ABSTRACT

It is a regular practice in the oil industry to modify mechanical equipment to incorporate new technologies and to optimize production. In the case of pressure vessels, it is occasionally required to cut large openings in their walls in order to have access to the interior part of the equipment for executing modifications. This cutting process produces temporary loads, which were obviously not considered in the original mechanical design. Up to now, there is not a general purpose specification for approaching the assessments of stress levels once a large opening in a vertical pressure vessel has been made. Therefore stress distributions around large openings are analyzed on a case-by-case basis without a reference scheme.

This work studies the distribution of the von Mises equivalent stresses around a large opening in FCC Regenerators during internal cyclone replacement, which is a frequently required practice for this kind of equipment. A finite element parametric model was developed in ANSYS, and both numerical results and illustrating figures are presented.

INTRODUCTION

The mechanical design of a pressure vessel is governed by design codes such as the ASME [1] or the recommendations of the British Standards Institution [2] and is based on the analysis of extreme conditions that the pressure vessel shall withstand during its operation.

In general, during the life of a pressure vessel it is required to perform modifications and major repairs in order to improve their performance. In the case of FCC Regenerators, it is frequently required to replace their internals, e.g. cyclones, raisers and distributors. This operation involves cutting the vessel wall, which has an important impact on the integrity of the structure. These modifications, considered major repairs, are not included in the scope of referenced design codes and they demand removing the vessel from normal operation, which gives rise to different load cases than those used for design. In effect, the vessel will be subject to structural loads at atmospheric conditions and its response can be estimated with structural design codes such as [3, 4].

In the authors’ experience, cyclone replacement procedures can be classified in two main categories, as described in Table 1. The first category, i.e., Mode 1, implies removing the vessel’s top head, while the second one – Mode 2, involves cutting an opening in the cylindrical section of the vessel and installing both an internal and an external platform for accessing the interior of the vessel.

Since 1980, in the authors’ knowledge, most oil refiners have preferred Mode 1 for replacing the cyclones of FCC Regenerators since many of the required activities can be performed outside the regenerator and before the plant’s turndown, therefore simplifying project’s schedule. However, in those cases where the plant layout does not provide enough room for accommodating a large capacity crane and supporting structures close to the pressure vessel, Mode 2 is the selected option. Table 2 shows some Latin-American refineries that have selected Mode 2 for cyclone replacement in the last ten years. It is also important to notice that in some cases Mode 1 has presented some practical problems, e.g. elastic deformations of dome periphery making the welding between head and shell difficult [5].