Multiobjective Shape Design in a Ventilation System with a Preference-driven Surrogate-assisted Evolutionary Algorithm

The goal was to formulate and solve real world optimization problem of designing air intake system of tractor cabin. The method selected for solving the problem was surrogate assisted, preference based multiobjective optimization algorithm. The two main challenges were incorporating the decision maker's preferences into the process and that simulating air flow in air intake system requires computationally expensive CFD simulations. The extended K-RVEA method that could take into an account the decision makers preferences were proposed to handle these challenges.

The first task was to formulate the optimization problem, air intake system in question, had one air inlet and four air outlets. Ideally, when designing air ventilation systems, flow rates from all the outlets should be the same. However, since the outlets have different sizes and diameters, flow rates are usually bit different. Also, what needs to be taken into an account is that simultaneously when optimizing flow rates from different outlets, the pressure loss of whole ventilation system should be minimized because high pressure loss means low overall ventilation performance, which then means usage of larger and powerful fans might again increases the energy consumption of the ventilation system.

In real world optimization cases where in theory there usually exists countless objectives and decision variables, it is important to identify the most important objectives and variables which affect these objectives. In the paper selected objectives were:

- Minimize variance between flow rates at outlets 1 to 3
- Minimize static pressure loss of the air intake
- Minimize the difference between the flow rate at outlet 4 and the average of the flow rates at outlets 1 to 3

Selected decision variables were diameters of each outlet, and it was noticed during CFD simulations that placing two wedges inside the air intake system could improve the results and thus width, height and angle of each wedge presented six more decision variables.

K-RVEA algorithm is designed for problems with three or more computationally expensive objectives, thus making it suitable for solving this problem. However, algorithm needed to be extended so that it could consider the decision makers preferences. Since K-RVEA uses preference vectors, these vectors can be adjusted according to decision makers preferences.

Results indicate that the optimization process was successful. In the paper it was mentioned that also normal K-RVEA algorithm was tested but the extended version was able to find the solution with less function evaluations and also the solution with extended algorithm was in the area where decision maker had placed the references.