INFLUENCE OF THE WHIRL MOTION ON THE CAVITATION INDUCED INSTABILITIES IN AN INDUCER FOR SPACE APPLICATION

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Long Abstract

Introduction

Propellant feed turbopumps represent one of the most crucial components of all primary propulsion concepts powered by liquid propellant rocket engines because of the severe limitations associated with the design of high power density, dynamically stable machines capable of meeting the extremely demanding suction, pumping and reliability requirements of space transportation systems. Cavitation is the major source of degradation of the suction performance, reliability, power density and useful life of this kind of turbopumps, and the cause of other equally undesirable effects such as the reduction of the overall efficiency and the drastic increase of the noise level. Cavitation can also provide the necessary flow excitation, compliance and load-dependence for triggering dangerous rotordynamic and/or fluid mechanic instabilities. The combined effects of rotordynamic fluid forces and cavitation represent the dominant fluid mechanical phenomena that adversely affect the dynamic stability and pumping performance of these turbopumps. The most critical rotordynamic instability is the development of self-sustained lateral motions (whirl) of the impeller under the action of destabilizing forces of mechanical or fluid dynamic origin.

1. Methods

The Cavitating Pump Rotordynamic Test Facility (CPRTF) at ALTA S.p.A. is a versatile and easily instrumentable facility operating in water, at temperatures up to 90 °C. The facility can readily be adapted to conduct experimental investigations on virtually any kind of fluid dynamic phenomena relevant to high performance turbopumps. The CPRTF has been especially designed for the analysis of unsteady flow phenomena and rotordynamic impeller forces in scaled cavitation tests under fluid dynamic and thermal cavitation similarity conditions. The test section can be equipped with a rotating dynamometer, for the measurement of the instantaneous forces and moments acting on the impeller, and with a mechanism capable of adjusting the eccentricity of the impeller axis. The inlet section allows for multilateral optical access to the inducer flow and can be instrumented with several flush-mounted piezoelectric pressure transducers, located at different axial stations.

The present paper will investigate the effect of the whirling motion on the pumping and suction performance of the pump. The typical cavitating performance plots will be obtained at several values of the whirl motion.

Moreover, during the cavitating tests performed by progressively reducing the inlet pressure, the rotordynamic forces will be measured and compared to the classical spectral analysis of the cavitation-induced instabilities typically summarized in the well-known waterfall plots. This approach will permit to identify the influence of the whirl motion on the cavitation-induced instabilities.

Figure 1. The cavitating pump rotordynamic test facility

References

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