SHAPE DESIGN OF THE PRESSURE VESSELS UNDER THE WORKING PRESSURE BASED ON AN OPTIMAL APPROACH

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ABSTRACT

In this paper, a simplified method for designing typical pressure vessels, which consist of the hemisphere head and the head with nozzle, and it was usually apply to petrochemical industry and gas storage, etc. Since the dome regions undergo the highest stress levels and are the most critical locations with regard to failure of the structures, the optimal design of the domes is one of the most important issues in the design of pressure vessels. The optimum design of pressure vessel is used the finite element method combine with the simple conjugated gradient method (SCGM). The objective function is to find the minimum stress of the pressure vessel. This study can improve the stress distribution and reduce the stress concentration of the pressure vessel in the optimum design process.

INTRODUCTION

The purpose of this research is to optimum the design of the pressure vessel to minimum the stress concentration, which applies to the petrochemical industry and gas storage, etc. In general, the pressure vessel is subjected to the complex environment, such as high pressure and high temperature. This not only presents a strong challenge to the physical and mechanical performance of structure, but also to the reliable and economical design about how to achieve a perfect combination of favorable safety performance under a series of design parameters.

To the best of our knowledge, little previous paper has been published about the shape optimization for the axisymmetric shells under the action of internal pressure. Most published studies examine the shape in the two-dimensional problems; a fairly detailed review is given by Ding [1], although no other general surveys have been published recently apart from that of Rozvany et al. [2] on the related problem of layout optimization.

In addition, the ASME Boiler and Pressure Vessel code does not require detailed stress analysis but only sets the wall thickness requirement to keep the basic hoop stress below the allowable stress. The safety factors and design rules [3] are assumed to cater for the high localized stresses. This code provides a quick design method; a safer procedure will be to have the data analysis in detail [4].

The extra requirements in various industries make it necessary to conduct the detailed stress analysis under primary loads for analyzed structure configurations. In particular, the well known codes such as ASME (1983), BS 5500 (1976), and Russian GOST (1989) do not contain enough information about nozzle connections on the pressure vessel heads [5]. Therefore, there is a need for the overall optimal design in order to reinforce the regulation on the deficient part. Most of the accidents (about 80%) in the pressure vessels are resulted from the stress concentration. The associated stress concentration factor (SCF) depends on the size, and the shape of the vessel. The peak stress occurring at the stress concentration may be critical in determining the design life of a vessel [6].

The stress concentration is a highly localized effect. The high stresses exist only in a very small region in the vicinity of the hole. In approaching the study of localized stresses, it is well to note that their significance does not depend solely on their absolute value. At the same time it also depends upon [7]: (i) the general physical properties of the material, (ii) the relative proportion of the member highly stressed to that under stressed which affects the reverse strength; it can develop in resisting excessive loads, (iii) the kind of loading to which the pressure vessel is subjected.

The hoop and equivalent stresses are optimized and become smooth in the boundary of vessel [8]. In addition, to minimize the raising effect of the stress at the inside of wall is important. This research is to demonstrate how the application of numerical optimal simulation techniques can be used to search for an effective optimization of the pressure vessel design. The numerical optimal simulation techniques is used the finite element method combined with the simple conjugated gradient method (SCGM). The optimal objective function is to reduce the maximum stress of the pressure vessel. This study will be able to improve the stress distribution and reduce the stress concentration of the pressure vessel in the optimal design process.