THEORETICAL RESEARCHES CONCERNING BENDING PROCESS OF THE PRESURIZED PIPES

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Abstract: In this paper, the results of the theoretical researches concerning the variation of characteristics lines as a function of the constructive parameters (D – the outer diameter of pipe and h – the thickness of pipe wall) and mechanical parameters (σ_c), in the case of pressurized pipes bending process, are presented.

Keywords: pressurized pipes bending process, variation of characteristic lines

1. INTRODUCTION

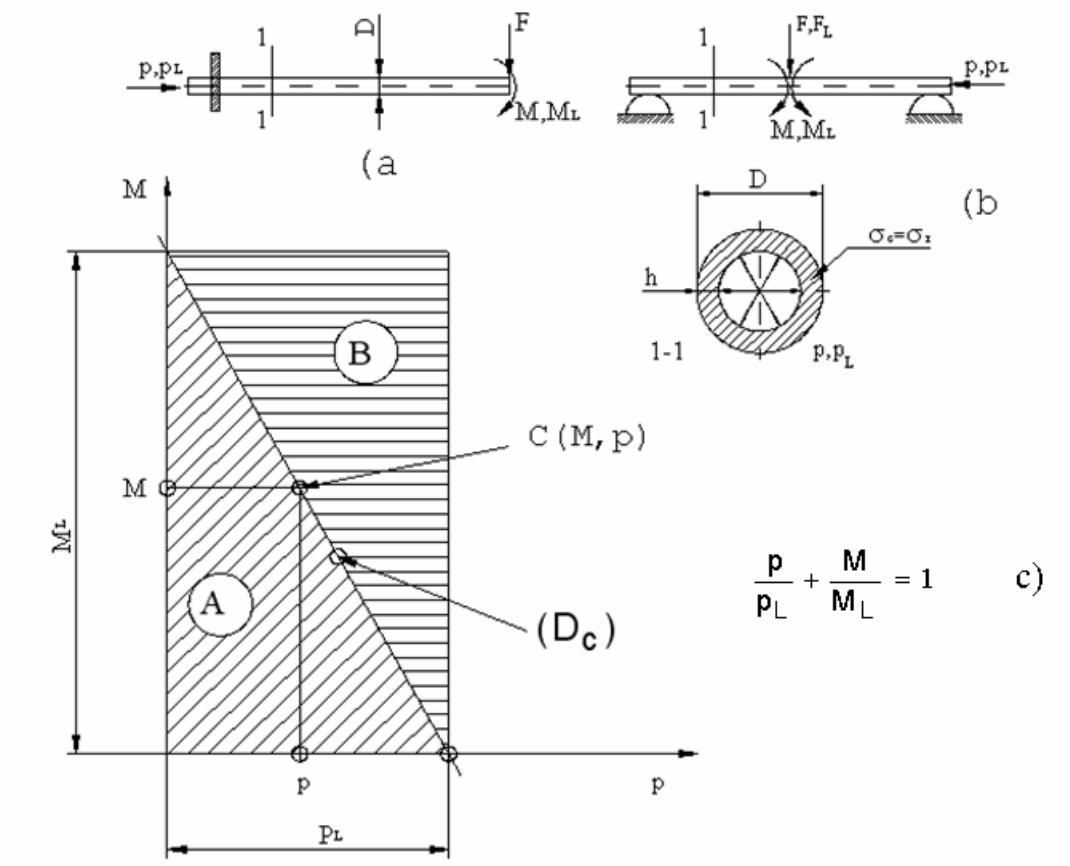
The mathematical model that describes the pressurized pipes bending process was formalized in [1] with the following relations:

$$\frac{p}{p_L}+\frac{M}{M_L}=1 \tag{1}$$

$$\frac{\dfrac{p}{\sigma_c}}{\dfrac{1}{4}\left[\dfrac{(D-2h)^2}{(D-h)h}+\dfrac{D-2h}{h}\right]-1}+\frac{M}{\dfrac{\pi}{4}\sigma_c Dh(D-h)} \tag{2}$$

where: p, M - the pressure respective the moment when the bending of pressurized pipe occurs
p_L, M_L - the limit pressure respective the limit moment when the pipe flattening occurs during the under pressure bending process
h- the thickness of pipe wall
σ_c - the yield strength of pipe material.

This mathematical model connects all the significant parameters (p, p_L, M, M_L, D, h, σ_c) of the pressurized pipes bending process, allowing a scientific analysis of the process, the theoretical research of the above mentioned influence factors and the statement of some pertinent observations and conclusions concerning the process. For instance, the mathematical model expressed by relation (1) represents the equation of a line through rips, where p_L, M_L – the limit pressure respective the limit moment when the pipe flattening occurs – are the rips of line (fig. 1). This line - the characteristic line of the process (D_c) - was determined. It contains the range of pairs $p < p_L$ – $M < M_L$ for witch the bending of pressurized pipes is possible without their flattening. On the fig. 1 it can be observed that the characteristic line D_c determines two areas, respective: the area A where, theoretically, the pressurized pipes bending without their flattening is possible and the area B where, theoretically, this fact is impossible.



$$\frac{p}{p_L} + \frac{M}{M_L} = 1 \qquad c)$$

$$p\left\{\frac{1}{4}\cdot\left[\frac{(D-2h)^2}{(D-h)h} + \frac{D-2h}{h}\right] - 1\right\} + \frac{4M}{\pi Dh(D-h)} = \sigma_c$$

$$\frac{p}{p_L} + \frac{M}{M_L} = 1$$

$$M = 0 \Rightarrow p_L = \frac{\sigma_c}{C_p} = \frac{\sigma_c}{\frac{1}{4}\left[\frac{(D-2h)^2}{(D-h)h} + \frac{D-2h}{h}\right] - 1}$$

$$p = 0 \Rightarrow M_L = \frac{\sigma_c}{C_M} = \sigma_c W = \frac{\pi}{4}\sigma_c Dh(D-h)$$

$$C_M = \frac{1}{W} = \frac{4M}{\pi Dh(D-h)}$$

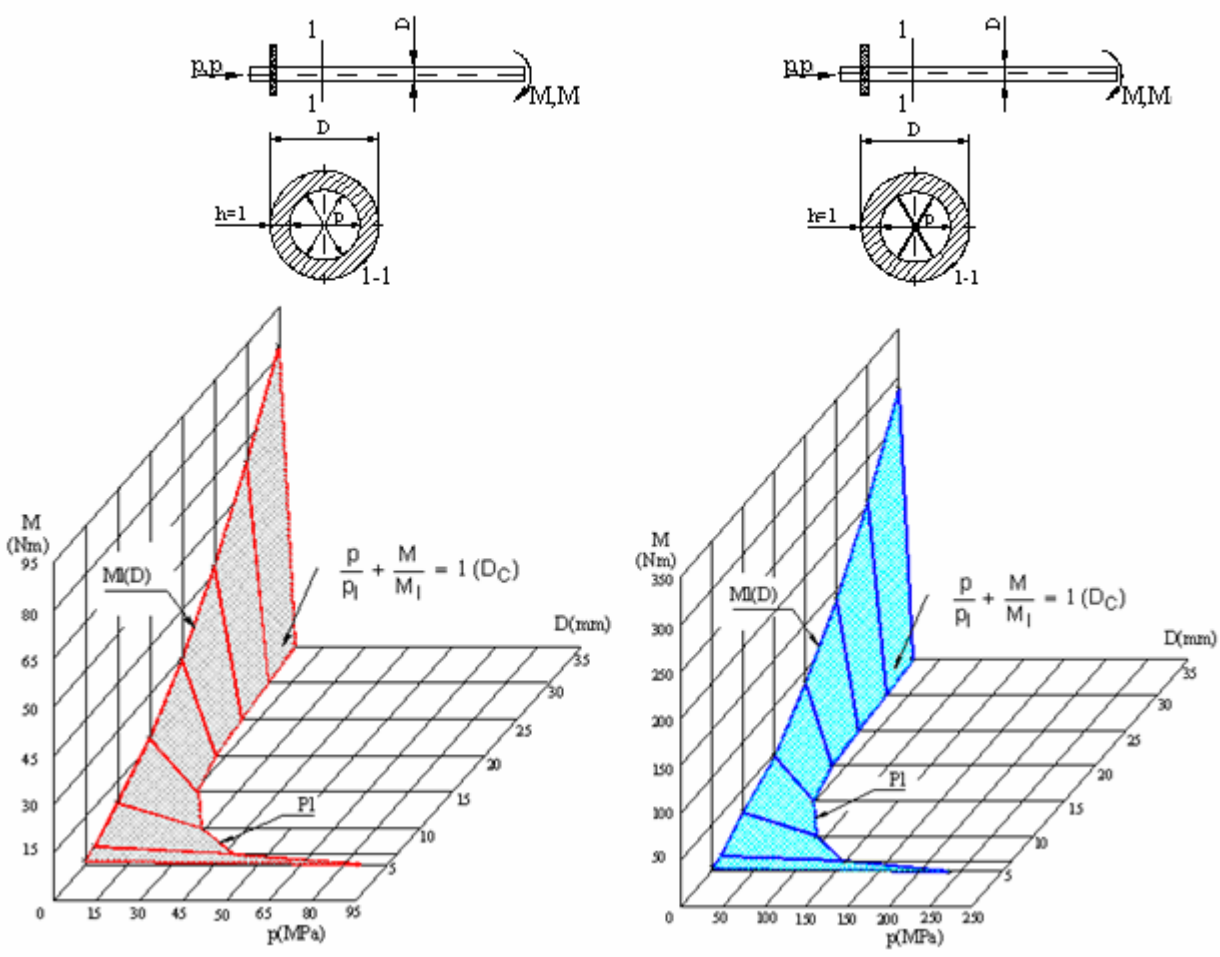
$$C_p = \frac{1}{4}\left[\frac{(D-2h)^2}{(D-h)h} + \frac{D-2h}{h}\right] - 1 \qquad d)$$

Fig. 1 Characteristic line (D_c)
a) Physical models; b) significant parameters (D, h, σ_c, p); c) characteristic line (D_c);
d) Mathematical models and calculus elements

Theoretically, a pair $p_A < p \cap M > M_A$ from the aria A leads to an elasto-plastic deformation of the pipe; any pairs $p_B > p \cap M > M_B$ from the aria B leads to the pipe flattening. In consequence, any pair $p \cap M$ situated on the characteristic line D_c allows the pressurized pipes bending process.

2. RESULTS OF THE THEORETICAL RESEARCHES

Based on the physical models presented in the fig. 1a, that lied at the basis of elaboration of the mathematical models, after the schedule of values for the significant factors (σ_c, D, h) of the process and their introduction into calculus relations, the characteristic lines $D_c(p, M)$ for the scheduled values of the diameter D of pipe and for two values σ_c = 100 MPa, σ_c = 300 MPa of the yield strength σ_c of pipe material were drawn (fig. 2).
It has be noted that the area of the scheduled values for these factors has taken into account the usual parameters of the pipes used in hydraulic circuits from machines building, the limit parameters of pipes used in experimental researches and the need of obtaining some significant calculated data for the graphical representations and their analysis.



a. b.

Fig. 2 Variation of the characteristic lines as a function of diameter D of the pipe

By analyzing the representations on the fig. 2, the following observation can be stated:

- The position of the characteristic lines $D_c(p, M)$, that contain the range of pairs p-M for which the pressurized pipes bending is theoretically possible, varies as a function of the pipe diameter D and the yield strength σ_c.

- The range of the characteristic lines D_c joins in the adjusted surfaces proper to different values of the yield strength σ_c and these, in their turn, cover the range of coordinate points p – M –D for witch the bending of the pressurized pipes having a certain prescribed or experimental determined yield (ultimate) strength, σ_c (σ_r), is possible.

3. REFERENCES

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