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EXPERIMENTAL RESEARCH CONCERNING THE INFLUENCE OF EXTERNAL DIAMETER ON THE BEHAVIOR OF COILED TUBING TO CYCLIC BENDING WITH INTERNAL PRESSURE

This paper presents results of experimental research concerning the influence of the external diameter on the fatigue behavior of coiled tubing manufactured from X70 steel, loaded by cyclic bending with internal pressure.

Представлены результаты экспериментальных исследований влияния внешнего диаметра на усталостные характеристики гибких насосно-компрессорных труб малого диаметра, изготовленных из стали марки X70 при циклическом изгибании с внутренним давлением.

Introduction

Because of the increased needs of the world economy concerning the oil and natural gas usage, the actual tendency is to extend the geographical area of hydrocarbon drilling and exploitation. Therefore, both in onshore and offshore drilling, the use of the coiled tubing units is imposed (which are transportable drilling – production – intervention equipments) [1, 2].

The coiled tubing is a continuous pipe, with more than 4000 m length, made of metallic material with special mechanical characteristics and chemical composition, which confers it some raised plasticity properties.

Based on the field data, it was concluded that a typical standard maneuver operation of coiled tubing in and out of the well (one bending cycle) consists in 6 bending and straightening operations (3 to run into well and 3 to pull out of the well) – as you can see in figure 1 [3, 5]:

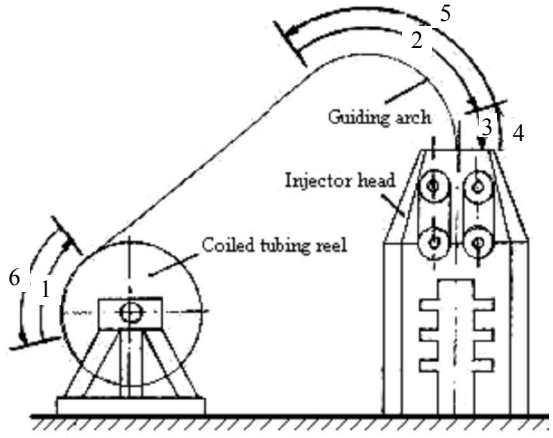


Fig.1. The bending cycles of the coiled tubing

- the coiled tubing, coiled on the reel is straightened on the layout reel – guiding arch;
- bending over the coiled tubing guiding arch;
- straightening again of the coiled tubing, between the chains of the injector head.

When the coiled tubing is pulled out of the well, the same bending and straightening operations take place, but in reverse order. Because in exploitation, the fatigue crack of the coiled tubing is produced by their bending over the reel and / or the guiding arch of the coiled tubing unit, the external diameter on the coiled tubing fatigue life plays an important part.

The object of the research for this article is the experimental investigation of the coiled tubing external diameter (manufactured from X70 steel) on the fatigue phenomenon, under the cumulative action of bending with internal work pressure.

Therefore, the stand for the coiled tubing tests to bending with internal pressure was used, whose functional – constructive scheme is presented in figure 2. The results are materialized in the analysis of the total number of cycles until the crack of the coiled tubing, manufactured of X 70 steel. The admitted criterion of

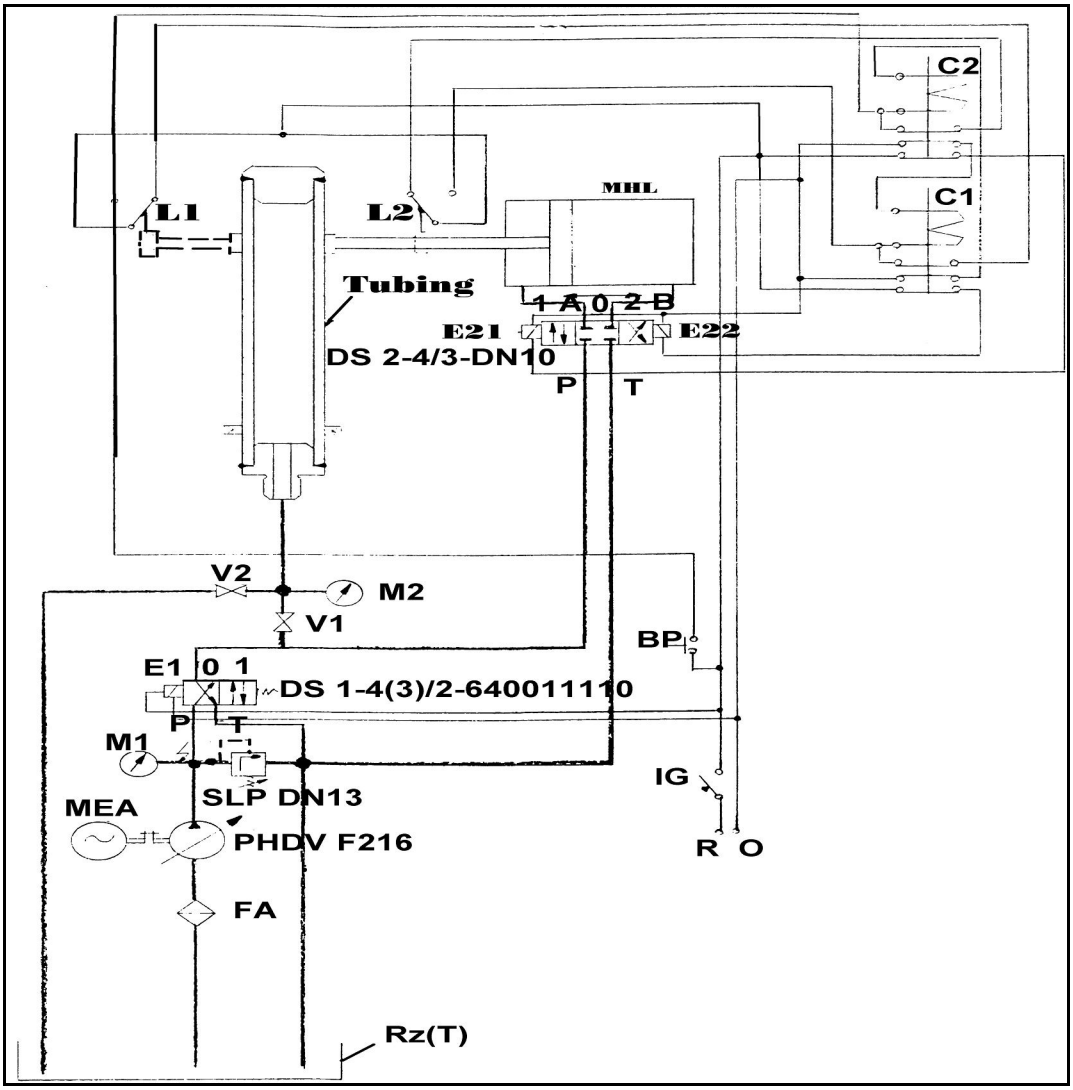


Fig. 2. The functional – constructive scheme of the stand:
L1, L2 – check pieces; C1, C2 – contact makers; Ds1, Ds2 – throttles; MHL – hydraulic linear engine;
MEA – nonsynchronous electric motor; E – electromagnet; PHDV(P) – controlled-volume hydrostatics pump;
FA – admission filter; M1, M2 – oil indicator; SLP (Dn13) – releif-valve jet;
Rz(T) – oil tank; V1, V2 – valve (needle valve); IG – general switch; BP – starter push button

the coiled tubing removal was its cracking, observed through the reduction of the internal work pressure [5].

Experimental research concerning the influence of the external diameter on coiled tubing fatigue life

The experimental tests were performed on 8 specimens of coiled tubing, manufactured from X70 steel.

The mechanical characteristics and the chemical composition of the specimens manufactured steel are presented in table 1, respectively table 2 [3, 4].

Table 1. The mechanical characteristics of the coiled tubing specimens

Type of steel*	Yield Strength	Ultimate Tensile Strength	Hardness	Elongation
	N/mm^2	N/mm^2	HRC	%
X70**	483	552	22	30

* According to the API classification

** Pipe for coiled tubing QT 700: QT = Quality Tubing; 700 = 70000 psi = 483 N/mm^2 – minimal yield strength

The stand used for experimental tests (figure 2), whose functional – constructive scheme

Table 2. The chemical composition of the coiled tubing specimens

Type of steel	C	Mn	P	S	Si	Cr	Cu	Ni
	%	%	%	%	%	%	%	%
X70	0,10-0,15	0,60-0,90	max 0,030	max 0,005	0,30-0,50	0,55-0,70	0,20-0,40	max 0,25

Table 3. The results of the coiled tubing tests on bending with internal pressure

No	Material	Diameter of pipe	The wall thickness	The guiding arch diameter	The internal pressure	The total number of cycles until fatigue cracking
-	-	[mm]	[mm]	[mm]	[MPa]	[cycles]
1.	X70	32	3,18	2438	0	903
2.					7,0	842
3.					13,5	696
4.					20,5	594
5.		38			0	618
6.					7,0	577
7.					13,5	459
8.					20,5	336

is presented in figure 2, follows the achievement of the representative loads in exploitation: bending with internal pressure [5]. The admitted criterion of the coiled tubing reject was its cracking, noticed through the reduction of the internal work pressure.

The results of the experimental tests are summarized in table 3 [3, 5].

The influence of the external diameter on the total number of cycles until the fatigue crack of the coiled tubing is illustrated in figure 3.

Conclusions

The results of the experimental tests show the influence of the external diameter on the behavior of coiled tubing to bending with internal pressure. The crack was produced from outside to inside of coiled tubing and was initiated by the defects caused by the mechanical abrasion or the material flaws.

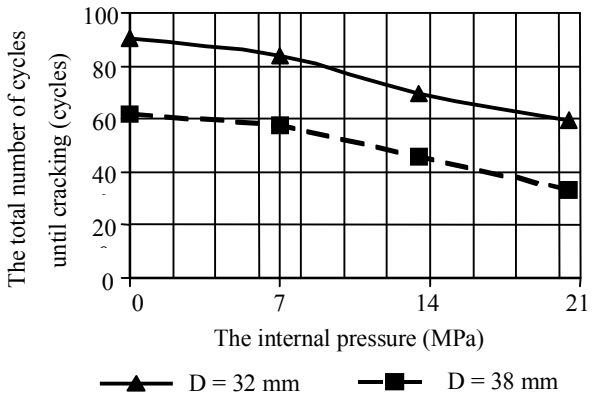


Fig.3. The influence of the coiled tubing external diameter on the total number of cycles until cracking

Reducing the coiled tubing external diameter with 16 % (from 38 mm to 32 mm), in the conditions of a constant internal work pressure, determined the decreasing of its fatigue life with 43 %. Once with the growth of the internal work pressure from 0 to 20,5 N/mm^2, the total number of cycles until the coiled tubing crack have been reduced up to 12 %.

The experimental researches presented in this article are going to be extended through the influence of other material typo dimensions, as well as using internal work pressures up to 80 N/mm^2.

LITERATURE

1. *Oliviu*, *Rusu*. The Metals Fatigue, Estimation Bases. Volume I, II. Technical Publishing House, Bucharest, 1992.

2. *Tipton*, *S.M.*, *Behenna*, *F.R.* An Investigation of the Efects of the Physical Properties of Coiled Tubing on Fatigue Modeling, SPE 89571, Houston, Texas, 2004.

3. *Ulmanu*, *V.* Oil Tubular Material, Technical Publishing House, Bucharest, 1992.

4. *Ulmanu*, *V.*, *Zisopol*, *D.G.*, *Trifan*, *C.N.* Theoretical-Experimental Research Concerning the Exploitation Characteristics Influence on Coiled Tubing Lifetime Used in the Oil Industry, 33350/29.06.2004 CNCSIS Grant, type TD, 2004-2005.

5. *Zisopol*, *D.G.* Research Concerning the Construction of the Coiled Tubing Used in the Oil Industry, Ph. D. Thesis, Petroleum – Gas University of Ploiesti, September, 2000.