THE INFLUENCE OF COMPRESSION FITTINGS ON TOTAL HEAD LOSS IN ISOPROFLEX 115-A PIPELINE SYSTEMS

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Introduction

The rapid development of production technology for plastic pipeline systems has widen their potential applications to other areas such as heating networks. Expanding the range of ISOPROFLEX plastic pipelines is the next step towards enhancing operating parameters. ISOPROFLEX-115A flexible heat insulated pipes are designed for wide range of operating temperatures up to 115°C and pressures to 1.25 MPa.

Adopting greater operational parameters meant that a review of the traditional ways in which fittings are installed was required. This led to the creation of a completely new design for connecting joints and a toughening the requirements for installation methods and technology. A new type of connecting component was developed for ISOPROFLEX-115A, press fittings with a plastic ferrule (pic. 1).

The major difference with this design is that there is no need for mechanical expansion of the pipe end during installation. Such technology helps to avoid the destructive impact of the hydraulic expander which can cause damage the structure of the reinforcing fibres in the pressure pipe and result in reduced durability and operational properties.

The inner geometry of the press fitting with plastic ferrule is designed to minimise hydraulic losses within the pipeline system. This research evaluates hydraulic losses in a pipeline system caused by the connecting components (press fittings) and their impact on the total head loss of the system.

Pic. 1. Press fitting components and ISOPROFLEX-115A plastic ferrule

Object of the research

The subject of the research is a section of the pipeline system consisting of ISOPROFLEX-115A flexible plastic pipe (with pressure pipe G-PEX-115-AMT) (hereinafter referred to as PIPE) and two press fittings with a plastic ferrule on both ends of the pipe.

The main supposition we used while doing this task is that the pipe placed on ideally straight surface without inclinations. In real conditions it is practically impossible to achieve this, but in this case let's omit the additional hydraulic losses.

Calculations were done for the whole range of ISOPROFLEX-115A pipes with outer diameters of the pressure pipes from 50 to 160 mm.

Methods and approaches

The theoretical calculations based on the method described in specialised literature were used to solve the problem [1–3].

Specific energy loss (head loss), that is used to overcome the heat transfer agent resistance (hydraulic resistance), is combined from two types of losses:

1) head loss to overcome hydraulic resistance by length, proportionate to the length of pipe sections, where agent is moving – loss by length $h_{дл}$;

2) head loss to overcome hydraulic resistance within the short sections near to local design components of the pipeline – local head loss $h_{м}$.

Total head loss equals the sum of loss by length of separate sections and all local head losses:

$$h_{тр} = \Sigma h_{дл} + \Sigma h_{м}$$

The study shows that the value of the head loss by length $h_{дл}$ is directly proportional to the length of the pipe section where these losses are calculated, and depends on the inner cross-section of the pipeline and the agent movement modes:

$$h_{дл} = f(L, V, d, K_{э})$$

where L – length of pipe section, m;
V – velocity of the agent, m/s;
d – diameter of the inner cross-section of the pipeline, m;
$K_{э}$ – equivalent roughness coefficient, m.

For the pipes of PEX $K_{э}$ = 0,0000136 m (the value is achieved after experiments in the lab).

The calculations of local resistance reduces to head loss calculation at the presence of end connection components. Pic. 2 shows the design of a press fitting with a plastic ferrule. Further during the course of the study we will use the 'fitting' definition with as the reference to the coupling with the pipe end for welding (pos. 1). The inner geometry of the fitting can be referred to as the confuser-diffuser [3]. Therefore, the coefficient of hydraulic resistance of the fitting is:

$$\zeta = \zeta_{конф} + \zeta_{диф}$$

where $\zeta_{конф}$ – coefficient of hydraulic resistance of the conf user;

$\zeta_{диф}$ – coefficient of hydraulic resistance of the diffuser.

$$\zeta_{конф} = \frac{\lambda_{Т}}{8 \cdot \sin(\alpha/2)} \cdot \left(1 - \frac{1}{n_{c}^{2}}\right)$$

where $\alpha/2$ – conjunction angle of the cone and cylinder surfaces;
n_{c} – degree of confuser narrowing.

$$\zeta_{диф} = \frac{\lambda_{Т}}{8 \cdot \sin\left(\beta/2\right)} \cdot \left(1 - \frac{1}{n_{p}^{2}}\right) + k \cdot \left(1 - \frac{1}{n_{p}}\right)^{2}$$

where $\beta/2$ – conjunction angle of the cone and cylinder surfaces;
n_{p} – degree of diffuser expansion;
k – softening coefficient; $k = \sin\alpha$ (at 5° ≤ α ≤ 20°).

The total head loss near the fittings on the given pipeline section can be calculated using the following formula:

$$h_{м} = \sum \zeta \cdot \frac{V^{2}}{2 \cdot g}$$

where
V – velocity of the liquid, m/s;
g – gravity acceleration, m/s^{2}.

Pic. 2. Compression fitting design.
1 – insert with pipe joint for welding; 2 – plastic ferrule; 3 – sliding sleeve; 4 – pressure pipe

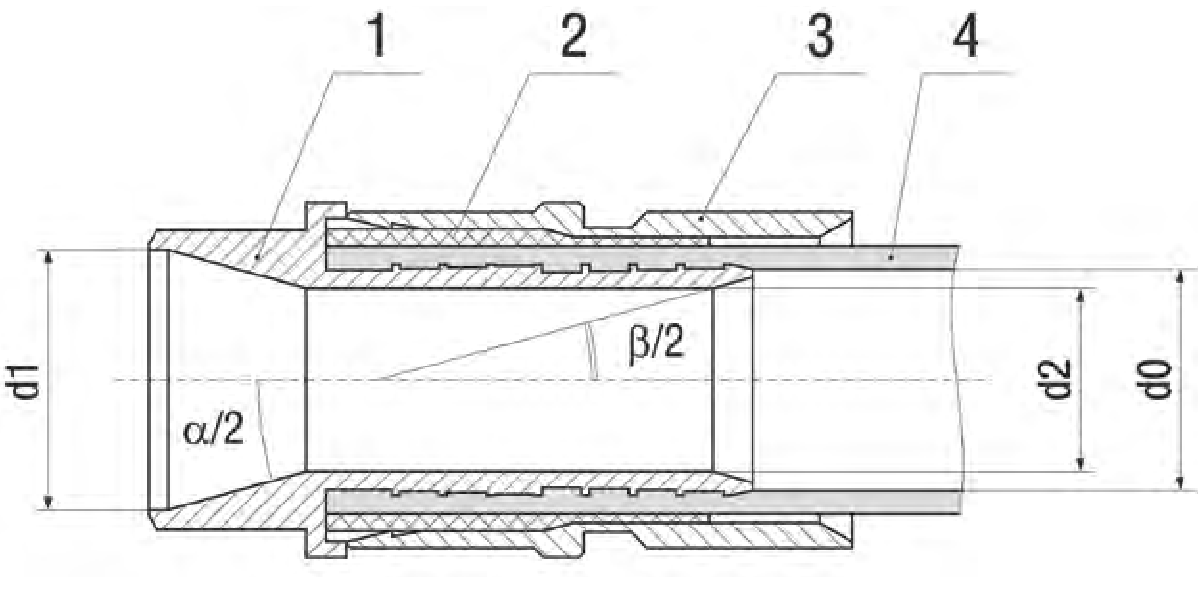


Table 1. $L_{экв}$ **coefficient for different pipe sizes at different flow rate**

Temperature of heat medium, T, °C	Flow rate, V, m/s	Pipe sizes							
		50	63	75	90	110	125	140	160
60	0,3	0,56	0,54	0,76	0,88	1,04	1,07	1,04	1,31
	1,5	0,72	0,76	1,06	1,22	1,43	1,47	1,42	1,79
	3,0	0,78	0,75	1,05	1,21	1,42	1,46	1,41	1,78

Results

As seen above, the level of hydraulic loss at fittings depends on the inner cross-section of the pipeline and the velocity of the heat-transfer agent. To simplify the data after the calculations, we input a special value equivalent $L_{экв}$ – ratio of local losses on a pair of fittings to head loss at one lean metre of a pressure pipe:

$$L_{экв} = \frac{h_1}{h_2}$$

where h_1 – head loss at fittings, m;

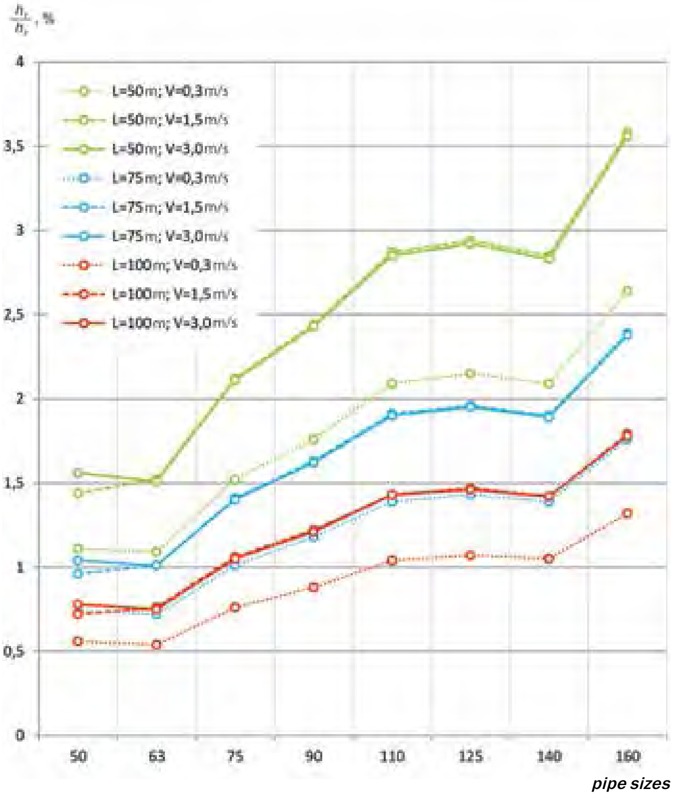
h_2 – head loss on one lean metre of the pipe; h_2 – is a dimensionless value.

Physical meaning: $L_{экв}$ coefficient shows how random pipe increases on the given pipe section after adding two fittings to the system. The value of $L_{экв}$ is shown in Table 1 for different pipe sizes and various liquid velocity.

The above calculations have helped to determine that head loss at the press fittings of the ISOPROFLEX-115A pipeline system is in the range of heat transfer medium velocity 0.2–3.0 m/s do not exceed the value equivalent the head loss at the section of the pressure pipe of 0.7–1.8 metre (depending on the pipe size).

The local loss on the pair of the pipe end press fittings relating to the total hydraulic loss of the section decreases (from 1.6–3.7% on the 50 metres section to 1.8–1.8% on the 100 metres section) if the length of the given pipeline section increases.

Therefore, hydraulic head loss, caused by forced narrowing of the inner cross-section of the pipeline at the places of installation of the fittings is negligibly small when crating long sections of the pipeline.



Pic. 3. Head loss at fitting $h_ф$ to head loss at pressure pipe $h_т$ ratio.

References

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