DESCRIPTION FOR THE GENERAL PUBLIC

Cavitation is a process of forming and collapsing vapour bubbles in liquid flow. The formation and growth of vapour bubbles proceeds in low pressure region. Next they flow into higher pressure region and they sudden collapse occurs. This collapse can be described analogous to shocks in mechanical systems. It causes great pressure and temperature augmentation at the bubble centre. The pressure wave is generated and it propagates through the flow. It is a source of high frequency noise which is one of the cavitation signs. The others are vibrations and erosion of solid surfaces near cavitation structures collapse. It is common phenomenon that can be met during power machines exploitation such as water turbines and pumps. As the effects of cavitation are dangerous for machines and lead to shorten their lifetime it is essential to be able to predict cavitation occurrence and development. Nowadays the most popular methods of fluid system assessment are numerical simulations which can provide wide range of information about parameters distributions in the flow. There is a few mathematical models of cavitating flow behavior which are used in these simulation. However, as it is complex phenomenon including phase transition and rapid structures and parameters changes, they still need to be developed.

The aim of the project is to carry out both numerical and experimental investigation of cavitating flow in case of two geometrical arrangement: a Venturi nozzle and a hydrofoil. For the hydrofoil flows at different angle of attack are planned to be observed. The measurements will be performed in closed circuit with controlled flow parameters such as flow velocity and pressure. The concept of the extended test stand assumes a water loop with the heated container and vacuum installation. The course of the cavitation phenomenon will be recorded by using a fast camera and through the measurement of static pressure distributions. The dynamics of cavitation structures as well as their lengths and shapes will be described as the result of actual flow parameters. This will provide necessary knowledge for future prediction of most endangered region in power machines in regards to cavitation erosion. Also the air content in circuit water will be measured and its influence on cavitation structures is to be determined. The vibroacoustic measurements are planned to find the relation between cavitation intensity and parameters of generated acoustic waves. Noise is one of the symptoms of cavitation occurrence and can be recorded easier than the other cavitation effects such as erosion and break of flow continuity. Air content in water can be used to control cavitation dynamics, as the additional gas in the flow increase pressure in the cavitation bubble and cushion the negative effects of bubble collapse. Therefore, the free air injection installation will be also designed and constructed. The experience gained during the project will control cavitation intensity by means of free air injection in the regions endangered by the cavitation erosion.

The other important aspect of the project is developing tools for complex multi-phase flow numerical analysis. This will include assessment of existing models utility in case of investigated cavitating flows regimes (flow in the nozzle and over the hydrofoil at different angle of attack). Moreover, the improvement of models are to be defined, especially considering additional air in the flow. In most models the influence of dissolved and free additional gas in the liquid is neglected so with the project framework they will be completed by this aspect. The selection of the turbulence modelling method for the two-phase system with vapour bubbles will be an essential part in the construction of the computational model. Different variants of the two-equation turbulence model will be applied in the analyses. The numerical model will be constructed in both ANSYS and OpenFOAM environment. Commercial codes such as ANSYS are common used in industry and academic environment. The OpenFOAM code is an open source type and makes it possible to use various integration schemes of conservation equations. The main objective in this scope, apart from improving the accuracy of simulation results, is to ensure stability of the computational process and shorten the computation time. It is also important that the proposed computational algorithm should be usable, i.e. that it should be useful in analyses of the flow system complex geometry.

Better understanding of processes responsible for cavitation appearance and development in the liquid flow, connection flow parameters with noise generated by bubbles collapse and investigation of the air phase influence on the cavitation structures will support efforts to extend a lifetime of power machine and to avoid machine failure. Such a broad approach to the study of cavitation phenomena was not developed so far. It is most important aspect of the project providing for its originality.