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TOPOLOGY OPTIMIZATION WITH FATIGUE CONSTRAINTS OF NOZZLE CONNECTIONS OF PRESSURE VESSELS

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ABSTRACT

The nozzle connections are the most stressed areas of pressure vessel structures [1-3]. Finding an optimal shape of this detail is important from the point of view of fatigue life of the vessel. In the paper, a methodology of topology optimization with fatigue constraints of the nozzle to pressure vessel connections is presented.

In the optimization investigation a steel cylindrical pressure vessels subjected to cyclic loading conditions were considered. As a design example a standard nozzle connection with reinforcement was chosen. The optimization problem was to find the minimum mass shape of the nozzle connection. The method of topology optimization with stress constraints was proposed to solve the optimization problem. As a stress constraint, an equivalent stress according to the Dang Van multi-axial high-cycle fatigue criterion was assumed [4-6].

A 3D finite element model of the examined pressure vessel was prepared with the ANSYS® code. Only a part of the pressure vessel was modelled and symmetry boundary conditions were applied. As a load regime, five consecutive load cases of pulsating pressure were taken in to account. For topology optimization a special macro was written by means of the APDL language. To assure a high safety factor the admissible equivalent stress limit of the Dang Van criterion was assumed at a relatively low level.

As a result of the optimization investigation, a new form of the nozzle reinforcement was obtained. Apart from the mass reduction, the nozzle connection area obtained a more uniform distribution of stresses. Taking into consideration the fatigue criterion, it can be stated that the fatigue life of the structure was considerably increased.

The proposed methodology of topology optimization with fatigue constraints turned to be effective and easy to apply. The presented approach is likely to find engineering application in industry. The above work is a part of wider authors' investigations on fatigue life optimization of structural systems [4-6].

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