Experimental Investigation on the Performance of a Vortex Pump using Winglets

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Long Abstract

Introduction

Vortex pumps can impel fluids that contain solid and fibrous materials with a minimized risk of clogging. A semi-open impeller and a large volute width at its front chamber characterize vortex pumps, whose operating principle is assumed to be by a vortex that is formed in the front chamber. Compared to conventional centrifugal pumps, the efficiency of vortex pumps is overall low. Not surprisingly, many attempts have been made to improve the efficiency of vortex pumps. One attempt is to add winglets to the blade tip. This addition separates a large part of the impeller channel from the front chamber of the pump. The resulting design resembles a front shroud (compare Figure 1).

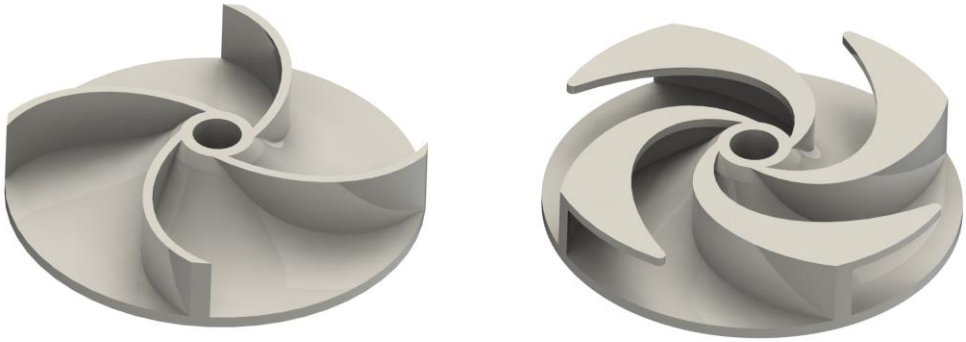

Figure 1. Schematic View of the Impellers of a Vortex Pump without Winglets (left) and with Winglets (right)

The publicly available literature on how winglets affect performance is contradictory. On the one hand, *Cervinka* investigated the operation of winglets using a numerical model that compared an impeller with winglets to a geometrically similar impeller without winglets [1]. He concluded that an impeller with winglets deteriorates the pump characteristic as well as its efficiency. On the other hand, *Dalian et al.* [2] and *Rongsheng et al.* [3] presented numerical studies on how winglets influence the pump characteristic. The authors examined one impeller without winglets and compared it to two other geometrically similar impellers with different winglet depths respectively. In both cases increased winglet depths lead to an increased pump head and efficiency. These results are further bolstered by commercially available vortex pumps whose added winglets supposedly prevent back flows on the blade top and improve the pump characteristic [4].

The above points show that there are inconsistencies in relation to the use of winglets at vortex pumps. This raises the question whether winglets lead to an improvement of the pump performance or not. Further, it is unclear how winglets affect the NPSH-characteristics. Therefore, this paper examines experimentally the influence of winglets on the pump characteristics including the NPSH behaviour.

1. Methods

For a first test series three different impellers were investigated on a closed test rig design (according to ISO 9906): A semi-open impeller, an impeller with winglets and an impeller with a front shroud. The latter allowed the question to be examined, whether there was an upper limit to the depth of the winglets and how the winglets influence the potential vortex in the front chamber. All other geometric parameters of the impeller and the housing remained unchanged for all measurements. The performance curve, the aggregated efficiency and power consumption were measured.
For a second set of impellers, different in blade depth to the first set tested, the NPSH behaviour was investigated in addition to the performance curve and efficiency. This set of impellers contains one impeller without winglets, one impeller with winglets and one impeller with winglets whose surface was very smooth compared to the others. By variation of the surface roughness it should be investigated to what extend the winglets lead to a carrier effect similar to a rotating disc.

2. Results

The addition of winglets improved the head as well as the efficiency of the pump. The impeller with front shroud led to a similar characteristic but lower efficiency. The semi-open impeller was associated with a significantly lower efficiency and the head decreased considerably. Thus, it is unclear whether a vortex pump works with a vortex in the front side chamber, or rather similar to a conventional centrifugal pump with a large gap. These results indicate a mixture of the two mentioned working principles.
For the second set of impellers the NPSH-characteristic was investigated. The measurements show that the $NPSH_{3\%}$ values of an impeller without winglets are similar to an impeller with winglets.
Thus winglets clearly exert a positive influence on the performance of vortex pumps.

References

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