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Simplified CFD model for flow field investigations at no-load conditions

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Abstract

In a more and more dynamic energy market, pump-turbines play an important role due to their flexibility and fast start up procedure. This is however depending on the time needed for synchronization of the machine with the electricity grid, which should be, following the wish of the turbine operators, as short as possible.

During the start up procedure, more precisely close to the no-load (or runaway) condition, it can happen that a system instability occurs, which involves the turbine and the whole hydraulic system (see for example Staubli, Dörfler and Martin). The instability leads to fluctuations in head, mass flow, torque and speed, thus delaying the synchronization process.

The flow physics involved in the phenomena leading to the instability are not yet well understood. In the last years, with increasing computational power availability, various numerical investigations have been performed in order to unveil the key mechanisms behind it (Staubli, Liang).

The usual approach is by computing the complete machine, from spiral inlet to draft tube outlet. Recent attempts have shown that a reduced 360° model (stay vanes – guide vanes – runner – outlet diffuser) can lead to satisfactory results (Liang).

However, both approaches are still too time consuming to be included as standard analysis in the design process. From the investigations it could be found that the most important phenomena occur in the vaneless space between guide vanes and runner and/or in the runner itself. The flow field in these regions is unsteady and chaotic, with different vortex systems interacting with each other. However, upstream of the guide vanes little influence of the disordered flow is detected.

In this paper an even more simplified CFD model will be assessed, reducing the computational domain to a single runner passage.

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