CEPS a. s.
Centre of Excellence in Pipeline Services

MEASUREMENT OF HYDRAULIC PARAMETERS OF PIPELINES IN OPERATION

Why to measure hydraulics of pipeline?

Hydraulic properties of the pipeline defined by friction factor (of flow) are one of the fundamental parameters affecting projection and economy of the pipeline operation.

Determination of value of friction factor is already very important in the design stage. Under the given specific transit conditions the size of this coefficient depends the pressure loss in a pipeline. On the basis of value of pressure loss the proper dimension of pipeline is determined and—when pipeline is equipped with compressor stations—the compression work needed for the elimination of pressure loss, and thus determined the necessary working power installed at compressor stations. Considering the high cost of construction of the pipelines and the compressor stations it is clear, how important is to determine the necessary pipeline dimension and working power at the compressor stations correctly.

Knowing the value of the friction factor for individual sections of pipeline is also very useful for already operating pipelines. Value and especially changes in the value of the coefficient can show the status of the internal pipe surface and its changes, for example in connection with regular determination of operating effectiveness performed during pipeline cleaning. During regular operating cleaning of pipeline relatively large quantities of gas are irreversibly lost by blowing into the atmosphere when pig is rolling into the trap. This is the reason for minimizing frequency of cleaning to actual needs that are currently indicated by an increase of friction coefficient over the allowable limit.

The results of measurements of hydraulic parameters of pipeline in operation can determine the probable value of friction coefficient for newly designed pipelines and it may allow an estimation of changes in hydraulic behaviour of the pipeline after its commissioning. This knowledge significantly affects reliability of determination of required compression work and resulting amount of installed capacity.

Knowledge of the real values of hydraulic resistance of individual lines makes considerably more accurate the modelling of the operation which is crucial for the trade with free capacity at high-pressure pipelines.

The principle of measurement of hydraulic parameters during operation

For determination of the friction factor during operation of a gas pipeline is used the method developed by employees of CEPS specifically for this purpose, which is based on physical measurements of all parameters of the basic flow equation. Flow equation expresses the relation between pressure loss of gas pipeline and flow of gas, pipeline length and diameter, status and physico-chemical parameters of transported gas and hydraulic properties of gas pipeline.

Measurements shall be made in a stationary or quasi-stationary mode of operation of gas pipeline at sections with lengths from 10 km to 100 km. Within the measured sections of the pipeline there should not be branch pipes or interconnections with other pipelines.

The friction factor (λ) is set as follows

$$\lambda = 3.709502 \cdot 10^{-7} \cdot \frac{D \cdot z_{\Delta S}}{\rho_0} \frac{T_S}{P_S^2} \frac{\tau^2}{L^3} \cdot (P_1^2 - P_2^2)$$

Pressure at the end of measured section (P_1, P_2 [MPa]) is read by electronic recorders with an accuracy of 0.05% and reproducibility of measured value 0.01%. Gas temperature (T [K]) is measured by electronic sensors with an accuracy of ±0.1 K either in thermometer pockets on pipeline by submersible sensor or contact sensor of same accuracy at the above-ground part of pipeline which has the same temperature as the flowing gas. The measured values are stored in an optional interval, usually every 3 minutes.

Data regarding length of sections (L [km]) and altitudes of endpoints needed to correct the hydrostatic pressure difference at the end, are taken from the operator's documentation.

Diameter of pipes (D [mm]) and its tolerance are established on the basis of technical and delivery conditions made between the customer and a supplier of pipes for construction.

Gas velocity is measured indirectly by setting the flow time (τ [s]) of indicated gas volume within measured section. At the beginning of the section for marking injection of hydrogen gas into the pipeline is carried out and at the end of the section is removed from the gas flow a sample gas through a special detection device based on heat-conductive detector (TCD). The amount of hydrogen which is used for marking is so small that it has no impact on combustion characteristics of transited gas but due to that must be detection device more sensitive. The detector was therefore developed for this measuring and optimized especially in terms of stability of the zero signal level.

The values of gas density under standard conditions (ρ_0 [kg/m³]) and compressibility factor under the operating conditions (z) and normal conditions (z_0) are calculated with sufficient precision in standard thermodynamic relations on the basis of gas composition. The gas composition is defined from the chromatographic analysis conducted on the compressor (measuring) station adjacent to measured section, taking into account the time of the gas flow between the point of carrying out the analysis of gas and the place to measure the friction coefficient. If in the flow of gas is not any measuring station from which could be the value of the composition taken so the gas sample is taken during the measurement for the separate chromatographic analysis.

Reproducibility of measurement

This measuring method was already used on more than 1500 kilometres of high-pressure gas pipelines in sizes from DN 800 to DN 1400. Each measurement is performed several times and reproducibility of results is better than 3% which is more accurate than using data from common operating meters.

Time series that were formed after several years of measurements of hydraulic parameters of various lines allowed the evaluation of the development of pipeline hydraulics during operation and to put more precise data for designing of new lines.

CEPS *a. s.*
Belnická 628
252 42 Jesenice
Czech Republic

Tel. +420 241 021 511
Fax +420 241 021 512
E-mail ceps@ceps-as.cz
www.ceps-as.cz