RESIDUAL LIFE CONSIDERATIONS OF THE BABOCK - WILCOX TYPE PRESSURE VESSELS

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Samples have been taken from pressure vessels B-W drum after 2.17×10^5 service hours at 260°C and p = 34.5 bar.

These samples had been metallographycally analyzed and mechanically tested.

On the bases of the aging process development it has been estimated that at the acting parameters pressure vessels can operate safely for next $(5 - 6) \times 10^4$ hours.

INTRODUCTION

One of the Romanian steam power stations, built between 1930-1935, possesses 4 pressure vessels of Babcock-Wilcox (B-W) type.

The pressure vessels basic parameters are: capacity Q = 24 t/h, pressure p_N = 34.5 bar, the nominal temperature of overheated steam 410°C, and of the feed water 105°C.

The task is to establish whether after $(2.17\text{-}2.28) \times 10^5$ service hours, the pressure vessels can still operate safely.

SAMPLING AND TESTS

Samples were taken from the pressure vessels drum, from the overheating collector (second stage) and from the separation chamber.

The chemical analysis have shown following elements contents: 0.2 - 0.22%C, 0.22 - 0.25%Si, 0.53 - 0.55%Mn, 0.014 - 0.016%P, 0.018 - 0.019%S, 0.06 - 0.07%Cu, 0.1 - 0.11%Ni, 0.11 - 0.12Cr and 0.016 - 0.17%Al.

This is the steel similar to K 410, STAS 2883-80, used for high temperature boilers.

Mechanical tests of specimens taken from cut samples, performed according to Romanian standards, produced following results for yield strength ($R_{p0.2}$), ultimate tensile strength (R_m) and Charpy V impact toughness (KV):
at 20°C - $R_{p0.2}$ = 240 - 250 MPa, R_m = 470 - 480 MPa, K_v = 40 J;
at 410°C - $R_{p0.2}$ = 125 - 130 MPa, R_m = 420 - 425 MPa, K_v = 100 J.
These values also correspond to K 410 steel.

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Optical and electron microscopy revealed that structures consisted of 70% ferrite and 30% pearlite (Fig.1,2) and of 70% ferrite, 25% pearlite and 5% bainite (Fig.3).

Examination by electron microscope permitted to make evident the structure alternations during vessel operation. The bainite formation certifies the existence of an aging process, due to a long time operation (over 200,000 hours).

EVALUATION OF SERVICE RELIABILITY FOR PRESSURE VESSELS DRUMS

The following operating and design characteristics are given: inner diameter D_i = 1300 mm, wall thickness h = 35 mm, mid-section radius r = 667.5 mm, operating temperature 260°C, pressure p = 35.455 bar.

The drum is made with rings welded on their length, and lids are joined by welding.

Stresses and strains determination in the drum and lids was made by applying appropriate formulae for thin rotating shells.

Calculations were made for the stresses and strains in the wall of the cylindrical shell and of semi-spherical shell in the vicinity of welded joints between hemisphere and cylinder.

The scheme for the external forces and strains acting on a shell element is shown in Fig.4, and lid-drum joint bending effect is presented in Fig.5.

The calculations made under the above mentioned conditions led to the conclusion that the maximum stress in the drum during operation is a circumferential one.

This stress of 70 MPa acts at x = 225 mm from the joint, and of 67.6 MPa at $x \geq 400$ mm from joint, and is uniformly distributed through the wall thickness h.

Yield strength $R_{p0.2}$ = 170 MPa at 260°C had been found experimentally for welded joint between drum and lid.

Under these circumstances, the pressure vessels drum has, in the area of minimum resistance, a safety factor c = 2.42, a higher value than c = 1.8, admitted for these pressure vessels.

CONCLUSIONS

Metallographic examination made evidence of a process of the bainite separation in the drum material, after 2.17×10^5 operating hours.

These separations will go on, and will produce a degradation of the mechanical properties of the material.

It could be estimated that the operation of the pressure vessels with the same parameters for $(5 - 6) \times 10^5$ hours will cause a rising by about 20% of the quantity of bainite content in the structure.

Under these circumstances, $R_{p0.2}$, established by tests of samples from K 410 with 20% bainite, will reach the value of 130 - 140 MPa, and the safety factor tends to decrease to the minimum value admitted for these pressure vessels.

It is concluded that under the present operating conditions pressure vessels can work safely next $(5 - 6) \times 10^4$ hours.

REFERENCES

(1) Trusculescu,M. "Metal Science", E.D.P. Bucuresti 1977.
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Figure 1 Ferrite-pearlite structure 250:1

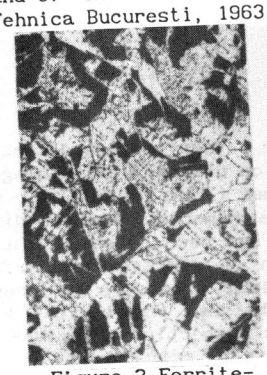

Figure 2 Ferrite-pearlite structure 250:1

Figure 3 Bainite-pearlite-ferrite structure 4700:1

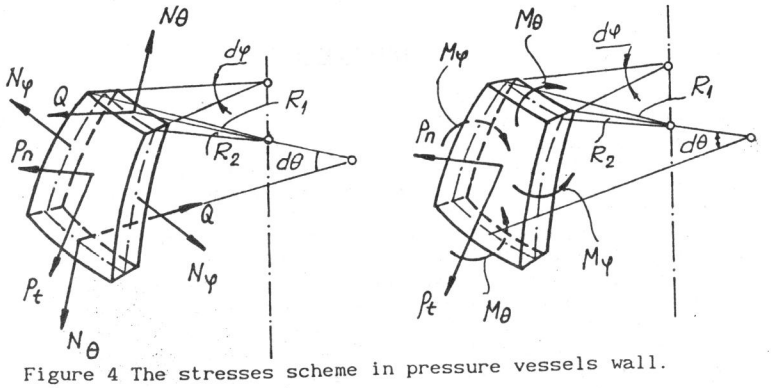

Figure 4 The stresses scheme in pressure vessels wall.

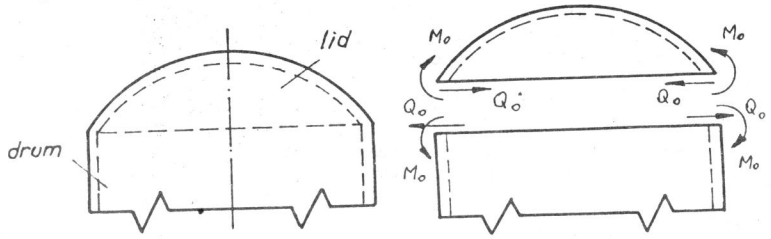

Figure 5 The stresses scheme in the lid-drum joint.