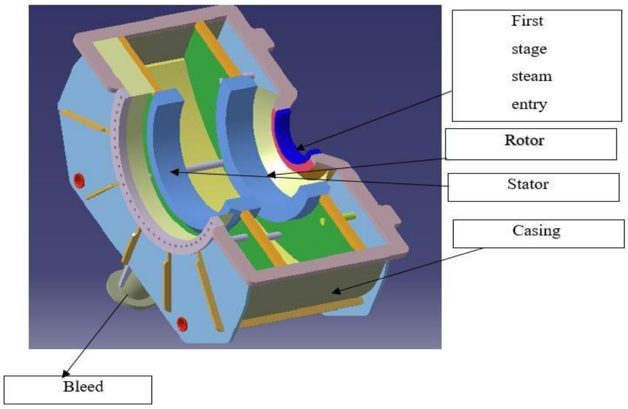

Fig -3: CAD Model of casing

The Computer aided design model of the bleed is generated using the calculated design specification.

4.Structural Analysis

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, machinery, furniture, attire, soil strata, prostheses and biological tissue.

4.1 Mesh Generation

Mesh generation in structural analysis. The mesh used is Quadra mesh.no refinement is given. The greater the rate of convergence, the better the mesh quality. It means that the correct solution has been achieved faster. An inferior mesh quality may leave out certain important phenomena such as the boundary layer that occurs in fluid flow. In this case the solution may not converge or the rate of convergence will be impaired.

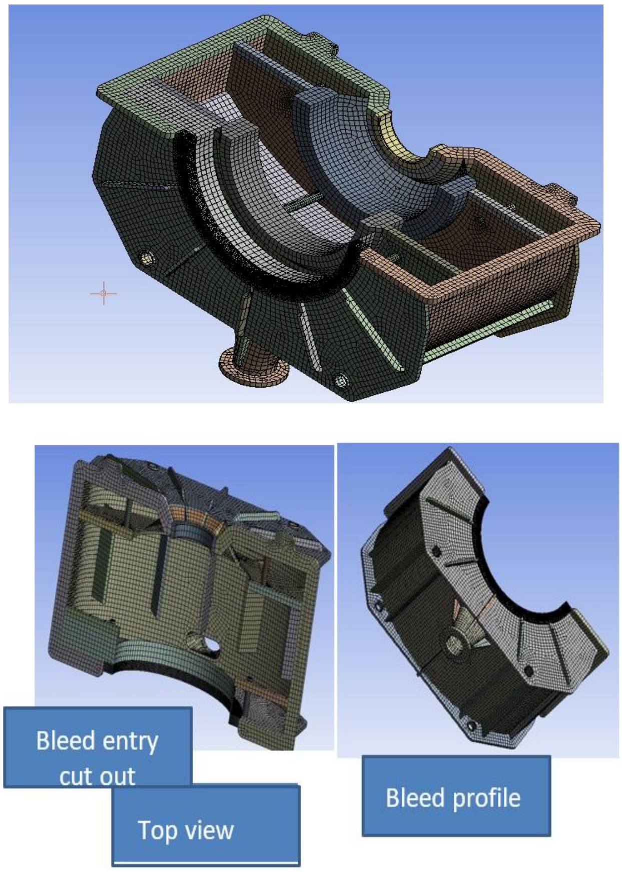

Fig -4: Meshed casing with bleed

4.2 Applying Boundary Conditions for Bleed

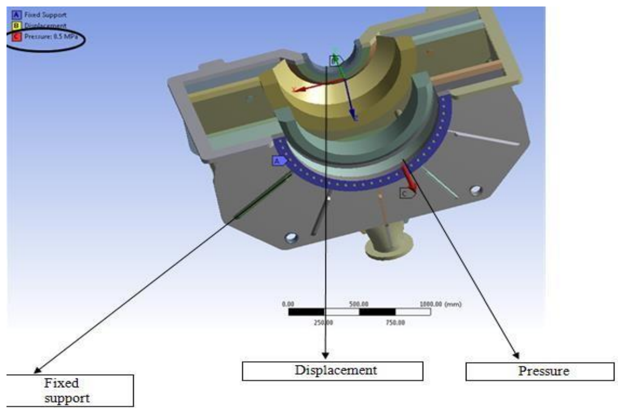

Fig-5: boundary Conditions for Bleed

The figure shows application of boundary conditions for static structural analysis of bleed. The displacement is given in Y direction at point B because movement of steam is assumed in this direction. The pressure is given for biphasic analysis at point C in above figure. Fixed support is given at point A.

4.3.1 Result of structural Analysis of bleed

Fig-6: Equivalent (von-mises) stress

This figure shows stress distribution in casing by the application of boundary conditions in steady state analysis through von misses yield criterion

4.3.2 Total deformation

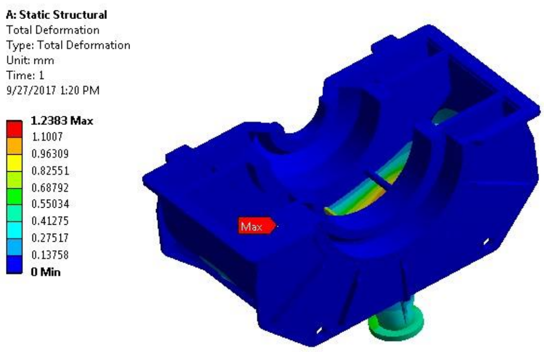

Fig -7: Deformation

Maximum deformation is shown red colour which is around 1.2383mm which is within acceptable limits.

4.3.3 Maximum principal stress

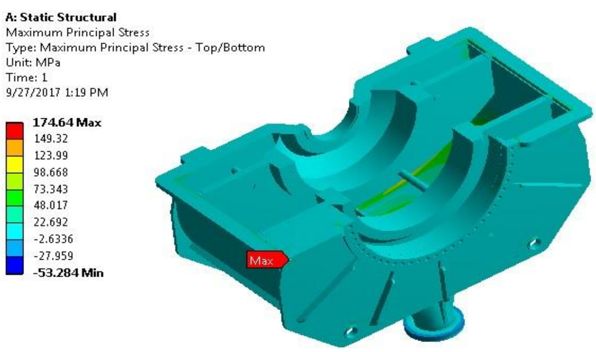

Fig-8: Maximum Principal Stress

Maximum principal stress in casing by the application of boundary conditions in steady state analysis. It is around 174.64MPa.

4.3.4 Minimum Principal stress

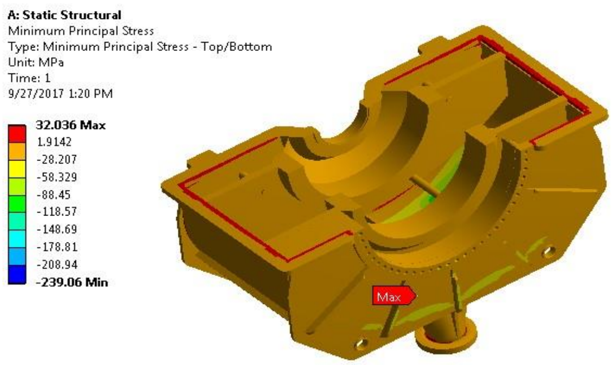

Fig -9: Min Principle stress

5. Structural Analysis of casing

Structural analysis is the determination of the effects of loads on physical structures and their components

5.1.1 Application of Boundary conditions

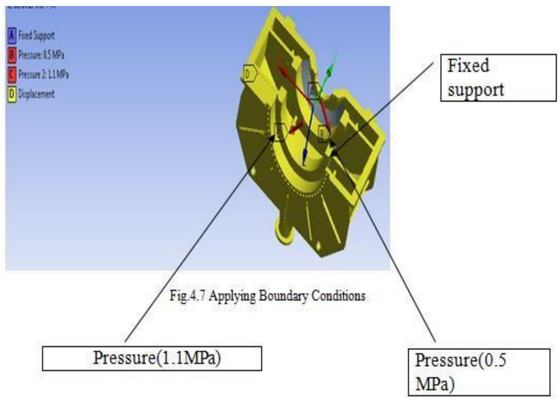

Fig -10: Boundary condition for casing

The figure shows application of boundary conditions for static structural analysis of casing. Fixed support is given at point A. The pressure of 0.5MPa is given for phasic analysis at point B in above figure. The pressure of 1.1MPa is given at point C. The displacement is given in Y direction at point because movement of steam is assumed in this direction.

5.2.1 Results of Static Structural Analysis

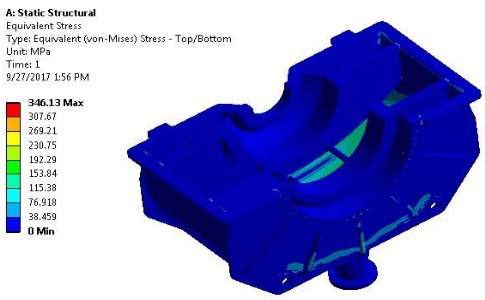

Fig -11: Equivalent (Von-mises) Stress

This figure shows stress distribution in casing by the application of boundary conditions in steady state analysis through von misses yield criterion. Equivalent stress is about 346.13MPa.

5.2.2 Total Deformation

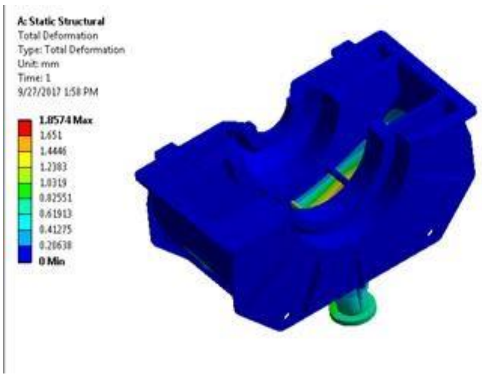

Fig -12: Deformation

This figure shows total deformation in casing by the application of boundary conditions in steady state analysis. Maximum deformation is shown red colour which is around 1.857.4mm which is within acceptable limits.

5.2.3 Maximum principal stress

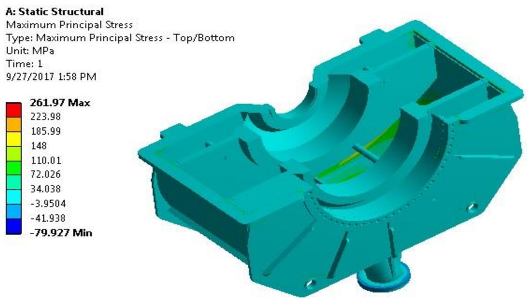

Fig -13: Max Principal stress

This figure shows maximum principal stress in casing by the application of boundary conditions in steady state analysis. Maximum principal stress is shown red colour which is around 261.97Mpa

3. CONCLUSIONS

The work presented is an attempt at designing a bleed in steam turbine of a given dimension. Extensive literature review was carried out to study the various aspects and applications of steam turbine bleed.

A suitable design procedure was chosen from the available methods to design different parts of bleed. CATIA is used extensively for making parts with diff types of operations. Then all the parts are assembled for making a complete turbine in CATIA Assembly section and analysed in ANSYS academia

Bleed are relatively new in the market and are attracting wide attention due to their varied applications. Development of a sophisticated engineering product like bleed is a continuous process.

A lot of work is yet to be done on the design aspects before the bleed can be readied for market consumption. The design procedure has to take into various other parameters to make it suitable for practical applications.

Also, manufacturing of such complex shapes of minute size is another ongoing research work. Further research into the design and manufacture process would result in production of even better bleed.

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