Velychkovych Andrii, Andrusyak Andriy, Petryk Ivan
(IFNTUOG, Ivano-Frankivsk)

DETERMINATION THE ADDITIONAL HOOP STRESSES OF AN OVERPASS PIPELINE INTERACTION WITH A SUPPORT

E-mail: ***a_velychkovych@ukr.net***

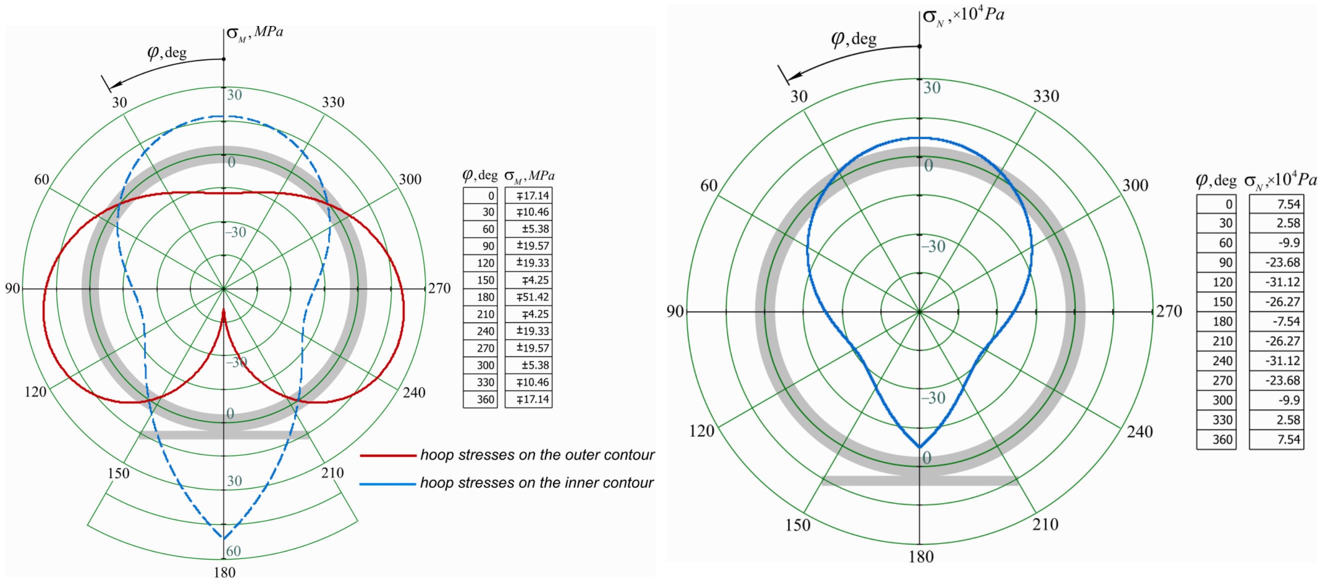
Today, pipelines are the safest and most economical way to transport petroleum products and one of the key components of modern energy infrastructure. Nevertheless, pipeline systems are associated with certain risks that can lead to environmental disasters. In the practice of construction of oil pipelines in mountainous areas, beam-type overpasses are often used. According to the results of the analysis of overpass transitions, such defects as a change in the shape of the pipe and local bulges in the area of the support nodes of the oil pipelines were revealed. The development of new and improvement of existing methods of studying the stress-strain state of overpasses of oil pipelines are really relevant applied problems, the solution of which will contribute to increasing the safety of pipeline transport.

Consider the model of the two-section overpass of the oil pipeline, which is built in the mountainous area [1, 2]. The effect of volume forces and operating loads on the support will cause a reaction P. Let's choose a pipe element of unit length above the support. All loads that cause the reaction of the support are represented by the averaged integral equivalent q which has the vertical direction and is distributed over the middle surface of the selected element of the pipe, the radius of which is R, and the wall thickness is h. The interaction of the oil pipeline with the support causes the occurrence of additional hoop stresses $\sigma_\varphi^{\text{add}}$, which consist of stresses from the influence of the bending moment σ_M and stresses from the action of the hoop force σ_N:

$$\sigma_M = \frac{1}{2\pi}\frac{6PR}{bh^2}\left[\varphi\sin\varphi + \frac{1}{2}\cos\varphi - 1 - \sin\varphi \cdot H(\varphi-\pi)\right], \quad (1)$$

$$\sigma_N = \frac{1}{2\pi}\frac{P}{bh}\left[\frac{1}{2}\cos\varphi - \varphi\sin\varphi + 2\pi\sin\varphi \cdot H(\varphi-\pi)\right]. \quad (2)$$

Let's analyze the obtained formulas on the numerical example of the support node of one of the overpass of the Druzhba oil pipeline in the Carpathians. We take into account that on the intermediate support of the overpass of the oil pipeline, the reaction is equal to $P = 9\,kN$ (this value was obtained experimentally). The diameter of the pipe is 720 *mm*, and the wall thickness is 9.5 *mm*. Fig. 1, a shows the distribution of hoop stresses σ_M that arise due to the influence of the bending moment. Stress σ_M is unevenly distributed along the pipe wall thickness (in the outer (red solid line) and inner (blue dashed line) contours of the pipe cross-section). The highest modulus value of such stresses occurs at $\varphi = 2\pi$, $|\sigma_M| = 51.4 MPa$, these stresses are tensile on the inner contour of the pipe cross-section and compressive on the outer contour of the cross-section pipe. Fig. 1, b shows the distribution of hoop stresses σ_N, which arise due to the influence of the hoop force. In most of the pipe they are compressive, only in the small upper area of the pipe these stresses are tensile. If we compare the absolute values of stresses σ_N and σ_M, then σ_N obviously have the significantly smaller effect on the strength of the pipe material.



φ, deg	σ_M, MPa
0	∓17.14
30	∓10.46
60	±5.38
90	±19.57
120	±19.33
150	∓4.25
180	∓51.42
210	∓4.25
240	±19.33
270	±19.57
300	±5.38
330	∓10.46
360	∓17.14

φ, deg	σ_N, $\times 10^4 Pa$
0	7.54
30	2.58
60	-9.9
90	-23.68
120	-31.12
150	-26.27
180	-7.54
210	-26.27
240	-31.12
270	-23.68
300	-9.9
330	2.58
360	7.54

a b

Fig. 1. The distribution of hoop stresses σ_M (a) and σ_N (b) that arise due to the interaction of the oil pipeline with the support

The normal pressure in the oil pipeline creates operational hoop tensile stresses in the pipe material. Therefore, the additional tensile stresses, which add up to the standard stresses, have a harmful effect on the strength of the oil pipeline. Analysis of formulas (1), (2) and graphs in Fig. 1 allows us to do the following conclusion. As a result of the interaction of the oil pipeline with the support, the maximum tensile stresses occur on the inner contour of the pipe cross-section in the contact area. These stresses can be determined by the following formula:

$$\sigma_{\varphi}^{\mathrm{add}} = \frac{1}{4\pi}\frac{P}{bh}\left(18\frac{R}{h}-1\right). \tag{3}$$

Figure 2 illustrates the effect of the ratio of the pipe's radius to the wall thickness on the value of the additional hoop stresses. The greater the ratio R/h, the greater the additional hoop stresses caused by the interaction of the pipe with the support, other things being equal.

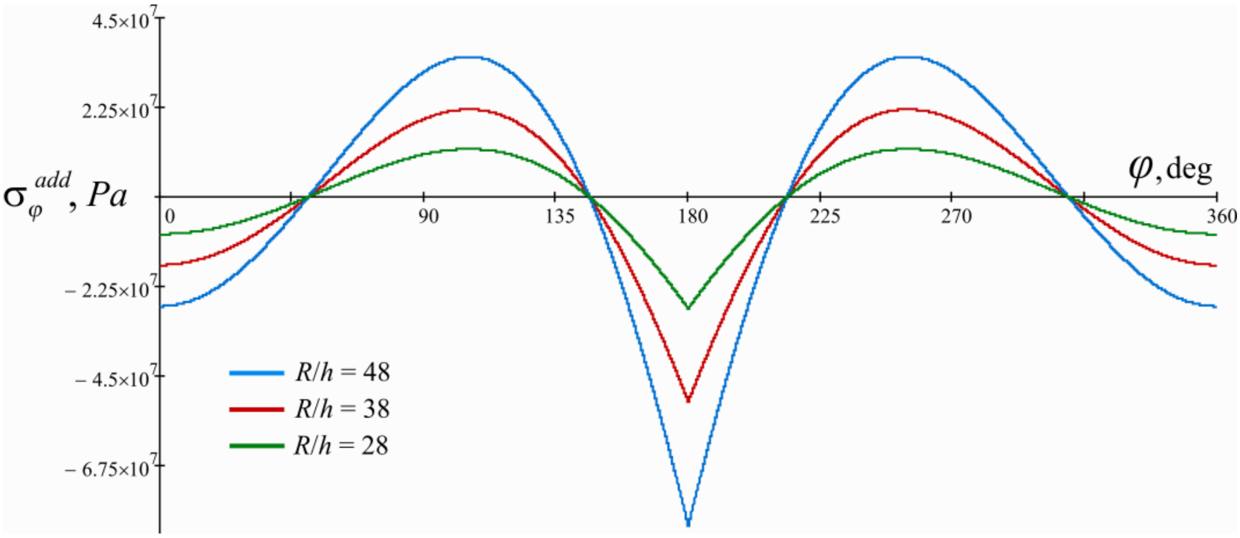


Fig. 2. The influence of the ratio of the pipe's radius to the wall thickness on the value of additional hoop stresses that arise due to the interaction of the oil pipeline with the support

The results of the study represent the engineering theory that allows analyzing the behavior of the support node of the oil pipeline and provides the numerical correction to traditional formulas for strength estimation.

1. Velychkovych, A.; Andrusyak, A.; Pryhorovska, T.; Ropyak, L. Analytical model of oil pipeline overground transitions, laid in mountain areas. *Oil Gas Sci. Technol*. 2019, 74, 65.

2. Dutkiewicz, M.; Velychkovych, A.; Andrusyak, A.; Petryk, I.; Kychma, A. Analytical Model of Interaction of an Oil Pipeline with a Support of an Overpass Built in a Mountainous Area. *Energies* 2023, *16*, 4464.

Горбань М.В., Тесля С.Ю., Соловйова Т.О.
(КПІ ім. Ігоря Сікорського, м Київ)

ФОРМУВАННЯ МІКРОСТРУКТУРИ ПОРОШКОВИХ БІОМАТЕРІАЛІВ НА ОСНОВІ МАГНІЮ ТА ЦИНКУ

E-mail: gorban.max@lll.kpi.ua

Сучасні тенденції медичної галузі показали перспективу та високий темп розвитку біоматеріалів, а потреба у надсучасних протезах все більше зростає [1]. Це свідчить про необхідність розробки нових технологій та матеріалів. Біоматеріал на основі магнію та цинку вже довгий час набуває актуальності, як дешевша альтернатива більш дорожчим металам. Але складність задачі полягає саме у вірній підготовці матеріалу, оскільки зв’язка магнію та цинку під час кристалізації може армуватись крихкими інтерметалідами, які знижують міцність [2].

Дослідження показали [3], що необхідно розробити зразок з високочистого порошку, з мінімальною кількістю домішок, також, що добавка цинку покращує механічні та антикорозійні властивості матеріалу, але важливо зазначити, що матеріали повинні бути максимально чистими магній (99,99 мас.%) та цинк (99,999 мас. %) [4].

Прогрес розвитку медицини та протезування потребує ефективного вивчення та розвитку нових матеріалів. Традиційні матеріали такі, як матеріали на основі