Effect of accumulators on cavitation surge in hydraulic systems.

[1]Donghyuk Kang, Department of Mechanical engineering, University of Aoyama Gakuin, Kanagawa, Japan
[2]Satoshi Yamazaki, Department of Mechanical engineering, University of Aoyama Gakuin, Kanagawa, Japan
[3]Shusaku Kagawa, Fluid Machinery @ Systems Company, EBARA Corporation, Chiba, Japan
[4]Byungjin An, Fluid Machinery @ Systems Company, EBARA Corporation, Chiba, Japan
[5]Motohiko Nohmi, Fluid Machinery @ Systems Company, EBARA Corporation, Chiba, Japan
[6]Kazuhiko Yokota, Department of Mechanical engineering, University of Aoyama Gakuin, Kanagawa, Japan

Long Abstract

Introduction

Recently, the authors observed cavitation surge with vibration and a periodic chugging noise in a double-suction centrifugal pump [1]. Since cavitation surge is caused by the mutual interference between cavitation and hydraulic systems [2], an installation of an accumulator in hydraulic systems is planned for suppression of cavitation surge.

To predict the effect of accumulators on cavitation surge, the authors performed the stability analysis of cavitation surge with respect to two hydraulic systems. All systems consisted of an upstream tank, an upstream pipe, a cavitating pump, a downstream pipe and a downstream tank. The first system has the accumulator installed at the upstream of a cavitating pump. The other has the accumulator installed at the downstream of a cavitating pump.

1. Methods

The dynamic of hydraulic systems were treated in terms of lumped-parameter models [3] which simplifies the description of the physical effects between two measuring points. The lump-parameter model is usally considered valid when the dimensions of a hydralic system are shorter than the acoustic wave length at the considered frequency.

The equations for upstream and downstream pipes were introduced by the unsteady continuity and energy equations. The change of cavity volume was considered to be functions of the upstream cavitation number and the upstream flow coefficient. The unsteady total pressure rise supplied from the cavitating pump was expressed as the functions of the discharge flow rate and the upstream cavitation number.

The accumulator was modeled by using the momentum equation with the mass and damping, and stiffness coefficients. The mass, damping and stiffness coefficients correspond to the pipe length between the accumulator and the main pipe, the resistance of valve and the compliance of fluid in the accumulator, respectively.

From above equations, we obtained the homogeneous linear equations with the complex angular frequencies with the angular frequency and the damping rate. For the negative damping rate, the infinitesimal amplitude grows, which means cavitation surge. The zero damping rate indicates the boundary of cavitation surge.

2. Results

Figure 1 shows the stability map of cavitation surge for valve resistances λ_u corresponding to the ratio of the valve opening of the accumulation installed at the upstream of a cavitating pump. The horizontal and vertical axes show mass flow gain factor and cavitation compliance, respectively. The upper and lower regions of the lines indicate the stable and unstable regions of cavitation surge, respectively. The result shows that the onset condition of cavitation surge indicates the positive slope. That is, the increase of cavitation compliance has the stabilizing effect and the increase of mass flow gain factor causes cavitation surge. Point A is located in the region of cavitation surge without the accumulator and for λ_u =0.5, but in the stable region for λ_u =5 and λ_u =50. This shows that the valve resistance larger than a certain value has the stablizing effect in the hydraulic system.

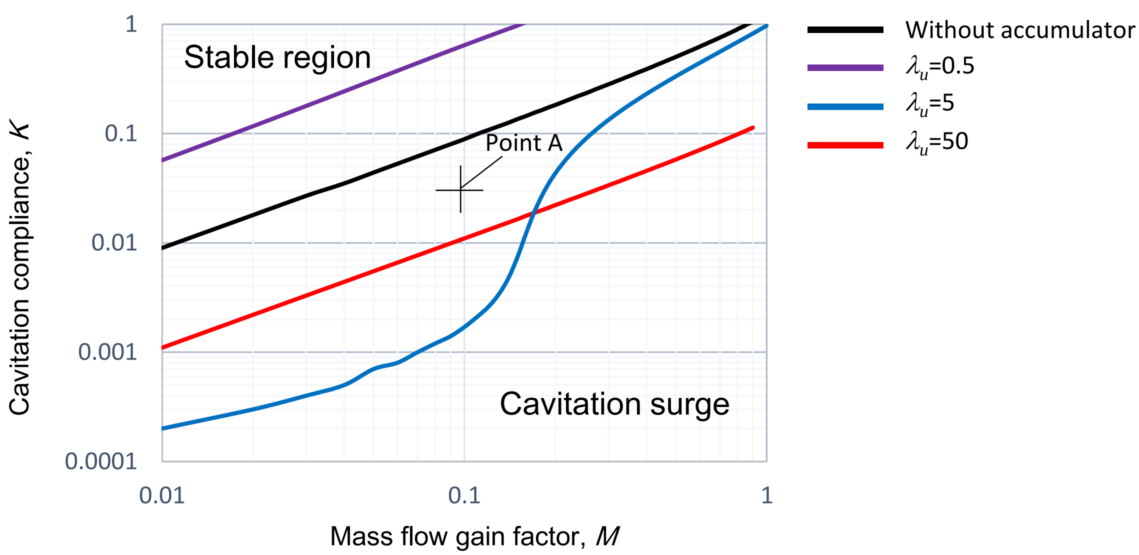

Figure 1. Stability map for valve resistances

References

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