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EXPERIMENTAL RESEARCH REGARDING THE HOT-ROLLED PIPES BEHAVIOR TO CYCLIC BENDING AND INTERNAL PRESSURE

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ABSTRACT. This paper presents the results of the experimental research regarding the hot-rolled pipes behavior to cyclic bending with internal pressure. There were presented the methodology and the results of the 12 hot-rolled pipes material testing on compound loadings (specimens from E 235 and 10MoCr10 materials, which are used in the oil tubular construction).

ЕКСПЕРИМЕНТАЛНО ПРОУЧВАНЕ НА ПОВЕДЕНИЕТО НА ГОРЕЩИТЕ ТРЪБИ ПРИ КРЪГОВО ОГЪВАНЕ И ВЪТРЕШНО НАЛЯГАНЕ

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Introduction

In this paper, there are presented the results of the experimental tests concerning the behavior on bending with internal pressure cyclic loadings of the real dimensions hot-rolled pipes, which are used in the construction of oil tubular material.

The tests issues performed on an original stand, conducted to the determination of the total number of cycles until the fatigue fracture of the pipes (NTCR).

The laboratory analysis performed on the fractured pipe specimens' permitted to establish the dynamics of the fatigue fracture process (Ulmanu, 1992).

Experimental researches concerning the hot-rolled pipes resistance on bending with internal pressure cyclic loadings

The stand (Zisopol, 2000) from figure 1 general view of the stand and figure 2 the functional-constructive scheme of the stand was utilized for the experimental researches concerning the bending with internal pressure cyclic loadings of the hot-rolled pipes.

In order to realize the bending form, the hot-rolled pipe (A) is reeled over the bending form with the diameter D_{AG} = 2438 mm (B) and then is straightened in contact with the straight form (C).

The hydraulic linear engine (D) generates the force which is necessary for pipe bending in both directions (towards B, respectively to C), through the profiled rollers (E).

The experimental tests methodology supposes the following phases:

- the 1200 mm length specimen, which is tested, is introduced on the superior part of the stand, through the rollers (E) and is fixed rigid in the clamp device (G);
- the superior end of the specimen is closed by the upper adapter (F). The inferior end of the specimen has a lower adapter (H), where is connected the hydraulic connection (I), in order to charge with under pressure work liquid;
- the specimen is filled with oil through the hydraulic connection (I) and the existent air is eliminated through the inferior valve (J);
- the specimen is loaded with the adequate hydraulic medium and it is actuated the hydraulic linear engine, which will deform the pipe, to the right, through the rollers (E);
- the check piece (L) detects the position of the pipe on the bending form (B) and reverse the motion sense (to the left). The sample is straightened on the straight form (C) until hits the other check piece (L) and the motion sense of the hydraulic engine (D) is inverted;
- the number of cycles made by the sample is counted;
- the test is stopped when it observes the meaningful reduction of the pipe internal pressure;
- the hydraulic medium is eliminated from the inside of pipe, the system is stopped and it is separated the sample from the stand.

The stand was utilized for determining the total number of cycles until the fracture (NTCR) of 12 hot-rolled pipe specimens (with the external diameter D = 32 mm and the wall thickness t = 3 mm) – 6 samples manufactured from E 235 (EN10297/1) steel and 6 samples manufactured from 10MoCr10 (STAS 3478) steel.

The mechanical characteristics and the chemical composition (Ulmanu, Zisopol, Trifan 2004-2005) of the hot-rolled pipes materials are presented in table 1, respectively table 2.

The admitted criterion for removal of the hot-rolled pipes was the fracture of them (distinguished through the reduction of the pressure to the oil indicator M2 of the installation – see Fig. 2).

The obtained results concerning the total number of cycles until the fracture of the hot-rolled pipes (NTCR) are centralized in table 3.

Table 1

The mechanical characteristics of the hot-rolled pipes materials

Type of steel	Yield Strength	Ultimate Tensile Strength	Elongation
	[MPa]	[MPa]	[%]
E 235 EN10297/1	329	451	39.0
10MoCr10 STAS 3478	320	662	26.4

Table 2

The chemical composition of the hot-rolls pipes materials

Type of steel	C	Mn	P	S	Si	Al
	[%]					
E 235 EN10297/1	0.117	0.544	0.007	0.006	0.262	0.020
10MoCr10 STAS 3478	0.130	0.610	0.009	0.006	0.230	0.025

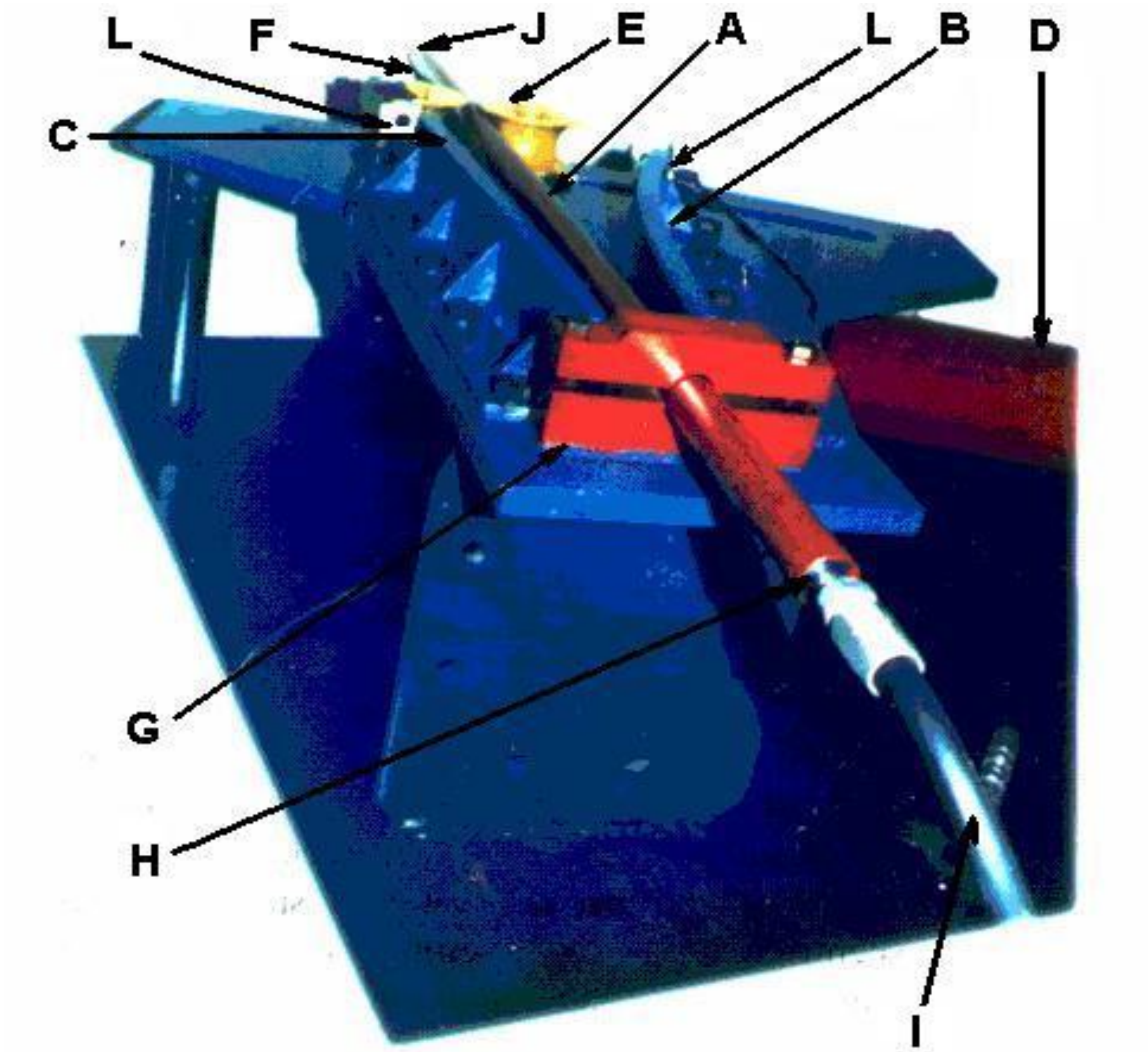

Fig. 1. The general view of the stand: A – hot-rolled pipe; B – bending form; C – straight form; D – hydraulic linear engine; E – profiled rollers; F – upper adapter; G – clamp device; H – lower adapter; I – hydraulic connection; J – inferior valve; K – superior valve; L – check piece; M – electric motor

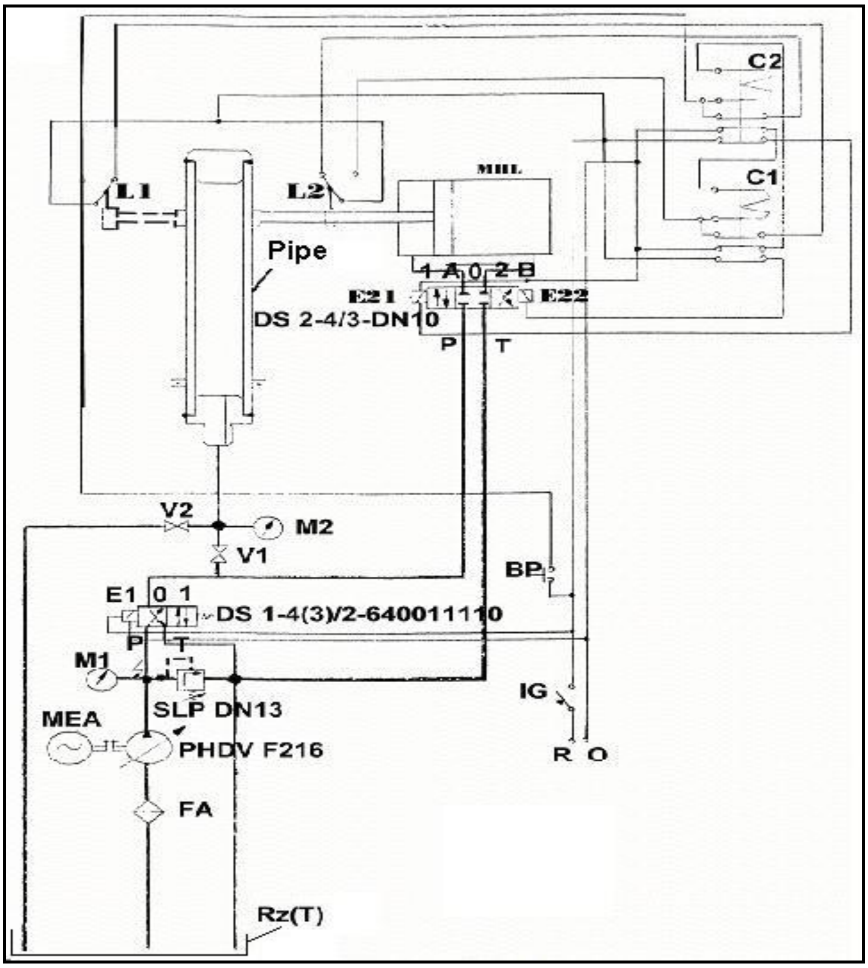

Fig. 2. The functional-constructive scheme of the stand: L1, L2 – check pieces; C1, C2 – contact makers; Ds1, Ds2 – throttles; MHL – hydraulic linear engine; MEA – electric asynchronous motor; E – electromagnet; PHDV (P) – hydrostatics pump with variable flow rate; FA – admission filter; M1, M2 – oil indicators; SLP (Dn13) – pressure limiter valve; Rz (T) – oil tank; V1, V2 – coupling cocks (needle valves); IG – general switch; BP – starting up button

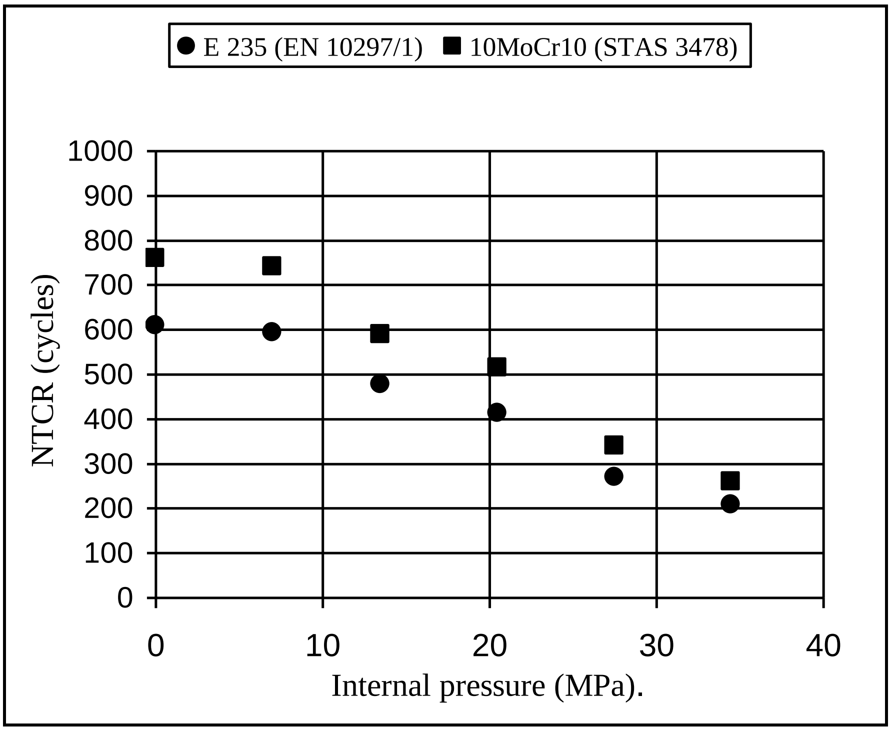

Fig. 3. The influence of the internal pressure on the total number of cycles (NTCR) for the two hot-rolled pipes (E235 and 10MoCr10)

Table 3

Total number of cycles until the fracture of the hot-rolled pipes (NTCR) constrained to cyclic bending with internal pressure

No.	Material	Diameter of pipe, D	Wall thickness, t	Diameter of the bending form, D_{AG}	Internal pressure, p_i	NTCR
-	-	[mm]	[mm]	[mm]	[MPa]	[cycles]
1.	E 235 EN10297/1	32	3	2438	0.0	609
2.					7.0	593
3.					13.5	477
4.					20.5	412
5.					27.5	269
6.					34.5	208
7.	10MoCr10 STAS 3478				0.0	760
8.					7.0	741
9.					13.5	589
10.					20.5	514
11.					27.5	339
12.					34.5	259

Conclusions

In this paper, there were presented the methodology and the results of the 12 hot-rolled pipes material testing on compound loadings of bending with internal pressure (6 specimens of E 235 material and 6 specimens of 10MoCr10 material, which are used in the oil tubular construction).

From these experimental researches, there were concluded the following:

- between internal work pressure and the life time of the hot-rolled pipes, constrained to bending with internal pressure, there is an inverse proportional connection (see fig. 3);
- when there are using work pressures under 20.5 MPa, it appears numerous fractures on the specimen surfaces as against the using of the internal pressures over 20.5 MPa, when there were recorded some fractures, but more dangerous;
- for situations when there were utilized internal work pressures under 20.5 MPa, there were recorded meaningful growth of the specimens diameters (15…20 %);
- the crazes were transverse initiated, from inside to outside of pipes, from the specimens' surface, which come into the contact with the bending form (B) of the test stand (see fig. 1). When the section which contains the craze cover the distance between the bending form (B) towards the straight form (C) and the pipe becomes rectilinear, the craze tends to close, but the fluid from inside (being incompressible) perform an hydraulic chock, which will determine the craze propagation;
- for the same value of the internal pressure (p_i) and the same bending moment, the total number of cycles until the fracture of the 10MoCr10 (STAS 3478) pipes is, appreciatively, 25 % bigger than the total number of cycles until the fracture of the E 235 (EN 10297/1) pipes.

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