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IMPROVEMENT IN PERFORMANCE PARAMETERS BY SHAPE OPTIMIZATION OF A CONICAL FLOW AROUND DIFFUSER

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Abstract. Diffusers are mounted downstream of turbine runners, converting the remaining kinetic energy into pressure by decelerating the flow which leads to an increasing efficiency in turn. The flow rate of the medium passing through the turbine is influenced by the diffusers geometry, so geometrical restrictions must be observed to avoid adverse flow phenomena. Those ones even affect the operation negatively and cause pressure fluctuations that might crack the construction, if resistance tolerances are exceeded.
Therefore, this paper aims to develop a fully automated shape design optimization of a 3D conical flow around diffuser with fixed main dimensions surrounded by turbulent incompressible flow. The optimization process is based on *OpenFOAM-1.6-ext* in combination with a metamodel assisted evolutionary algorithm (*MAEA*) [1, 2], implemented in the optimizer *EASY* [3].

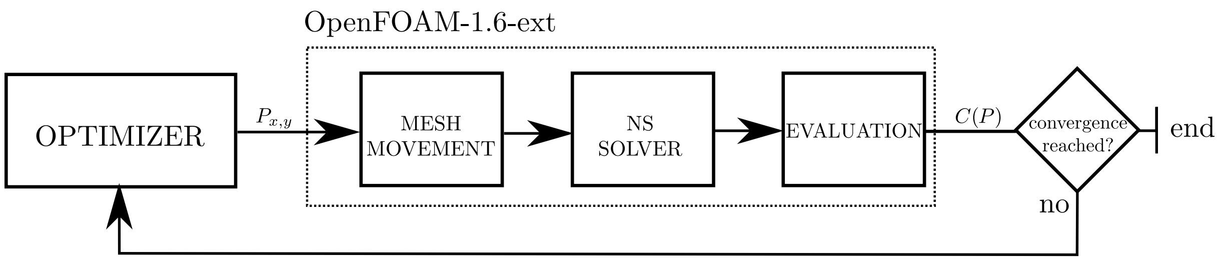

Figure 1: Simplified optimization process: After passing the costfunction obtained by the computation back to the optimizer, new x, y coordinates of all control points P are forwarded to the mesh deformation solver

For the parametrized boundary mesh movement a mesh motion solver based on Laplacian smoothing is applied. A variable diffusivity is prescribed during deformation to keep the distortions in the boundary region low. The simplified optimization process is given in Fig **??**.

Focusing on typical inflow conditions obtained at the runner outlet of a hydrokinetic turbine, flow behavior in the diffuser are carried out and integral performance parameters of the diffuser are evaluated in order to draw conclusions about the diffusers efficiency. During optimization, typical cost functions are considered, describing the corresponding operation of the diffuser. Since the investigated diffuser is mounted in a free surface flow, the hydrostatic pressure is taken into account as well. The inner and outer contours of the conical flow around diffuser wall are each independently parameterized with a smooth *Bézier*-Spline of 4^{th}-order. The effect of a shock diffuser mounted downstream on the flow behavior and performance parameters as well are carried out. On the one hand, its contour is parametrized with a polynomial of 2^{nd}-order initiating a discontinuous transition, as can be seen in Fig. **??**(bottom). On the other hand, the contour is defined by a *Bézier*-Spline of 4^{th}-order causing smooth contour shapes, see Fig. **??**(top). In order to capture the fairly strong curved swirling flow, a modified k-ω-SST model with streamline-curvature correction [4] is applied, which is validated by comparison with data from [5]. By varying the Reynolds- and the Swirl-Number at the diffuser inlet, different wall shapes are obtained as a function of the specific flow quantities. Results are additionally compared with commercial code.

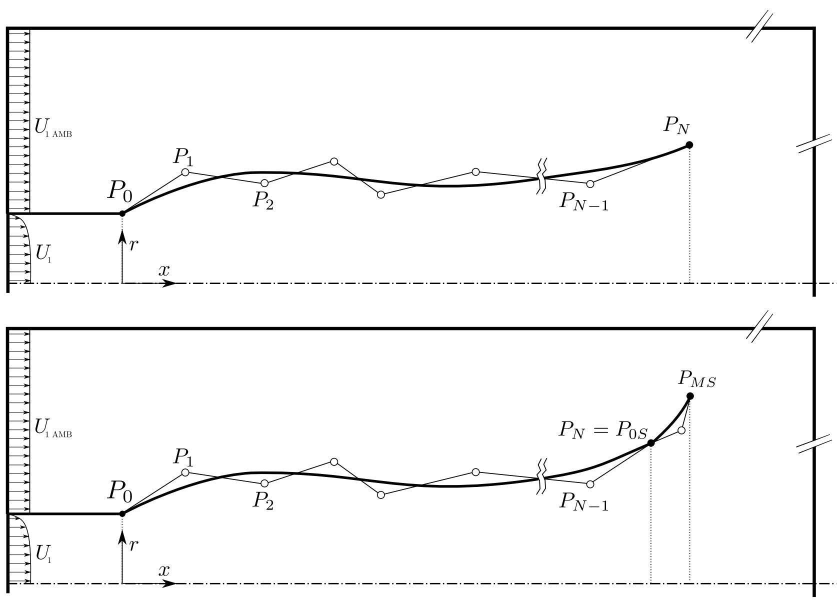

Figure 2: Interior Diffuser boundary with a *Bézier*-Spline Parametrization of N-order (top) or with an additional *Bézier*-Spline Parametrization of M-order for considering an installed shock diffuser (bottom); (dashed) evaluation plane

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