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Self-optimisation of pumping modules with hydrodynamic interaction

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Summary

Since the hydrodynamic design of modern pumps has reached a high level, the adequate sizing and use of a pump (or the control of rotational speed) is considered to be the most effective way to reduce energy consumption. The recent trend to achieve significant energy savings is a system approach, in which the whole fluid system consisting of several pumps is to be optimized through the rotational speed adaptation of each pump. The advantages of hydrodynamic interaction of the pumps in the fluid system are still unknown and thus unexploited.

In this work the possibility of optimizing the pumping performance by rotational speed adaptation will be illustrated by the example of a pumping unit consisting of a volute casing pump with a radial impeller ($n_s = 20 \text{ min}^{-1}$) and a pumping module with an axial impeller ($n_s = 180 \text{ min}^{-1}$) positioned upstream (hydrodynamic interaction). Each impeller should adjust its rotational speed to the pumping task in a way that the total power input of the pumping unit is minimal, while cavitation and unfavourable partial load is to be avoided in both impellers (self optimisation). Experimental investigations are carried out and some hypotheses on the hydrodynamic interaction of the pumping modules are presented.

The autonomous speed regulation of each impeller requires an independent actuation and also the determination of the operation conditions of each pump module by sensors and appropriate software. In order to reduce the measuring expenditure and thus to increase the industrial acceptance of the system, the operation data required for determination and self optimisation of the operating condition of the modules and the whole unit are obtained by correlations to other physical quantities (mostly pressure signals) which are easier and cheaper to acquire. The appropriate positioning and accuracy of pressure measurements for flow rate identification within the pump are determined by theoretical, numerical and experimental investigations and presented in this work.