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New adjoint optimization framework applied to a squirrel cage fan using OpenFoam

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ABSTRACT

Turbomachines play an important role in various sectors, including aviation, power generation, maritime, oil and gas, heating, ventilation, air conditioning (HVAC), and chemical processing. The squirrel cage fan is among the most common types of turbomachines and is considered in the present study for the air extraction in bathrooms. This fan model consumes substantial amounts of energy and generate unwanted noise, and has an impact on environmental and human well-being. The optimization of the squirrel cage fan using efficient approaches is essential. This study presents an automatic multi-objective optimization framework based on the adjoint method. The framework is built based on open-source tools, such as Salome (CAD and mesh generators), OpenFOAM v2206 (CFD solver) coupled to Python and bash scripts. The sensitivity is calculated using a new developed fully turbulent continuous adjoint solver in OpenFOAM v2206. Two objective functions, namely, aeraulic and mechanical powers are calculated. The objective of the following study is to maximize and minimize the aeraulic and mechanical powers, respectively. Reynolds-Averaged Navier-Stokes (RANS) equations closed with the k-ω SST model are used to simulate the turbulent flow in the squirrel cage fan. 2D sensitivity approach is developed to smooth the sensitivity over the 36 bladed rotor part of the squirrel cage fan. The new adjoint optimization framework allows to improve the aeraulic power by 2% and decrease the mechanical power by 1.5%.