CYCLIC TESTING OF PRESSURE VESSEL NOZZLE MODELS IN ELASTIC-PLASTIC REGION

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INTRODUCTION

Strain processes in stress concentration regions have the decisive effect on the life-time of complicated construction elements. A partial goal of tests of the Js 850 pressure vessel nozzle models in 1:3 scale (Figure 1) was experimental verification of relations for strain calculation in elastic-plastic region which are used in rules and standards for strength calculations of pressure vessels.

The models were made of cyclic softening steel 15Kh2NMFA and loaded by pulsating stress cycle with maximum force 36 MN. The static steel characteristics after heat treatment by quenching were : Rp 0.2 = 562 Mpa; Rm = 672 Mpa; E = 211 GPa. The strains on four congruent models were measured by strain-gauges of types HBM 6/120 LX 11 and HBM 6/120 LD and by clip gauges of 5 or 6 mm measuring length.Theoretical stress concentration factors were calculated from the strains measured in stress concentration regions (Figure 1) in points 1-10 and from nominal strain established from measurements on a loading machine; the factors received values $2 < \alpha_H < 3.7$.

CALCULATION CONCEPT

Three well known approaches were used for comparison. Hardrath-Ohman relation accepted in ASME (1)

$$\alpha_H = \alpha_\varepsilon \quad (1)$$

Neuber relation adopted by (2)

$$\alpha_H^2 = \alpha_\sigma \cdot \alpha_\varepsilon \quad (2)$$

and equivalent strain energy density method mentioned in (3)

$$W_t = \int_0^{\varepsilon t} f(\sigma)\, d\,\varepsilon t = \frac{(\alpha_H \sigma_n)^2}{2E} \quad (3)$$

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COMPARING THE EXPERIMENTAL RESULTS WITH CALCULATION

At the first loading cycle for $\Delta\sigma_n$ = (0.46 - 0.55) . Rp 0.2 the calculation according to (2) corresponds to the measured values, the other calculational methods give lower values than the measured ones in the whole range of α_H (Figure 2 and 3).

From Figure 2, 3 it is clear that the dependence of $\Delta\varepsilon t$ on α_H has a linear character in both cases. With increasing the nominal stress the slope of this dependence is raising.

After saturating the material for $\Delta\sigma_n$ = 0.55 . Rp 0.2 the calculation according to (1) (Figure 4) answers best to the measured values.

In all the investigated cases the highest values $\Delta\varepsilon t$ are given according to (2) and the lowest ones according to (1). After saturating the material for $\alpha_H < 3$ the values given by relations (1) and (3) differ only slightly.

USED SYMBOLS

α_H = theoretical stress concentration factor (1)

α_σ = stress concentration factor (1)

α_ε = strain concentration factor (1)

$2\varepsilon t = \Delta\varepsilon t$ = range of total local strain (%)

$2\sigma_n = \Delta\sigma_n$ = range of nominal stress (MPa)

Wt = strain energy (MPa)

LITERATURE

(1) ASME Boiler and Pressure Vessel Code. Section III Division 1

(2) Standards for Strength Calculations of Components of Reactors, Steamgenerators, Pressure Vessels and Piping for Nuclear Reactors and Nuclear Power Plants, Moscow,1973

(3) Standards for Strength Calculation of Nuclear Power Plants Devices and Piping. Calculation of Cyclic Strength, Standard of MKhO INTERATOMENERGO,1987

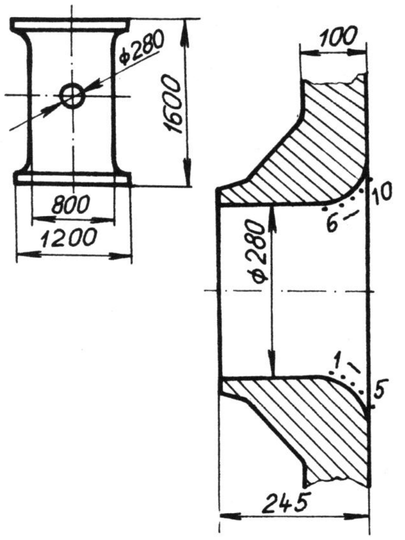

Figure 1 Js 850 nozzle model in 1:3 scale

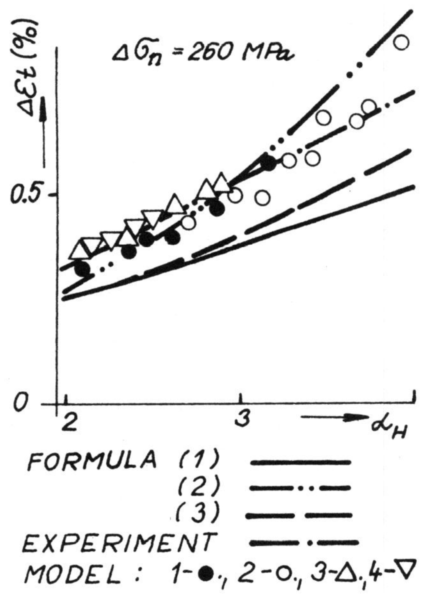

Figure 2 Local strains in first cycle

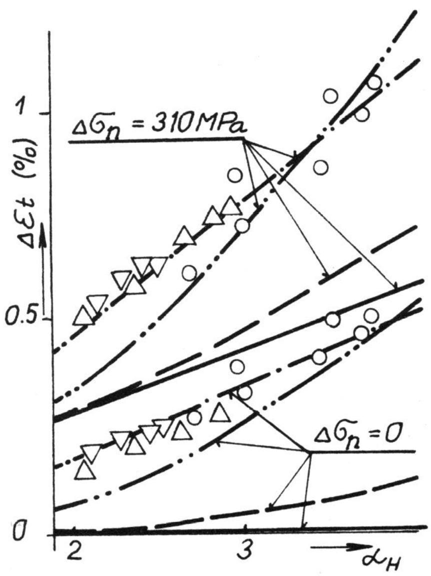

Figure 3 Local strains in and after first cycle

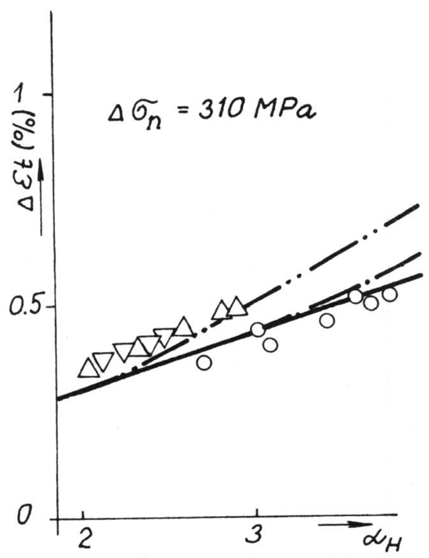

Figure 4 Local strains after saturation