Analysis of phenomena occurring in hydrogen compressors operating in variable working conditions as a result of changes in the composition of the transport medium

Anthropogenic global warming has become one of the most frequent topics of public debate in recent years. Numerous studies have shown that a significant increase in the concentration of carbon dioxide (CO_2) in the atmosphere is caused by human activity. Therefore, steps have been taken to reduce its emissions. The use of hydrogen was indicated as one of the most important elements of the economy which CO_2 zero emissions. This element has a huge potential to replace fossil fuels in energy and transport particularly in sectors where the replacement of oil, gas or coal is difficult.

The aim of the project is to analyze the impact of the hydrogen content in natural gas on the process of transport via pipelines. Hydrogen transport by pipelines is the most effective method in the case of high demand for this element. Within the scope of the project, the process of mixture compression in centrifugal gas compressors will be analyzed. The flow paths of typical methane compressors will be simulated by numerical fluid dynamics (CFD) methods. Maximum levels of hydrogen admixture will be determined, which do not require change in construction of the compressors. Moreover, the influence of hydrogen on parameters such as efficiency, power and flow capacities of compression devices will be determined. The results of numerical simulations will also be compared with modeling using classical one-dimensional methods taking into account loss correlations. In the case of mixtures where the hydrogen content is higher than a certain maximum, new compressor flow paths will be proposed along with the guidelines for their design.

As part of the project, flow simulations with the use of commercial software will be carried out. The impellers will be analyzed in terms of computational correctness. On its basis, the relationships describing the change in the amount of hydrogen relative to methane and the impact of this change on the operation of the impeller will be studied. The presented performance maps of the compressor stage for different percentages of hydrogen in the mixture composition will enable the determination of the operating area of the device.

The obtained results will be processed with the use of updated calculation scripts. This will allow for the development of a universal tool allowing for quick verification of one-dimensional calculations against numerical calculations for hydrogen compressors. Thanks to this approach, the design process will be significantly improved and the scope of the computational work that can be performed will expand.

As a result of the work, dependencies describing the effect of changing the amount of hydrogen in the composition of the mixture will be created. The efficiency of the hydrogen compressor stage will be regarded as a particularly important parameter. The relationship will also be developed to determine the structural loads on the impeller, which will determine the possible application areas of the machine. The project will also allow to determine the achieved parameters of compressors in the event of a change in gas composition in the pipeline. Ultimately, it will be possible to determine with how much change of composition the smooth operation of the gas pipelines will be possible.