GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

DESIGN ANALYSIS AND OPTIMIZATION OF POWER PIPING ROUTING SYSTEM FROM BOILER TO TURBINE UNDER OPERATING CONDITION

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ABSTRACT

A power piping system conveys hot fluid from one location to another within a process plant or individual process plants that are within the boundary of a process industry. Pipe stress analysis is become more important on the demands on piping designers to save material and maintain plant safety. The efficient design of the test pipe routing structure is the single most important aspect in structural systems, since it accounts for major portion of material weight budget. Hence, optimization of the pipe routing is necessary to have a cost effective and efficient structure. It was analyzed by a software tool as Caesar. In the selected pipe routing stress was analyzed from Boiler to Turbine with respect to ASME standards. In this analysis, three types of load cases were analyzed such as operating conditions, sustained conditions and expansion conditions.

Keywords: insulation density, restraints, hoop stress, fatigue fracture.

I. INTRODUCTION

A piping system conveys fluid from one location to another within a process plant (eg: Pumps, pressure vessels, heat exchangers, process heater etc.) or individual process plants that are within the boundary of a process industry. A piping system consists of Pipe stations, Fittings, Flanges, Gaskets, Bolting valves, Pipe supports and Restraints. Each individual component and the overall system must be designed for specified design conditions. Stress does not cause failure. Strain cause failure. If the strain is caused by an applied load of sufficient magnitude and direction, strain will result and failure will occur under a single load application. If the strain does not cause an initial failure, but is repeatedly applied, incremental strain accumulates and failure will occur in number of cycles.

Piping systems inside the boiler are called boiler piping. Piping systems outside the boiler are called power piping. A power piping system is the piping arrangement between the stream turbine and stream boiler. A piping system employed for processing industries including refineries, chemical and textile are called process piping. The diameter of power piping system normally selected greater than 100 mm and the pipe material for the power piping system is selected as Cr-Mo Alloy steel.

II. MATERIAL & METHODS

In this work, power piping system was identified and analyzed with respect to the following data: (Design pressure = 7109.82 kpa, Working medium = SH steam, Working temperature = 540^0C, Pipe size = dia 114.3 x 8 mm, Pipe material = SA 335 P22, Pipe density = 0.078 kg/cm^3, Insulation thickness = 100 mm, Insulation density = 100 kg /mm^3)

Piping stress analysis is highly interrelated with piping layout and support design. The layout of the piping system should be performed with the requirements of piping stress and pipe supports. If necessary, layout solutions should be iterated until a satisfactory balance between stresses and layout efficiency is achieved. Once the piping layout is finalized, the piping support system must be determined. Possible support locations and types must be iterated until all stress requirements are satisfied and other piping allowable valves are met. The piping supports are then designed based on the selected locations and types and the applied loads.

A piping system needs supports and restraints because of the various loads that are imposed upon it. Supports absorb system weight and reduce longitudinal pipe stress, pipe sag, and end point reaction loads. Restraints control of thermal movement may be necessary either to keep pipe thermal expansion stresses within allowable limits, or to limit the loads that are imposed on connected equipment.

Operating and control points should be located so that they can be used safely and easily. There must be enough clearance above and below the pipe to perform basic operations on valves and flanges. The piping system must be laid out so that its components can be inspected, repaired or replaced with minimum difficulty. Piping layout must be considering the safety of personal near the pipe. The specifically includes access for firefighting equipment and fire prevention.

The primary stress limits are intended to prevent plastic deformation and bursting. Primary stresses which are developed by the imposed loading are necessary to satisfy the equilibrium between external and internal forces and moments of the piping system. Primary stresses are not self-limiting. Therefore, if a primary stress exceeds the yield strength of the material through the entire cross section of the piping, then failure can be prevented only by strain hardening in the material. Secondary stresses are developed by the constraint of displacements of a structure. These displacements can be caused either by thermal expansion or by outwardly imposed restraint and anchor point movements. Under this loading condition, the piping system must satisfy an imposed strain pattern rather than be in equilibrium with imposed forces. Local yielding and minor distortions of the piping system tend to relieve these stresses. Peak stresses are the highest stresses in the region under consideration and are responsible for causing fatigue failure. Common types of peak stresses are stress concentrations at a discontinuity and thermal gradients through a pipe wall.

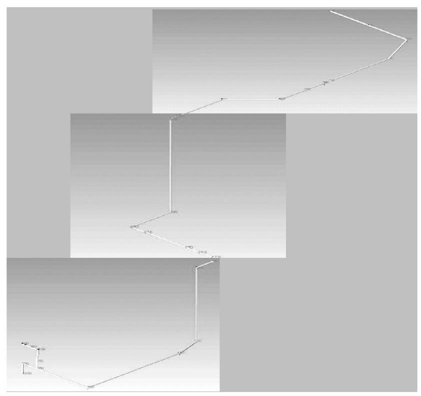

Fig.1 selected pipe routing system

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III. RESULT & DISCUSSION

The global forces, moment, displacement, stress and code stress have been calculated at different nodal points of pipe routing. Figure shows for operating condition, the component forces, moments and displacement have been plotted for the nodes from 100 to 900. For expansion condition, the code stress and allowable stress have been plotted for different nodes.

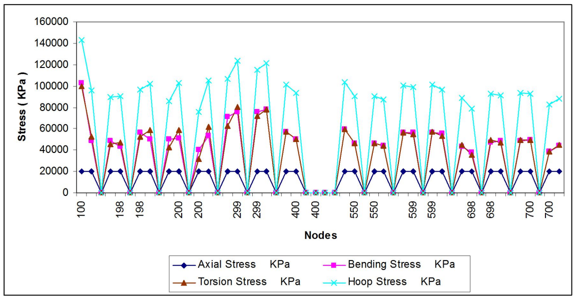

Fig.2 Axial, Bending, Torsion and Hoop Stresses

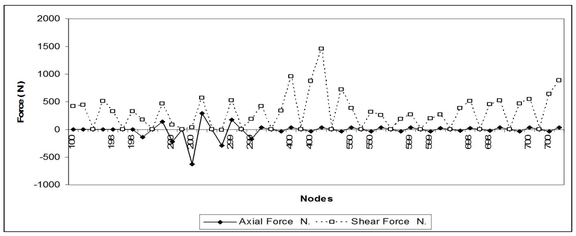

Fig.3 Axial and Shear Force

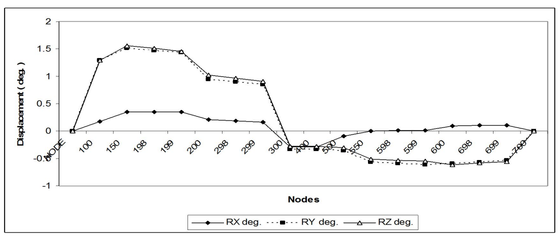

Fig.4 Angular Displacements

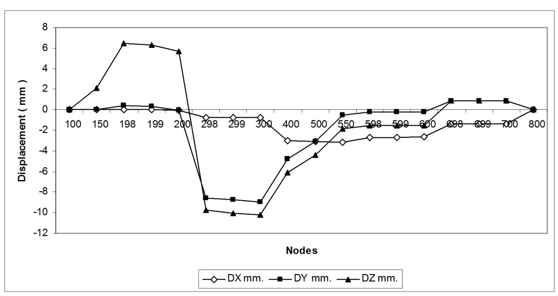

Fig.5 Axial displacement

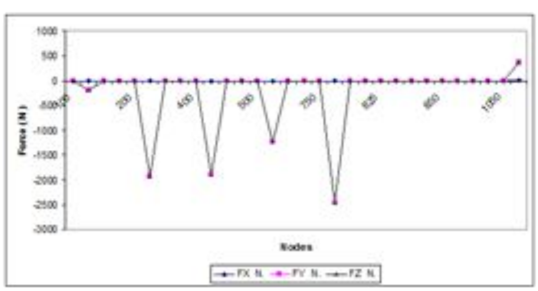

Fig.6 Force, Moment and Displacement Report

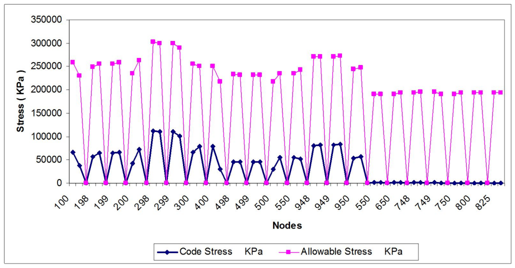

Fig7 Code stress and Allowable stress

In the pipe routing, the global forces, moment, displacement, axial stress, bending stress, torsion stress and hoop stress have been calculated at different nodal points. The code stress and allowable stress have been calculated and design safety of pipe routing was optimized with ASME B31.1. The code stress is depending on the self weight of the pipe and its supports. The code stress is depending on the rate of heat transfer and the temperature of steam.

IV. CONCLUSION

In this research pipe routing was analyzed in operating condition and expansion condition. The entire pipe routing was analyzed as per standard. The optimum results of pipe routing such as displacement, stress, global forces, and restraint and code compliance values were obtained. The design safety of piping system was optimized with respect to ASME 31.1 standards.

V. REFERENCES

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