World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:10, No:04, 2016

Analytical, Numerical, and Experimental Research Approaches to Influence of Vibrations on Hydroelastic Processes in Centrifugal Pumps

Authors : Dinara F. Gaynutdinova, Vladimir Ya Modorsky, Nikolay A. Shevelev

Abstract : The problem under research is that of unpredictable modes occurring in two-stage centrifugal hydraulic pump as a result of hydraulic processes caused by vibrations of structural components. Numerical, analytical and experimental approaches are considered. A hypothesis was developed that the problem of unpredictable pressure decrease at the second stage of centrifugal pumps is caused by cavitation effects occurring upon vibration. The problem has been studied experimentally and theoretically as of today. The theoretical study was conducted numerically and analytically. Hydroelastic processes in dynamic “liquid – deformed structure” system were numerically modelled and analysed. Using ANSYS CFX program engineering analysis complex and computing capacity of a supercomputer the cavitation parameters were established to depend on vibration parameters. An influence domain of amplitudes and vibration frequencies on concentration of cavitation bubbles was formulated. The obtained numerical solution was verified using CFM program package developed in PNRPU. The package is based on a differential equation system in hyperbolic and elliptic partial derivatives. The system is solved by using one of finite-difference method options – the particle-in-cell method. The method defines the problem solution algorithm. The obtained numerical solution was verified analytically by model problem calculations with the use of known analytical solutions of in-pipe piston movement and cantilever rod end face impact. An infrastructure consisting of an experimental fast hydro-dynamic processes research installation and a supercomputer connected by a high-speed network, was created to verify the obtained numerical solutions. Physical experiments included measurement, record, processing and analysis of data for fast processes research by using National Instrument signals measurement system and Lab View software. The model chamber end face oscillated during physical experiments and, thus, loaded the hydraulic volume. The loading frequency varied from 0 to 5 kHz. The length of the operating chamber varied from 0.4 to 1.0 m. Additional loads weighed from 2 to 10 kg. The liquid column varied from 0.4 to 1 m high. Liquid pressure history was registered. The experiment showed dependence of forced system oscillation amplitude on loading frequency at various values: operating chamber geometrical dimensions, liquid column height and structure weight. Maximum pressure oscillation (in the basic variant) amplitudes were discovered at loading frequencies of approximately 1,5 kHz. These results match the analytical and numerical solutions in ANSYS and CFM.

Keywords : computing experiment, hydroelasticity, physical experiment, vibration
Conference Title : ICCFDM 2016 : International Conference on Computational Fluid Dynamics and Mechanics
Conference Location : Venice, Italy
Conference Dates : April 11-12, 2016

Open Science Index, Aerospace and Mechanical Engineering Vol:10, No:04, 2016 publications.waset.org/abstracts/45113.pdf