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# LOCAL SHAKEDOWN ANALYSIS OF REACTORS SUBJECT TO PRESSURE AND THERMAL LOADS

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## ABSTRACT

This paper deals with FEM shakedown analysis of high pressure reactors which are used in process engineering. The reactors have thick-walled cylindrical structure with characteristic small radial holes, which are necessary for charging and discharging medium. The structure is subjected to internal pressure and temperature gradient. The radial holes are strong concentration sources, which significantly decreases elastic capacity of the reactor and causes development of plastic strains having usually very local range. The loads have usually cyclic character, thus, a mechanism of low-cycle fatigue can occur, mainly as a result of reverse plastification. This mechanism can result in development of cracks dangerous for the whole structure. The cracks of this kind were observed in a polyethylene reactor in Polish refinery.

The influence of mechanical and thermal loads was earlier considered separately. A phenomenon of low-cycle fatigue with respect to mechanical loadings in such installations has been well recognized [1,3,4,5,6]. Limit values of pressures were established according to lower-bound shakedown theorem.

Internal temperatures result in thermal gradients through wall thickness, which cause development of thermal stresses. Moreover, high temperatures significantly change the material properties. Thermal effects are especially visible during unsteady periods. Scale of the thermal stresses is then comparable with such effects caused by mechanical loads. An investigation of limit values of starting period rates was presented in [2]

The present study includes simultaneous effects of pressures and temperature gradients. Different pressure and thermal load correlations were taken into account. Numerical simulations of loading and unloading periods were undertaken to evaluate stress and strain state during and after unsteady processes. The parametric study included changes of loading rates, different load and boundary condition configurations and different geometrical proportions of the reactors. All investigations were performed regarding to mechanism of low-cycle fatigue and possible reverse plastification. Optimization of unsteady periods of loading and heating was performed. An optimal result of pressure and temperature rates gave a solution, which eliminated the reverse plastification effect.

Some constructional modifications of the reactor increasing the shakedown limits are proposed. The most effective one makes use of sleeves introduced into the hole with strong interference fit. The proposed modification considerably increases its elastic shakedown limit. Optimization of the sleeve geometry and the interference fit parameters was performed. Behaviour of the sleeve during unsteady loading and unloading process was also verified.

Further work concentrates also on experimental verification of the performed calculations. Not only the steady state of stresses and strains but also unsteady loading and unloading process as well as constructional modifications are planned to be included into these investigations. The physical model of a reactor is now in design.

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