Overview of different approaches for completing the nozzle design of pressure vessels

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Abstract - In practice, vessel designers are often confronted with the lack of actual nozzle loads at the initial design phase of the pressure vessel. This article provides the designer with three possible options that can be applied to complete the nozzle design of a pressure vessel, despite the fact that final nozzle loads are not yet available. As such, the drawbacks resulting from the absence of the piping reactions can be eliminated at an early stage.

***Key words* - designer, nozzle loads, pressure vessel, piping reactions, nozzle design.**

Introduction

Nozzles are a crucial part of the pressure vessel design and every designer of pressure vessels realizes the importance of external loads acting on those process nozzles which are exerted by the connected pipework. Unfortunately, the magnitude of these loads are unknown during the initial design phase (i.e. procurement phase) of the pressure vessel since the piping design has not yet been completed. It is up to the pressure vessel designer to choose the most appropriate approach to this rather vexing problem. To assist the designer of the pressure vessel in his effort to a proper execution of the nozzle design, he has three options at his disposal that have appeared in recently published publications and which are briefly described in the next section.

Approaches

Option # 1 Based on: "Load Capacity Limits of Flanged Pressure Vessel Nozzles" [1]
The essence of this approach is aimed at controlling the stresses in the vicinity of the nozzle intersection. Both the stresses induced by internal pressure and the stresses due to the loads exerted on the nozzle by the connecting pipework are hereby discounted. The method employed provides for the determination of the permissible individual nozzle loads for both the nozzle intersection and for the nozzle flange. These calculated individual allowable loads are available for the pipe stress analyst, who must ensure that these are kept under the piping reactions, as determined by the piping structural analysis he has performed. In case the piping reactions exerted on the nozzle by the connecting pipework exceed the permissible load capacity of the nozzle, the relevant piping system must be adapted in terms of re-routing and / or modified support arrangement, so that admissible nozzle loads are met.
Option # 2 Based on: "Determination of nozzle loads to facilitate the initial pressure vessel design" [2]
With this approach, it is assumed that the load on the standard nozzle flange is decisive for the permissible piping reactions that are exerted on the nozzle flange by the connecting pipework. This implies that the nozzle-vessel connection must be designed in such a way that the stresses around the nozzle-vessel intersection due to internal pressure including piping loads acting on the nozzle flange stay within permissible values.
Option # 3 Based on: "Standardized nozzle loads for the initial pressure vessel design" [3]
The starting point for this approach is formed by a set of standard nozzle loads. When designing the pressure vessel, it should be emphasized that these loads relate to both nozzle-vessel intersection and to the nozzle flange. The magnitude of the standard nozzle loads depend on the nominal diameter of the nozzle (DN) and the pressure number (PN) of the relevant piping class. The vessel designer must ensure that the nozzle design is suitable for the combination of internal pressure and standard loads, while the Piping Stress Engineer has the task to ensure that the piping reactions remain within the limits of the standard loads.

Conclusions

If option # 1 is chosen, it is sufficient to design the pressure vessel exclusively for internal pressure. Based on this design, the permissible external loads can be calculated for the respective process nozzles, as described in detail in reference [1].
In case option # 2 is chosen, the permissible loads for the nozzle flanges must first be calculated according to the method indicated in reference [2]. Successively, the nozzle-vessel intersections of the various process nozzles must be evaluated to see whether they can withstand the permissible flange loads in conjunction with the internal pressure. If this is not the case, than the nozzle must be additionally strengthened. Reconsideration of this option should be considered in case a heavier vessel wall thickness is required than for internal pressure alone or that huge nozzle reinforcement is needed.
If finally option # 3 is chosen, then the pressure vessel design and in particular the nozzle design must take into account the standard nozzle loads as discussed in reference [3]. However, if this will lead to a necessary increase of the flange rating class and / or vessel thickness, reconsideration of this approach is recommended.

Closing remarks

This informative article is intended to enable pressure vessel designers to complete the final pressure vessel design at an early stage without open ends. This is important with a view to obtaining a reliable cost estimate during the procurement phase of a project. Moreover it permits parallel engineering of piping and vessels and avoids delays and prevents discussion between different disciplines.

References

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