CASE STUDY

Autoclave Residual Lifetime Assessment

Task

An autoclave is a double-walled pressure vessel-mounted on four supports. The device is in use as a polymerization autoclave. A computational analysis was conducted to determine the allowable static loading of the device and to asses the remaining life of the autoclave with regard to the previous operating history.

Methodology

The fatigue of the autoclave was assessed in two steps. In the first step, the calculation by the finite element method (FEM) analysis was performed to capture the stresses at typical load conditions. The effect of cyclic load on fatigue and the remaining lifetime in the most stressed areas was done complying to the standard EN STN 13445-3.

Stress Analysis

For the stress-strain analysis of the autoclave computational model was created. The model was created using shell and volume finite elements.

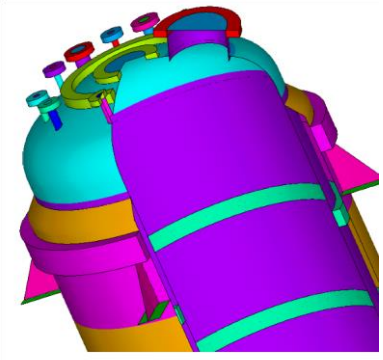

Fig.1 Computational model

The results of the computational analysis show that an important stress concentrator is the elliptical manhole on the upper lid (fig. 3) and the transition of the duplicator bottom into the flange (fig. 4). The maximum values of the stresses meet the requirements of the STN EN 13445-3, that is

$$\sigma_{MAX} \leq 1{,}5R_{p02}$$

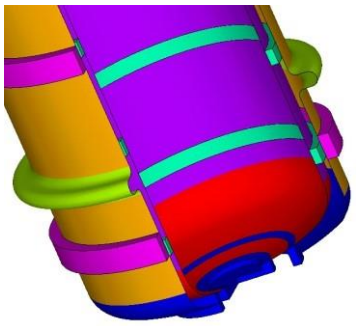

Fig.2 Computational model cutout

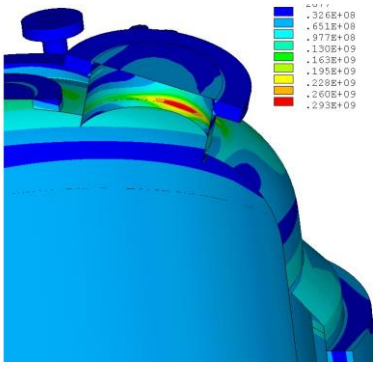

Fig.3 Stresses, upper autoclave part

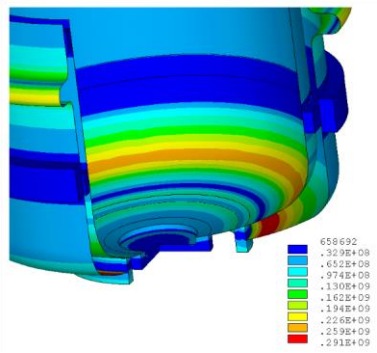

Fig.4 Stresses, lower autoclave part

Assessment of fatigue life

Based on the results of the stress state analysis, four control areas were selected for fatigue life assessment (fig. 5, 6). For the fatigue life estimation the operating conditions like the pressure test,

CASE STUDY

duplicator pressure test, vessel and duplicator leak test were considered.

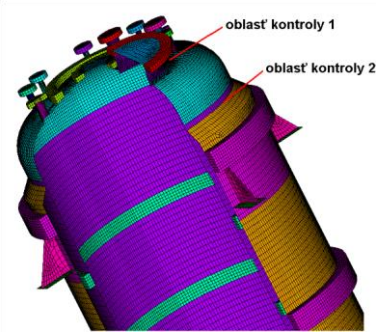

Fig.5 Control areas

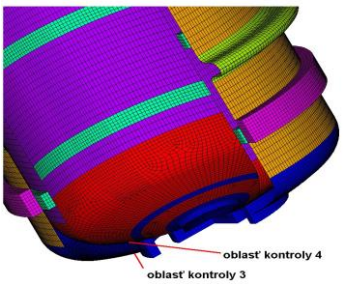

Fig.6 Control areas

The calculation results of damage accumulations in the respective control areas show that the most exhausted place from the point of view of fatigue life is the connection area of the duplicator to the flange (check area 3). Accumulation of damage determined based on the results of FEM analyzes (Fig. 7) in this area is

$$D_{1\_2007} = \frac{N_P}{N_{PD}} + \frac{N_{TZ1}}{N_{TZ1D}} + \frac{N_{TZ2}}{N_{TZ2D}} + \frac{N_{TZ3}}{N_{TZ3D}} + \frac{N_{TZ4}}{N_{TZ4D}} =$$

$$= \frac{15847}{21685} + \frac{8}{161360} + \frac{8}{61321} + \frac{12}{544692} + \frac{12}{121839} = 0{,}7311$$

N_P - number of autoclave start

$N_{TZ1(2)}$ - number of pressure tests

$N_{TZ3(4)}$ - number of leak tests

N_{PD} - allowed cycles (operation)

$N_{TZ1(2)D}$ - allowed cycles (pressure test)

$N_{TZ3(4)D}$ - allowed cycles (leak test)

$$D_{2007} + \frac{N_{PN}}{N_{PD}} + \frac{N_{TZ1N}}{N_{TZ1D}} + \frac{N_{TZ2N}}{N_{TZ2D}} \le 1$$

$$0{,}73 + \frac{N_{PN}}{N_{PD}} + \frac{N_{TZ1N}}{N_{TZ1D}} + \frac{N_{TZ2N}}{N_{TZ2D}} \le 1$$

NPN - number of cycles after shutdown

NTZ1N - number of pressure tests after shutdown

NTZ2N - number of leak tests after shutdown

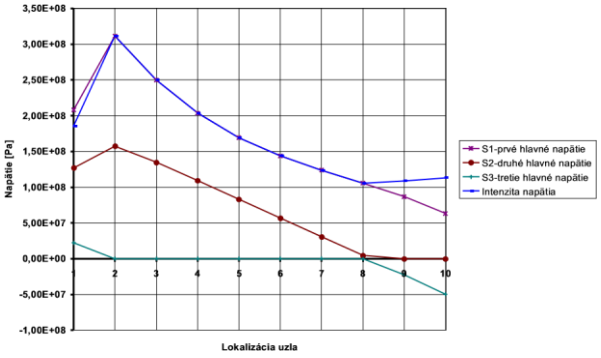

Fig.6 Example of the stresses [Pa] at operating conditions, control area 3

Conclusion

The results of the analysis show that the autoclave complies to the requirements according to STN EN13445-3. The damage to the autoclave by cyclic stress accumulates fastest in the connection area of the duplicator to the flange. Here, according to STN EN 13445-3 the service life is exhausted up to 73% of its lifetime. The autoclave is therefore capable of further operation.

Author: *Ing. Voštiar Vladimír, PhD.*