Aerodynamic Optimization of Centrifugal Fans Using CFD-Trained Meta-Models

Due to their significant contribution to the total electricity consumption of the European Union (nearly 10%), future minimum efficiency requirements for fans driven by motors with an electric input power between 125 W and 500 kW are set by EU regulations. As a consequence many currently available fans on the EU market may no longer be sold and the need for efficient design and optimization methods arises. In the context of the current project we focus on centrifugal fans.

This project aims to build a general metamodel for the efficient prediction of centrifugal fan properties depending on the fan geometry. A metamodel is a computationally inexpensive „model of a model", that tries to approximate a computationally expensive simulation with high accuracy. Here computational fluid dynamics (CFD) simulations should be substituted by an artificial neural network (ANN). Through the usage of computationally inexpensive ANNs, extensive optimization runs become feasible for a variety of different operating points.

For the generation of accurate ANNs examples are needed, where geometry parameters of a fan are linked with the resulting aerodynamic properties. Through a so-called training algorithm, the ANN is able to learn the relationship between the inputs (fan geometry) and the outputs (e.g. pressure, efficiency) with the help of these examples, such that predictions can be made for any new fan geometry. The used examples for the training come from CFD simulations, that have been validated on a test bench for several fan geometries. Crucial steps, that have to be carried out before the generation of the ANNs, are:

- Assessment of important geometry parameters to be varied
- Determination of the boundaries for the chosen geometry parameters
- Providing a software environment for the automatic creation, execution and evaluation of CFD simulations

After the ANN generation is finished, no more CFD simulations are needed. Aerodynamic optimization based on the computationally inexpensive metamodel (for centrifugal fans) should be applicable to all typical design points of centrifugal fans according to Cordier's diagram. Results from the extensive optimization runs will show, if the recommended operating range for centrifugal fans - based on today's knowledge - can be extended. This may open the door for completely new, more efficient fan designs.

I Project Management and Execution

Management:
Univ.-Prof. Dr.-Ing. M.Sc. Thomas Carolus
Univ.-Prof. Dr.-Ing. Oliver Nelles

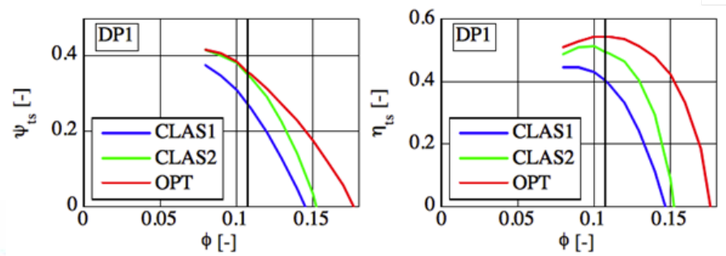
Contact:
Universität Siegen
Dept. Maschinenbau
Institut für Mechanik und Regelungstechnik - Mechatronik Paul-Bonatz-Straße 9-11
D-57076 Siegen

E-Mail: oliver.nelles@uni-siegen.de

Telefon: +49 (0) 271/740-4045
Fax: +49 (0) 271/740-2365

Fig. 1:
Test bench for the validation of the computational fluid dynamics (CFD) simulations.

Fig. 2:
Characteristic curves of two classical fan dimensioning methods (CLAS1 and CLAS2) compared to an optimized fan design (OPT). φ: Dimensionless volume flow, ψ: Dimensionless pressure, η: Efficiency.



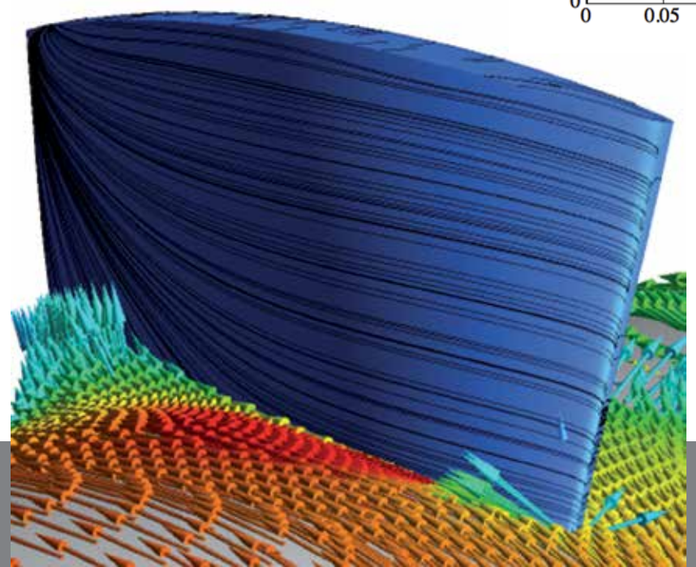


Fig. 3:
Computer simulation of the air flow around one blade of a centrifugal fan.