Multidisciplinary and parallel optimization of the runner blade of an axial turbine

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Abstract. The results of three optimization runs of an axial turbine's runner blade are compared with each other. In the first optimization run, only the efficiency is optimized. In the second run the minimization of the cavitation volume is added as an objective, while in the third run, additionally, structural mechanical aspects are taken into account. Three operating points are simulated during the optimization process. The results of the first two runs show an increased efficiency at full load and a decreased efficiency at part load if cavitation volume is minimized. Taking structural mechanics stress limits into account the efficiency at all operating points is reduced, especially at part load. Furthermore, the cavitation volume tends to increase at full load. Nevertheless, the permissible stress is not maintained by any of the best individuals of the optimization runs without taking into account structural mechanics stress limits. This points out the importance of simultaneously considering both structural as well as fluid mechanical aspects in the optimization process of a hydraulic machine.

1. Introduction

For the design process of hydraulic machines it is important to consider different objectives such as efficiency and cavitation. At the same time, there are also constraints such as the design head. In addition, the consideration of structural mechanical aspects, i.e. material dependent stress limits, is essential. The reason for this is that certain parameters of a geometry may have opposing requirements. A simultaneous structural and fluid-mechanical optimization eliminates the time-consuming iterations between the departments and thereby reduces the design cost. Furthermore, through the direct interaction between the disciplines it is possible to obtain innovative designs that would not be found using a conventional design process [1].

The aim of this work is to investigate the influence of minimizing the cavitation volume as well as maintaining a permissible stress on the optimization results of a hydraulic machine. Therefore, the results of three optimization runs of an axial turbine's runner blade are compared with each other. The first run includes only the efficiency as quantity to be optimized. In the second run, the minimization of the cavitation volume is added as an objective while in the third, the maintenance of a permissible stress is additionally included as a constraint. The optimization of only a runner blade is well suited to investigate different optimization strategies due to the lower numerical effort compared to an entire hydraulic machine. Nevertheless, the optimization problem is realistic enough to produce reliable results. Three operating points are simulated during the optimization process. This creates an additional challenge, as a good design must have low cavitation combined with high efficiency for all operating points while maintaining