structural and fluid flow optimization of a radial turbine blower.

MULTIPHYSICS

CORE COMPETENCIES

1. Structural mechanics
2. Fluid flow engineering
3. Product optimization
4. Multi-physical analysis

Goal

Demcon macawi respiratory systems is a total solution provider of respiration technology. Their OEM blower modules are suitable for use in respiratory systems, anesthesia systems and other oxygen rich environments. A macawi module contains a.o. a radial turubine blower and a flow diffuser around it (Figure 1). The radial turbine blower is specially designed for high pressure efficiency combined with high flow capacity.

The radial turbine blower needed to be optimized for simple integration into the module, noise reduction and mechanical vibration absorption. Low rotary inertia is required for optimal responsiveness.

Simultaneously, the diffuser around the blower needed to be optimized for mixing air and oxygen, sufficient flowrates and have a good efficiency. An in depth multi-physical analysis was done to ensure all above mentioned requirements.

DEMCON | MULTIPHYSICS

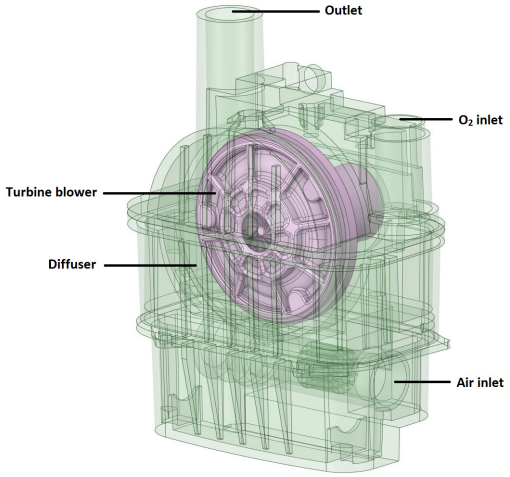

Figure 1 Turbine and diffuser in the macawi blower module.

Approach structural mechanics

A structural mechanical Finite Element Analysis (FEA) was performed on the turbine rotor. The analysis included the rotational effects to determine maximum stresses, deformations and possible unstable behavior during operation cycle (Figure 2). Making use of Campbell diagrams, representing the system's response as a function of its oscillation, a whirl speed map was created (Figure 4). Critical areas were identified, making sure that the critical speeds are well-damped.

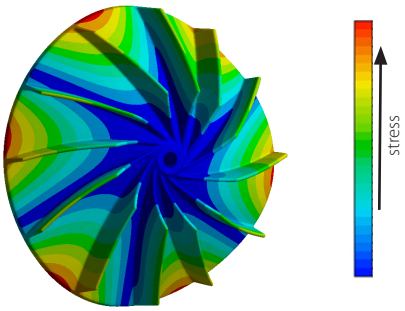

Figure 2 Stresses in the radial turbine during operation.

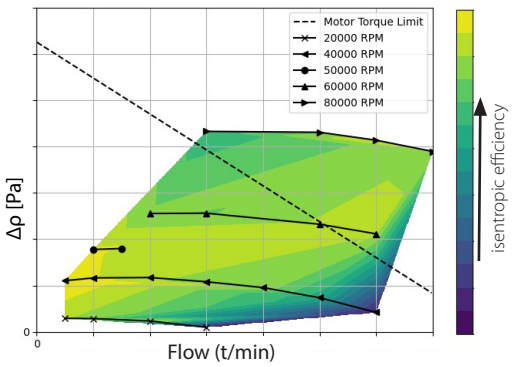

Figure 3 Performance map of turbine blower.

Approach fluid flow

Subsequently, Computational Fluid Dynamics (CFD) analysis was done on the module to calculate the velocity field, flowrates, pressure drops and air-oxygen mixing for several different designs of the diffuser. This led to an effective improvement of the design without the need for prototype testing in a laboratory. By cleverly rotating the outlet of the diffuser towards the oxygen inlet the mixing efficiency of the air-oxygen mixture was improved. Through CFD analysis at different operating conditions the performance map (Figure 3) of the turbine blower can be predicted and the best efficiency region was determined.

Results

From the FEA study, an optimized design of the turbine was achieved, ensuring producibility and preventing unstable behavior. The optimization of the turbine design led to a significantly prolonged product lifetime, providing our client with a substantial advantage.

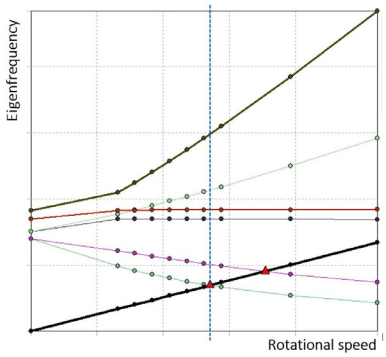

Figure 4 Whirl speed map of the radial turbine.

The CFD study yielded a diffuser design that achieved homogeneous mixing of gases at the outlet (shown in dark green in Figure 5). High efficiencies of the blower were attained at high rotational speeds. The patented technology of this dynamic blower module was successfully introduced to the market.

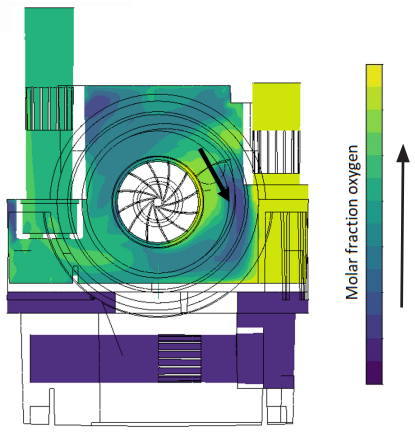

Figure 5 Molar fraction of oxygen in the turbine and diffuser.