Design and Validation of High Pressure Casing of a Steam Turbine

Major criteria in steam turbines used for producing electrical energy are reliability and safety factor due to frequent start-ups and shutdowns.

Steam Turbines are the devices used to produce electrical energy. This electrical energy is generated by converting thermal energy of steam into mechanical energy, to produce electrical energy. Steam turbines are used all over the world for electric power generation in thermal power plants. Major criteria in steam turbines are reliability and safety factor due to frequent start-ups and shutdowns.

Design considerations of steam turbines

During the last several years the primary changes to the design of steam turbines have focused on improving their efficiency, reliability and reducing operating costs.

Design validation involves design considerations, design checks, and sensitivity analysis to achieve the design criteria to fulfil the structural requirements for mechanical integrity .One such analysis is carried out blending the hand calculations and steady-state finite element analysis to evaluate the contact pressure in a high pressure steam turbine casing.

Contact pressure and pretension in bolts-analysis has been made easier in recent years due to the availability of high computational capabilities and flexibility in the computational methods using finite element analysis.

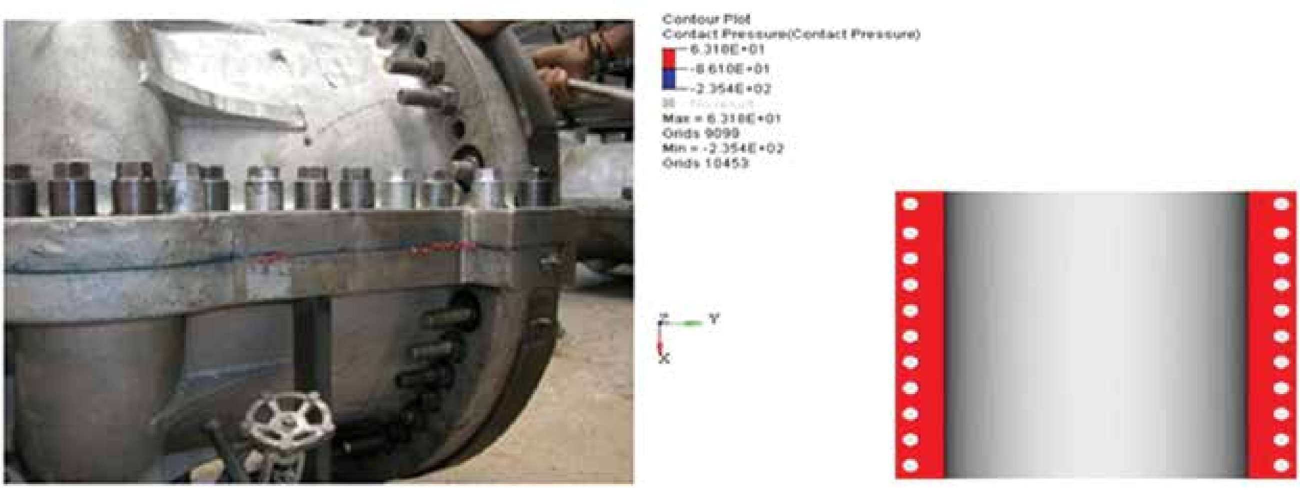
Industry Power Generation, for example, has improved the overall efficiency and availability of its steam turbines by decreasing the steam flow energy losses in each of the steam turbine components. The steam turbine unit largely influences the efficiency and reliability of power stations. Any improvement in the design of steam turbine enables more efficient use of fuel and results in reduced cost. The high pressure steam at 5650 C and 156 bar pressure passes through the high pressure turbine.

The exhaust steam from this section is returned to the boiler for reheating before being used. On leaving the boiler reheater, steam enters the intermediate pressure turbine at 5650 C and 40.2 bar pressure. From here the steam goes straight to the section of low pressure steam turbine expanding itself with increase in mass flow. From the intermediate pressure turbine, the steam continues its expansion in the three low pressure turbines. The steam entering the turbine is at 3060 C and 6.32 bar. To get the most work out of the steam, the exhaust pressure is kept very low. The casing witness, energy of the steam turned into work in HP and IP stages.

The ASME Boiler and Pressure Vessel Code embody rules for circular and non-circular pressure vessels of unreinforced and reinforced construction. These rules cover the sides, reinforcing ribs, and end plates of such vessels. For bolted flanged connections of such non-circular pressure vessels, which are employed extensively in industry, however, no design rules are presently included in the code.

Validation

The forces are considered to be the basis of the whole method proposed by Shlyakhin. These forces are resolved and



No leakages are observed during experimental and analysis

solved further to obtain the reaction forces. The validation is done by taking into consideration a single stage (1st stage) and applying the boundary conditions using ALTAIR HYPERWORKS .High pressure casing of a steam turbine is meshed with Hexa mesh to obtain accurate results.

3D casing model is taken up for contact pressure and structural analysis. By carrying out the contact pressure analysis it will be taken care that required contact pressure is maintained at the parting plane and thus no steam leaks out of the casing. By carrying out the structural analysis, the stresses and deflections in the casing can be determined

The finite element analysis gives a complete picture of mechanical behaviour of the flange structures, and design guidelines without costly experiments. 3D model of the top and bottom casing is generated and subjected for analysis. Contact pressure analysis is performed to validate structural integrity of casing. The modifications in the design at the parting plane with relief have resulted in the desired contact pressure. The required contact pressure (3 times the pressure at respective stage) is achieved in the high pressure as well as in the intermediate pressure stages.

The classical method in combination with knowledge based engineering is utilized to identify the trivial areas in the design of turbine casing. Custom-made methodology is developed to achieve the structural integrity of the casing, with the accomplishment of simulation engineering. Sensitivity analysis is made possible with the aid of modern computers which allows the user to explore the criticality in the core design. The design validation helps to meet the design considerations successfully and achieve the required safety factors for existing manufacturing and design uncertainties.The strength of steam turbine casing for a given operating condition reveals that the optimized casing geometry shall be used as design modification for future.

Conclusion

Based on the contact pressure criteria, no leakage is observed on the parting plane of casing. Significant increase in contact pressure ensures that further there will not be any steam leakage at operating conditions. From comparison of the results from experimental method and the finite element analysis, it shall be summarized that a good correlation is observed.

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