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Displacement Analysis of Gas Transport Pipeline to Overpass

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Abstract

After mounting gas transport pipeline in the overpass and filling it with gas pressure was found in the middle of overpass opening displacement in the vertical direction of the pipe. In this paper is analyzed the deformation of the section of pipeline gas from overpass and factors influencing the deformation.

Key words: *displacement, gas pipeline.*

Introduction

Gas pipelines route has pipeline sectors has overpass valleys or watercourses. In these locations pipe should be positioned so as not to be affected by any increase in flow caused by floods.

After installing the pipe in the overpass and filling it with gas pressure was found in the middle of overpass opening displacement in the vertical direction of the pipe. The purpose of this paper is to present a study of pipeline deformation and displacement factors influencing.

Analytical Calculation

The section of pipeline overpass area was treated with a statically undetermined structure requested by a system of forces F, produced by internal pressure acting on the elbow, as shown in Figure 1.

Not consider the weight of the displacements pipe as pressure pipe deformation occurs after the installation overpass area.

Calculation of displacement of point C was achieved using the efforts method [1, 2]. As I considered variable of calculation: pipe wall thickness, bend radius attachment area, length and angle of the inclined section.

Given the geometric and loading symmetry was taken into account half of the structure according to Figure 2a.

The curvature of the pipe was treated as a crank area in Figure 2b, c. In this case, we have:

$$l_1 = l_{1a} + a \quad \text{and} \quad l_2 = l_{2a} + a \qquad (1)$$

$$a = R\tan\frac{\alpha}{2} \tag{2}$$

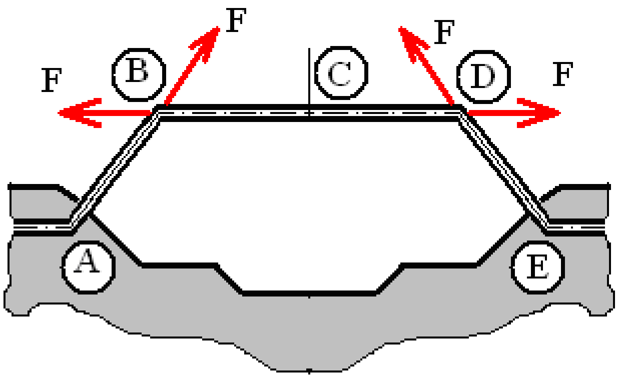

Fig. 1. Overpass zone

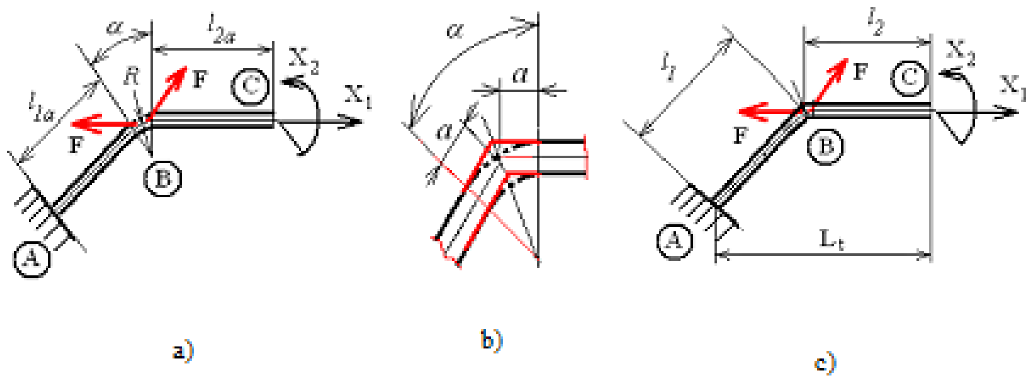

Fig. 2. Base system

The system of equations will have the form:

$$\begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{bmatrix} \cdot \begin{Bmatrix} X_1 \\ X_2 \end{Bmatrix} + \begin{Bmatrix} \delta_{10} \\ \delta_{20} \end{Bmatrix} = 0 \tag{3}$$

where:

- in the symmetry axis we have the unknown axial force X_1 and bending moment X_2;
- δ_{11}, δ_{12}, δ_{21}, δ_{22} are displacements and rotations in both directions unknown, which requires Section *C*, produced by a unit force applied at the point of X_1 and X_2 of the unit applied;

$$\delta_{11} = \frac{1}{E \cdot A}\left(l_2 + l_1 \cos^2\alpha\right) - \frac{l_1^2}{2E \cdot I_z}\sin^2\alpha \tag{5}$$

$$\delta_{22} = \frac{l_2 + l_1}{E \cdot I_z} \tag{6}$$

$$\delta_{12} = \delta_{21} = \frac{-l_1^3}{2E \cdot I_z}\sin\alpha \tag{7}$$

- δ_{10}, δ_{20} are the deflection and rotation on the two unknowns, which requires section C, produced by forces F.

$$\delta_{10} = \frac{1}{E \cdot A} F \cdot l_1 \cdot (1 - cos\,\alpha) \cdot cos\,\alpha - \frac{F l_1^3}{3E \cdot I_z} sin^2\,\alpha \tag{8}$$

$$\delta_{20} = \frac{F \cdot l_1^2 \cdot sin\,\alpha}{2E \cdot I_z} \tag{9}$$

where:
$E=210\ GPa$ is the modulus of elasticity of the material [3];
I_z is the axial moment of inertia of the cross section;
A is the cross-sectional area.

To determine displacements in the vertical direction from the point C, we used the loading diagram from Figure 3.

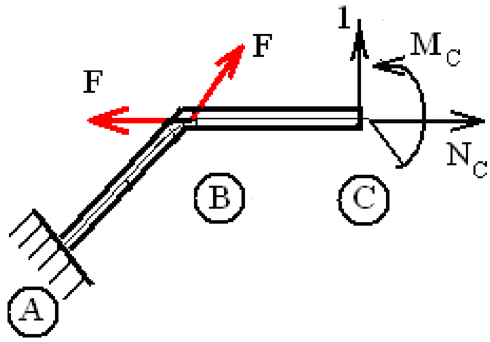

Fig. 3. The basis for determining the vertical displacement of point C

Relationship to calculate the movement will take the form:

$$\delta_C = \frac{l_1 \, sin\,\alpha}{E \cdot A}\left[F(1 - cos\,\alpha) + N_C \, cos\,\alpha\right] + \\ + \frac{1}{E \cdot I_z}\left[M_C\left(\frac{l_2^2}{3} + l_2 l_1 + \frac{l_1^2}{2} cos\,\alpha\right) + (F - N_C)\left(l_2 \frac{l_1^2}{2} + \frac{l_1^3}{2} cos\,\alpha\right) sin\,\alpha \cdot\right] \tag{9}$$

where:

- M_C is the bending moment determined after solving the system of equations (3);
- N_C is the axial force determined after solving the system of equations (3).

When calculating the displacement of point C, we have considered these value dimensions:

- angle of the section l_{1a} is $\alpha \in [30^o, 40^o, 50^o, 60^o]$;
- segment length L_t=7 m;
- length of segment inclined is $l_{1a} \in$[1m, 2m, 3m, 4m]
- outside diameter of the pipe is $D_e=323.9\ mm$, [4] ;
- pipe wall thickness is t = 7.9 mm, internal pressure p = 6.1 MPa, respectively t = 15.9 mm, internal pressure is p=12.1MPa [4];
- average radius of the bend pipe connection is $R=3D_e,\ 4D_e,\ 5D_e$.

In Figure 4 is represented the δ_c displacement variation depending on the angle α.

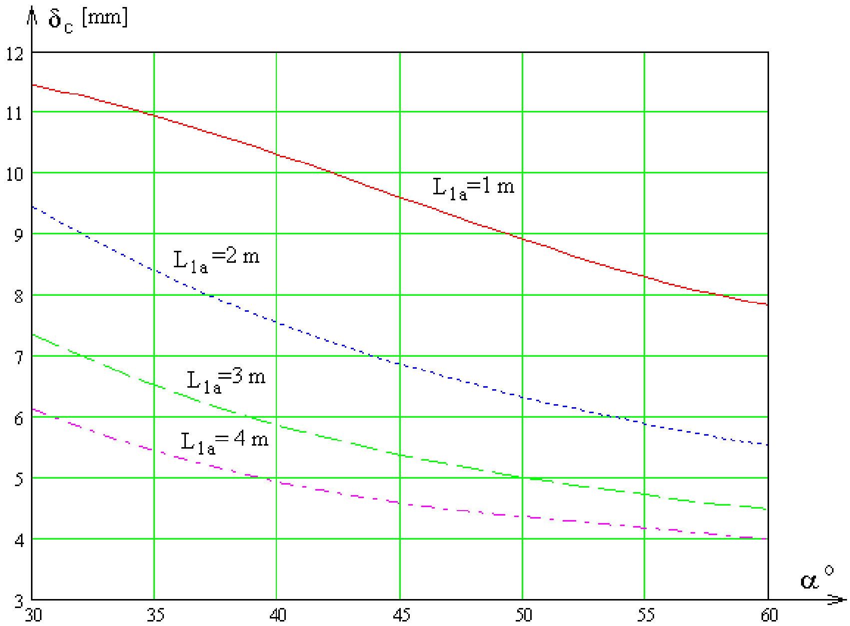

Fig. 4. Displacement variation δ_c depending on the angle α.

In Figure 5 is presented the variation of displacement δ_c depending on length of pipe section l_{1a}.

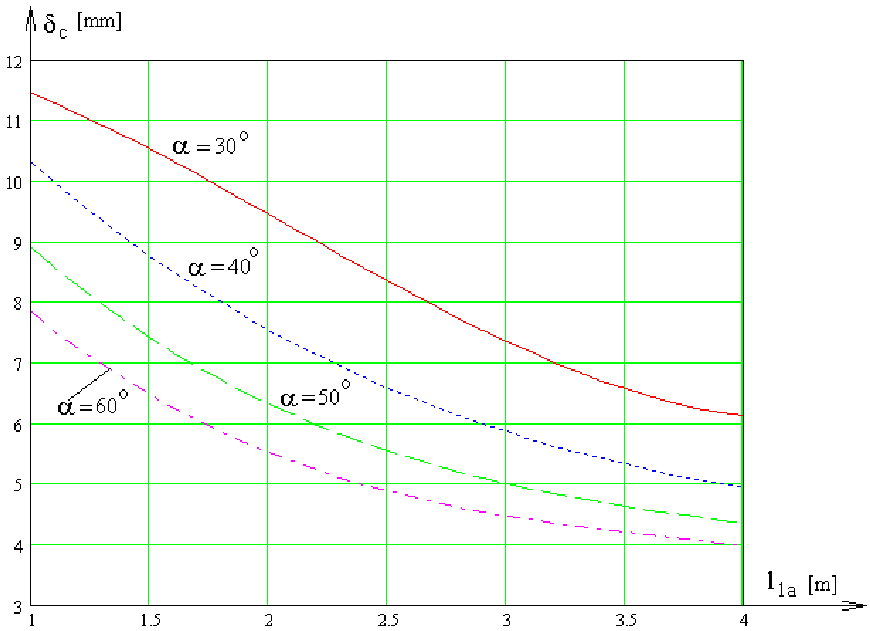

Fig. 5. Variation of displacement δ_c depending on the length of the section l_{1a}

In Figure 6 is presented the variation of displacement δ_c depending on pipe wall thickness.

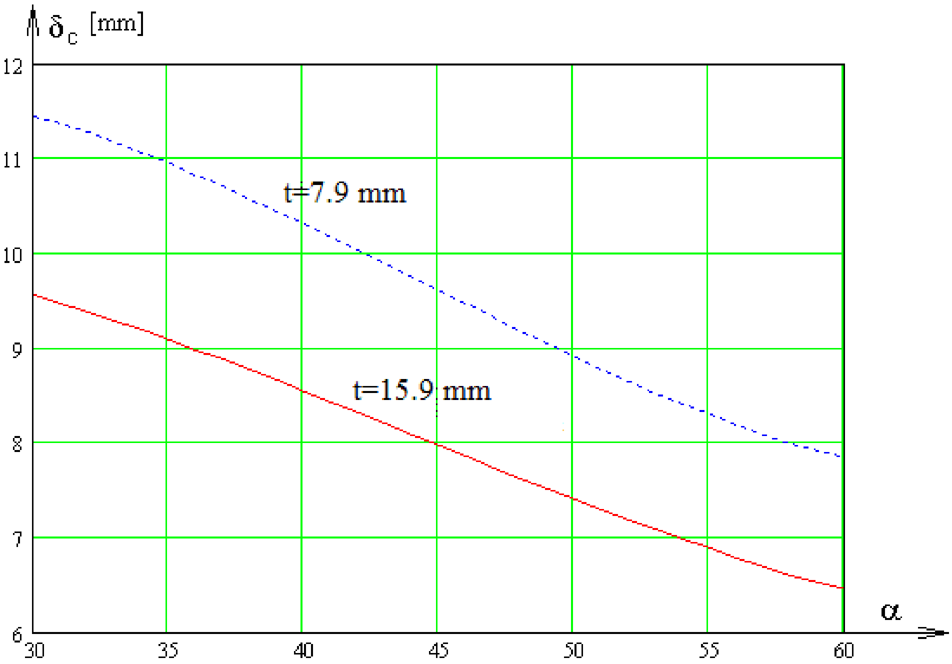

Fig. 6. Variation of displacement δ_c depending on pipe wall thickness

In Figure 7 is shown how variation of displacement δ_c is depending on the connection radius *R*.

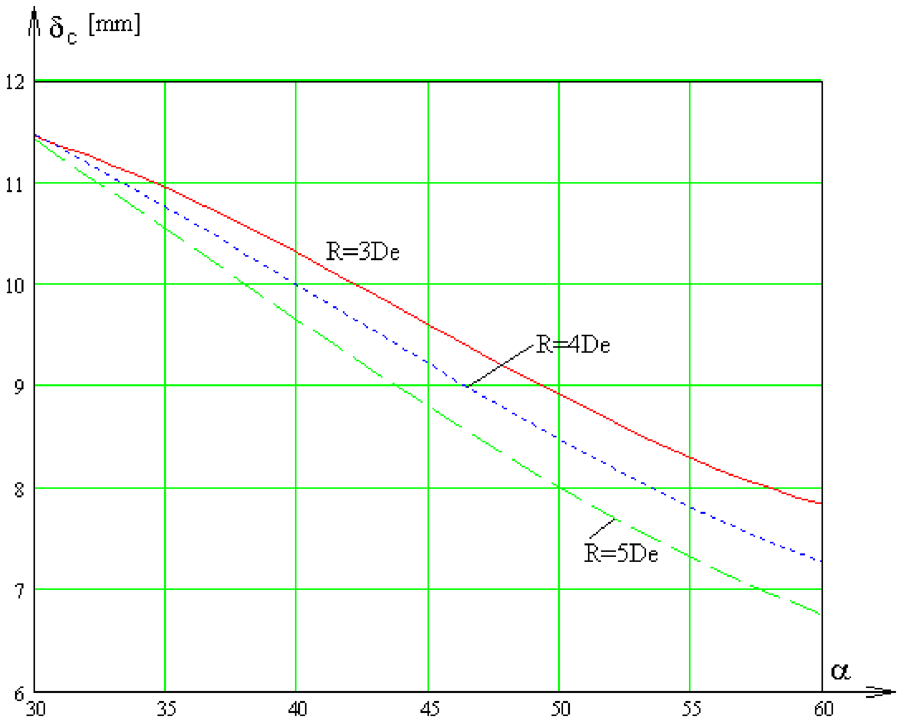

Fig. 7. Variation of displacement δ_c depending on connection radius *R*

Conclusions

Displacement of point C, produced by forces due to internal pressure of the pipeline is influenced l_{1a} segment length of the segment angle α and the thickness of the pipe wall. Connection radius of the bend has a smaller influence.

As follows:

- if l_{1a} segment length increases by 4 times displacement δ_c is reduced by 50%;
- if the section l_{1a} angle increases 2 times displacement δ_c is reduced by up to 35%;
- if the pipe wall thickness is increased by 2 times, and the internal pressure is increased by the same proportion, movement δ_c is reduced by 20%;
- if the bend radius is increased connection to $3D_e$ from $5D_e$ movement δ_c is not significantly affected.

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Analiza deplasării conductei de transport gaz metan la supratraversări

Rezumat

După montarea conductei de transport gaz metan, în zona supratraversări şi umplerea ei cu gaz sub presiune, s-a constatat în zona mediană a deschiderii supratreversării o deplasare pe direcție verticală a conductei. În prezenta lucrare este analizat modul de deformare a tronsonului de conductă de transport gaz metan, din zona supratraversării şi factorii care influențează deformarea.