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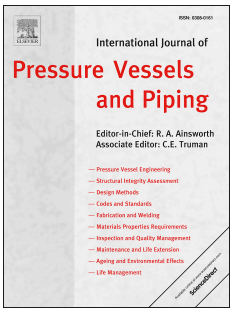

Thermo-structural fatigue analysis of shell and tube type heat exchanger

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Abstract

Increased demand of alternative fuels, need of high pressure and temperature vessels for petroleum refineries, chemical plants gave rise to the development in the pressure vessel technology from last few decades. Many advancements in the field of pressure vessel engineering such as fracture mechanics, fatigue and creep process understanding, new material grades & composite materials, welding techniques such as explosion welding and various finite element analysis techniques like thermal coupled structural, transient thermal, dynamic simulations like response spectrum and nonlinear buckling which accurately assessing the stresses encountered in pressure vessels are developed.

This paper describes the means with which one can reasonably accurately ascertain the thermal fatigue analysis of pressure vessel in accordance with design by analysis approach. It highlights the various failure modes, design by analysis approach used for pressure vessel. It allows the engineer to investigate a range of variables within the design process and contributes significantly to the basic requirement of a safe design within an economic framework.

Keywords: Finite element analysis; Heat exchanger; Design by analysis; fatigue

1. Introduction

A pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Most of pressure vessels like reactors and heat transfer devices used in the industry are heat exchanger. Shell and tube heat exchangers are the most widespread and commonly used basic heat exchanger configuration in the process industries due to its advantages like, large ratio of heat transfer area to volume and weight, easy to construct and clean, mechanical rugged to withstand fabrication.

The tubesheet is very crucial component of shell and tube type heat exchangers [2]. Large number of tubes are employed to achieve the required heat transfer. The tubes run either horizontally or vertically and the lengths are also quite large. This tubes are supported by tubesheet at the ends. Also, tubesheet separates the shell side and tube side region which are subjected to differential pressure and temperature conditions. It causes quite several mechanical and thermal loads on tubes and tubesheet. Hence, tube to tubesheet and shell to tubesheet junctions are the critical region of the heat exchanger which needs to be addressed carefully. Design by analysis approach were introduced which highlights detailed design procedures utilizing the results from a stress analysis to evaluate components for plastic collapse, local failure, buckling, and cyclic loading.

This paper highlights the fatigue assessment of design by analysis approach is used to predict the permissible number of cycles of heat exchanger which are subjected to various operating duty cycles like start up and shutdown cycles [4]. During this duty cycles heat exchanger is subjected to pressure and temperature loading which are cyclic in nature. Thermo-structural fatigue analysis [2] is used to evaluated the alternating stresses and permissible number of cycles complying ASME Sec VIII, Division-2 Part-5 guidelines.

2. Background Information:

2.1. Pressure vessel failure:

The pressure vessels are mainly subjected to pressure, thermal, external piping and nozzle