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Assessment of the Local Resistance Coefficient at the Coupling Point of Polypropylene Pipe

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Abstract:

The paper presents results of investigation of the local resistance coefficient in welded polypropylene coupling points with the internal diameter 17 mm. The investigations were performed on an independently constructed test rig. During the research, pressure loss was determined from the differences in the indicators of piezometers connected to the polypropylene pipe. The formula of the relationship between the average velocity of the liquid flow, the coefficient of local resistance and the pressure loss was used. The flow rate of the liquid flow was determined by the volumetric method.

Keywords: water supply system; local resistance coefficient; polypropylene coupling point; pressure difference; average velocity.

Introduction. Currently, the development of science in the field of materials science is the reason for the emergence of new materials on the world market, and the improvement of old ones. Therefore, plastic pipes are widely used in the process of designing and building water supply pipes. The main reasons for this are the low cost of plastic pipes compared to metal pipes, easy and simple installation and construction, long service life, low production and delivery costs due to relatively light weight, etc. Plastic is a common name for pipes made of various polymers, each type of such products has its own physical and hydraulic properties.

Polypropylene pipes. The most common type of plastic pipes is currently the most popular type of all pipes for water supply systems. The popularity of such pipes is due to many positive features, but first of all, ease of installation. Polypropylene pipes can have standard diameters from 16 to 125 mm. The PP pipeline is assembled by welding. There are specific types of pipes for each category of pipes (PN10, PN16, PN20, PN25). A digital indicator shows what pressure a certain product is designed for. That is, the marking of PN20 pipes tells us that such products are designed for systems with a pressure of 20 atmospheres.

Polypropylene pipes are often produced in the form of pipes with black or blue lines for cold water and red lines for hot water. All polypropylene pipes are marked with the letter PP. Polypropylene pipes can be divided into the following types:

- PP-H (Polypropylene Homopolymer). Such pipes are widely used for ventilation and cold water supply systems.
- PP-B (Polypropylene Blockpolymer). These types of pipes are often used for heating and hot water supply systems.
- PP-R (Polypropylene Randompolymer). An innovative material with high heat resistance used in many engineering communications.

In long pipes, pressure loss along the length is mainly considered, but in manufacturing plants, industry, residential, apartment complexes and service buildings, it is important to consider local resistance as well. installation, couplings in their connection also lead to loss of power.

Katarzyna Strzelecka et al.(2008) conducted a series of studies to determine the local drag in sudden expansion, including the value of D/d from 1.22 to 2.87 and the value of the local resistance coefficient ζ when the Reynolds number is higher than 10000 is smaller compared to the value determined by the Bordeaux formula It was determined that it is smaller from 3% to 80% depending on the value of sudden expansion. In addition, he proposed the formula for finding the local resistance value for the interval D/d=1.22-2.87 and $Re>10^4$:

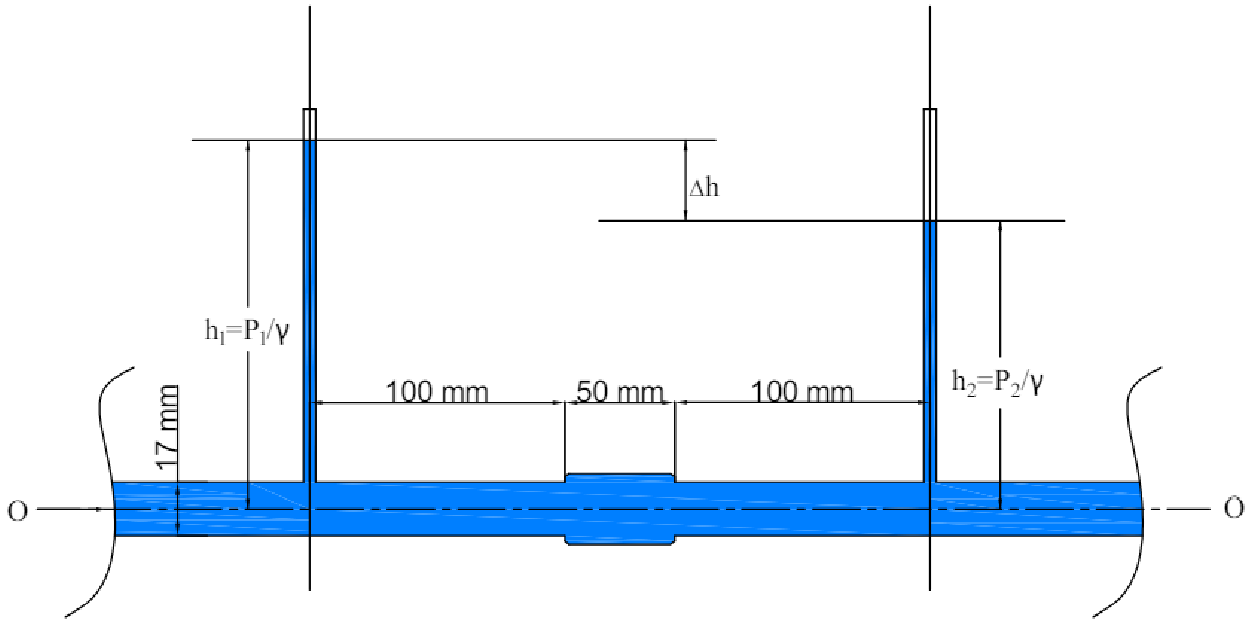
$$\zeta = 0.9239 \ln\left(D/d\right) - 0.1506$$

The above-mentioned scientist also conducted a number of studies on sharp tapering. In his 2010 article, he noted that 9 sudden contraction values were determined through experiments. According to him, the value of d/D is 0.35-0.82 and $Re>10^4$ when the experimentally determined value of the local resistance is 20-70% smaller than the value determined using the engineering formula. For the same interval and value of the Reynolds number, he proposed the following formula:

$$\zeta = -0.5658\left(d/D\right)^2 + 0.0002604\left(d/D\right) + 0.4094$$

Materials and Methods. Polypropylene pipes with an outer diameter of 25 mm and an inner diameter of 17 mm were joined using a coupling using an electric welder for plastic pipes produced under the Chinese P.I.T brand PWM 43-C1. All technical conditions for welding were carried out according to the manufacturer's instructions. piezometers were installed at a distance of 10 cm from both sides. The pressure loss was determined depending on the fluid level in the piezometers, and then the value of the local resistance was determined using the formula.

The flow rate of the liquid in the polypropylene pipe was controlled using an adjusting valve. The average flow velocity of the fluid in the pipe was increased from 25 cm/s to 108 cm/s.



Results. In general, the coefficient of local resistance is determined by the following formula:

$$h_m = \zeta \frac{\upsilon^2}{2g} \Rightarrow \zeta = \frac{h_m 2g}{\upsilon^2};$$

where h_m - is head loss due to local resistance in m, g- is the gravitational acceleration in m/s^2, υ - is the water flow velocity in m/s.

The pressure loss in the polypropylene pipe was determined by the difference in the levels of the piezometers placed before and after the coupling.

$$h_m = \Delta h = h_1 - h_2$$

The average velocity of fluid flow was determined from the following formula:

$$\upsilon = \frac{Q}{\omega}$$

Here, fluid flow rate was determined by volumetric method.

As the average velocity of the fluid flow in the pipe increased, the local resistance coefficient decreased, as can be seen from the graph below

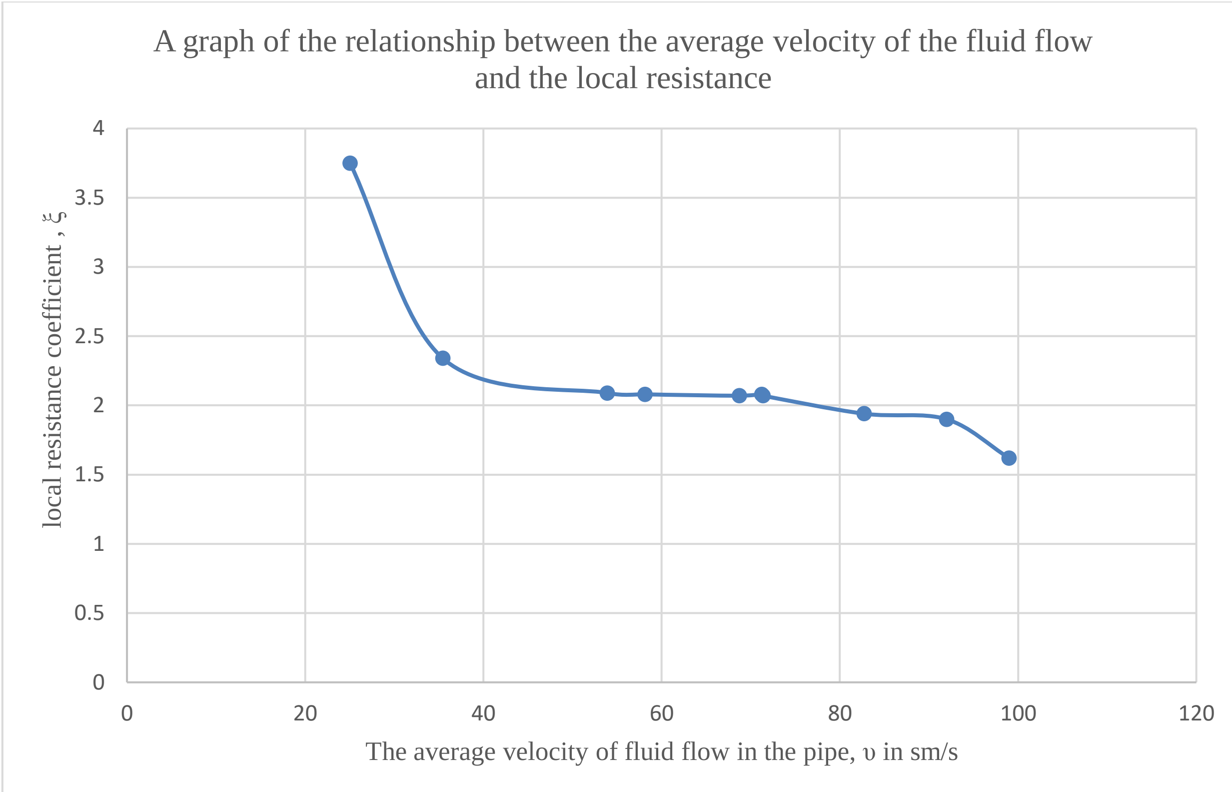


Figure 1. A graph of the relationship between the average velocity of the fluid flow and the local resistance

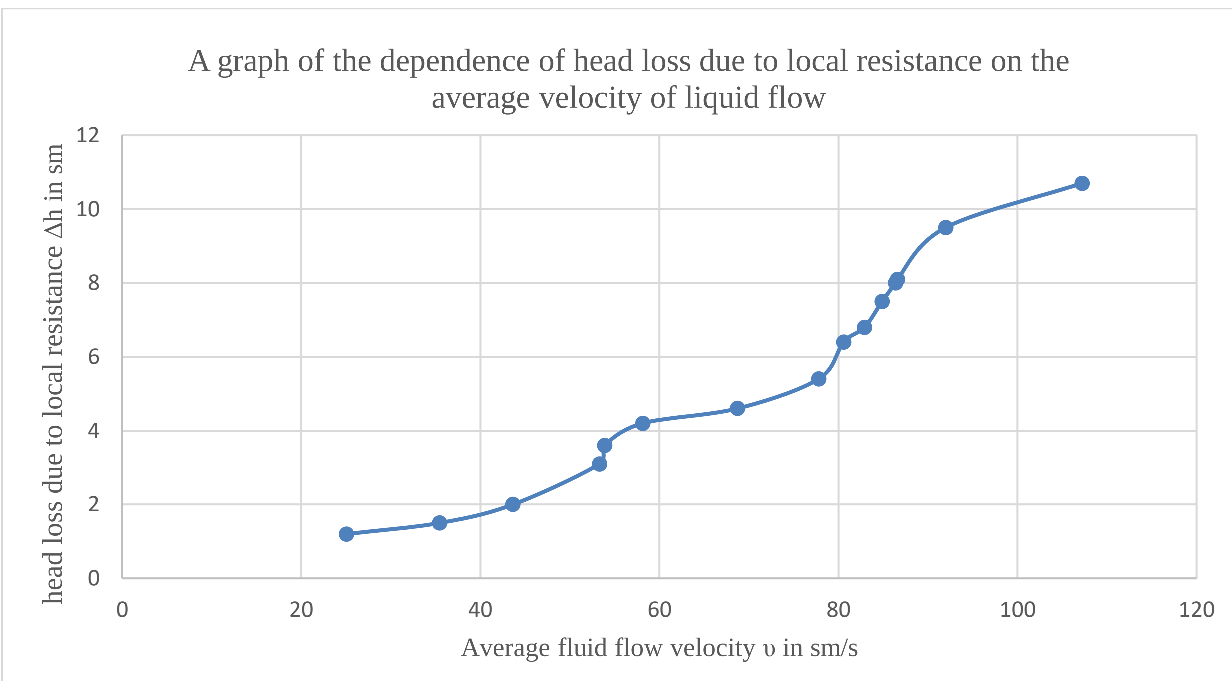


Figure 2. Graph of the dependence of head loss due to local resistance on the average velocity of the fluid flow

Conclusion. As it can be seen from the results of the research, when polypropylene pipes are connected together, there was a loss of pressure in the pipe due to a sudden expansion and a sudden contraction of the coupling at a very small distance. This has a significant effect especially when the average velocity of the fluid flow and the Reynolds number are small.

From the above research graph, we can also see that as the speed increases, the pressure loss also increases.

In conclusion, it can be said that the above experiences in the design of cold water and hot water systems for production, industry, construction and service, residential buildings, along with tap, deflection, sudden expansion, sudden contraction, filter and other local resistances means that the resistance of the couplings when the pipes are interconnected must also be taken into account.

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