



HYDRO

**RADIAL FAN LAYOUT: TOWARDS AN AUTOMATED  
OPTIMIZED, FAST AND RELIABLE DESIGN**  
**D. LANGMAYR<sup>1</sup>, G. KANDLER<sup>2</sup>**

1: ANDRITZ HYDRO GmbH

2: Ansys Austria GmbH

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**ANDRITZ**

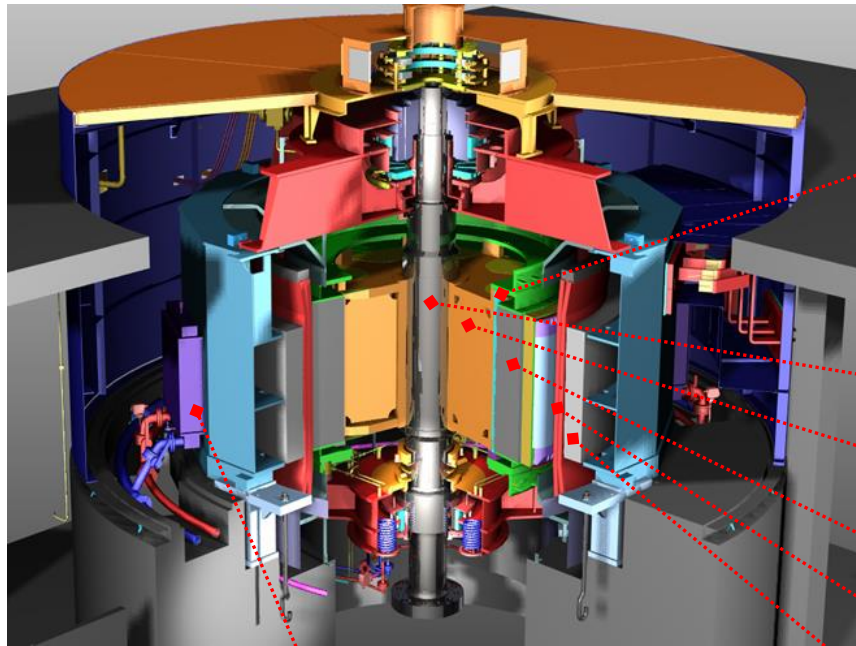
ENGINEERED SUCCESS

# OUTLINE



- Generator cooling
  - Air cooling of a hydro generator?
  - How much power needs to be dissipated?
- Design of radial fans
  - Current approach
- Optimization process
  - Strategy
  - Comparison executed projects
- WebApp

# RELEVANT COMPONENTS FOR AIR COOLING



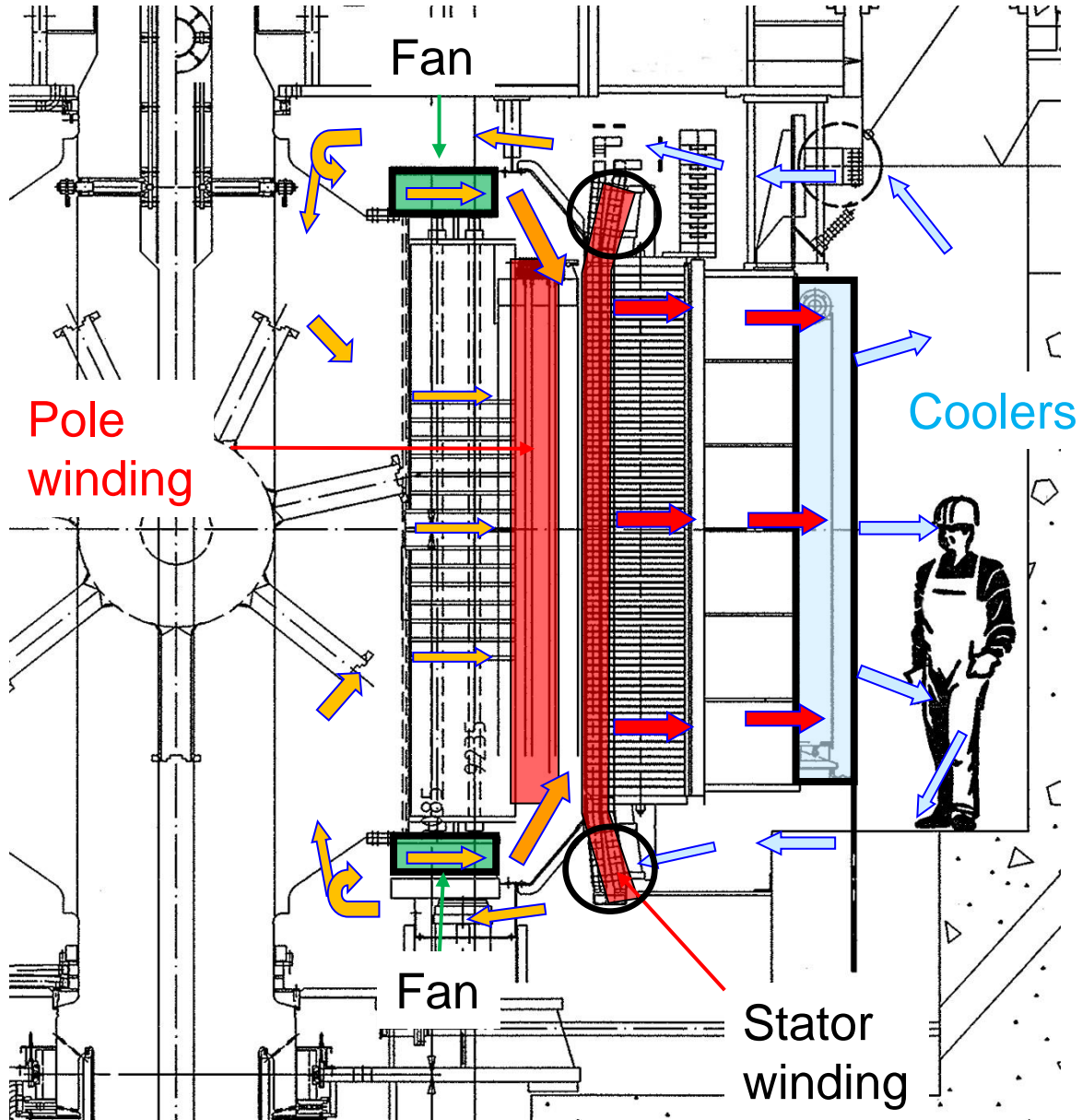
- Fan
- Shaft
- Rotor hub
- Poles
- Stator winding
- Stator core

Air-cooler



Generators can be very big ...

# COOLING AIR FLOW



In a closed ventilation circuit cold air enters the generator, and passes in general

- the endwinding Zone,
- the fans,
- the rimducts (if present),
- the interpolar space,
- the stator ventilation ducts,
- the coolers,
- and enters the generator again.

# DISSIPATED POWER



~2 Million mobile phones



21000 refrigerators



For large projects, cooling air has to dissipate a power loss of about 3 MW

30 cars



LMS Coronation Class



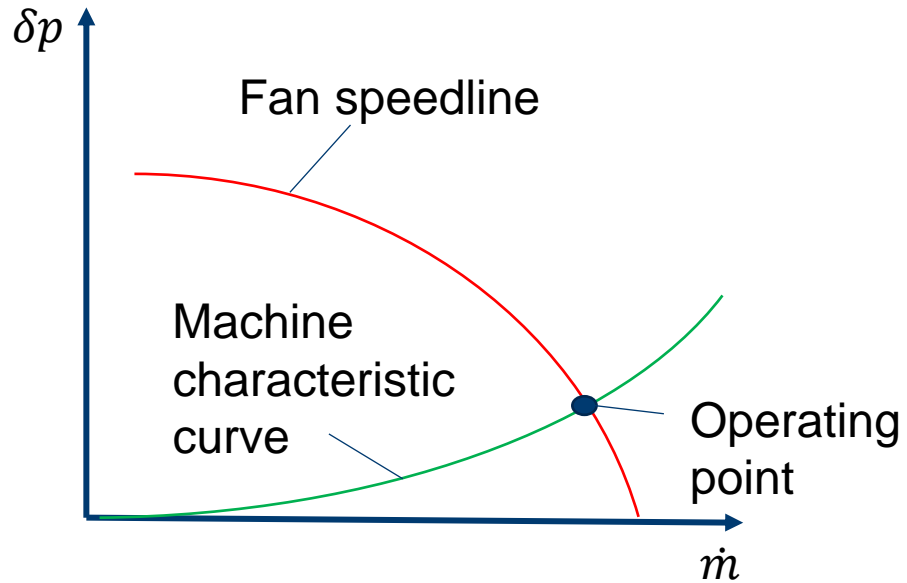
1 steam locomotive



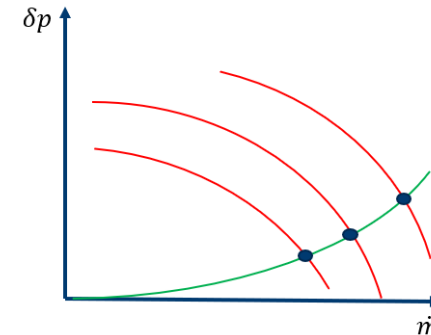
# VENTILATION LAYOUT



Cooling layout



- Ventilation calculations are done by different layout tools
- Operating point chosen so that all temperature requirements are met → Different fan geometries

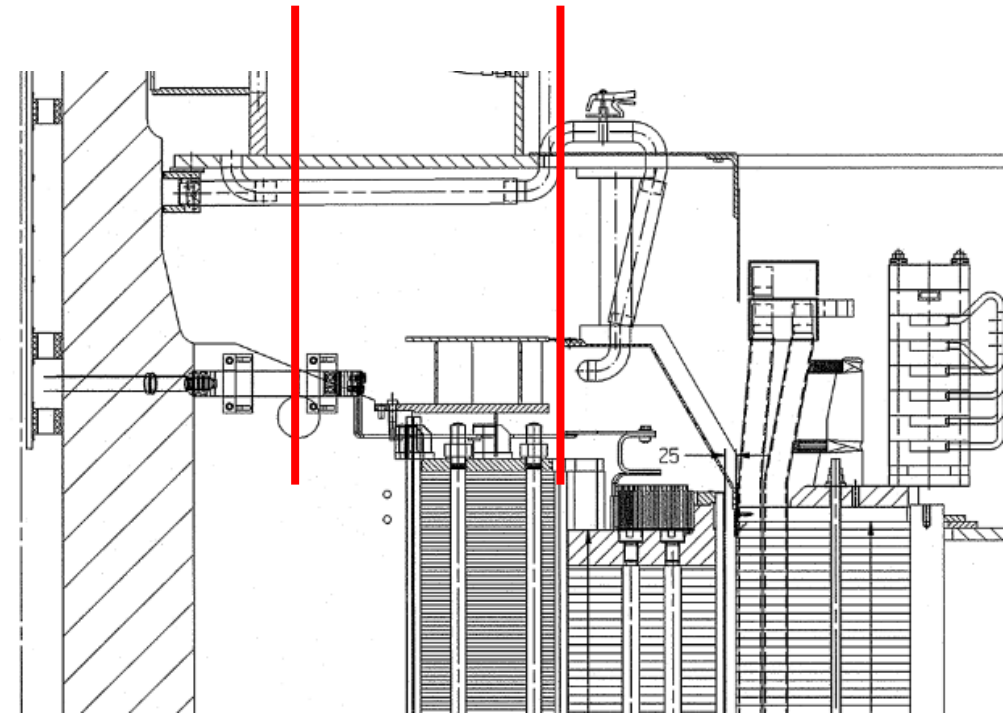
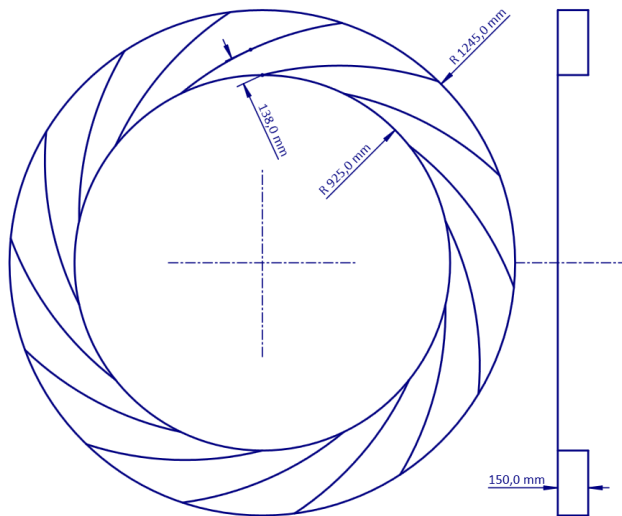


- Drawbacks:
  - Manual work necessary to get the desired pressure rise at the given flow rate
  - Different engineers will design different fans
  - Manual optimization requires effort

# OPTIMIZATION - PARAMETERS



- Fan Parameters:
  - Speed
  - Inner and outer fan radius
  - Leading and trailing edge blade angle
  - Blade height
  - **Number of blades**



Radius restricted by installations,  
pole dismantling, ...

# OPTIMIZATION - STRATEGY

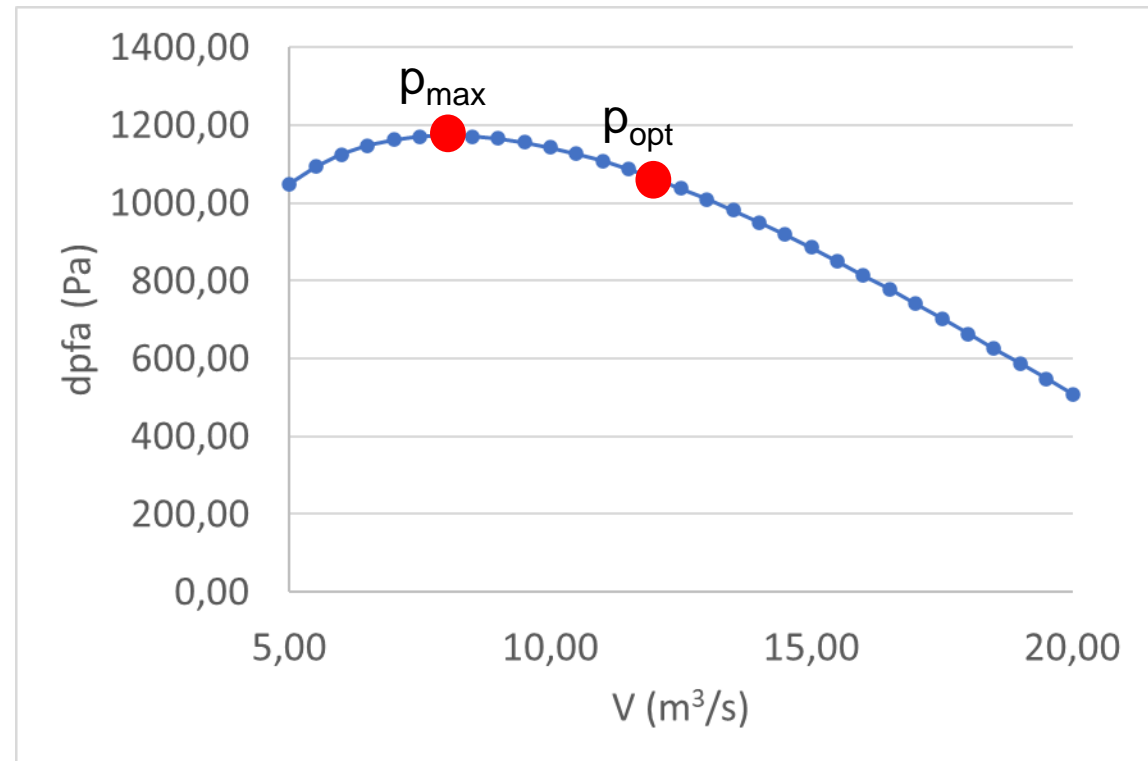


User has to define:

- Speed
- Min/Max limits for radius
- Design point

Optimization is done according to:

- $p_{opt} = 0.9 p_{max}$
- Pressure rise is in the range  
 $p_{def} < p_{opt} < 1.15 p_{def}$
- Volume flow rate in the range  
 $V_{def} < V_{opt} < 1.15 V_{def}$
- Losses  $\rightarrow$  MIN





# OPTIMIZATION - PROCESS



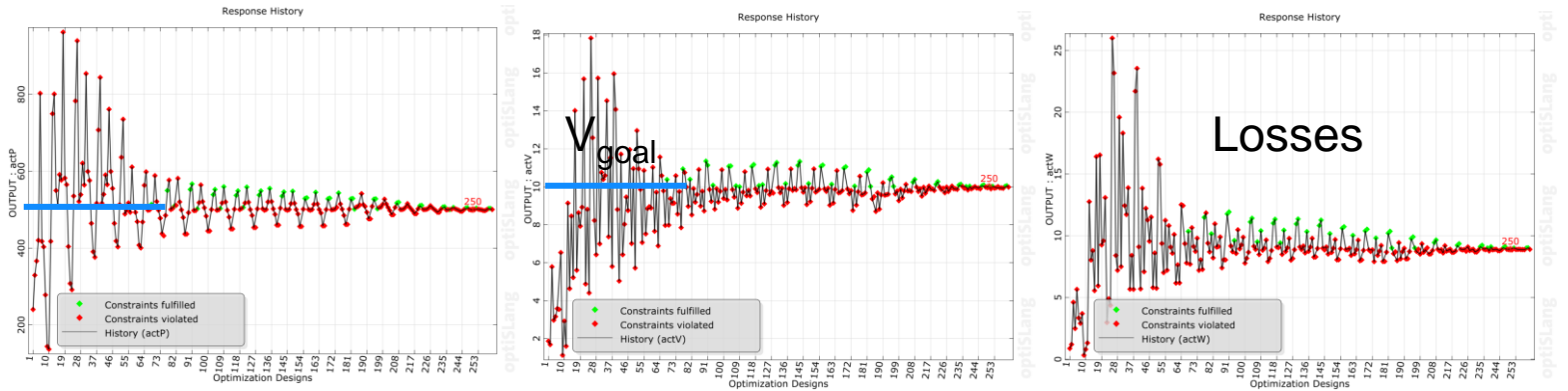
## Test Project Optimization

- Design point:
  - $dp = 500$  (Pa)
  - $V = 10$  ( $m^3/s$ )

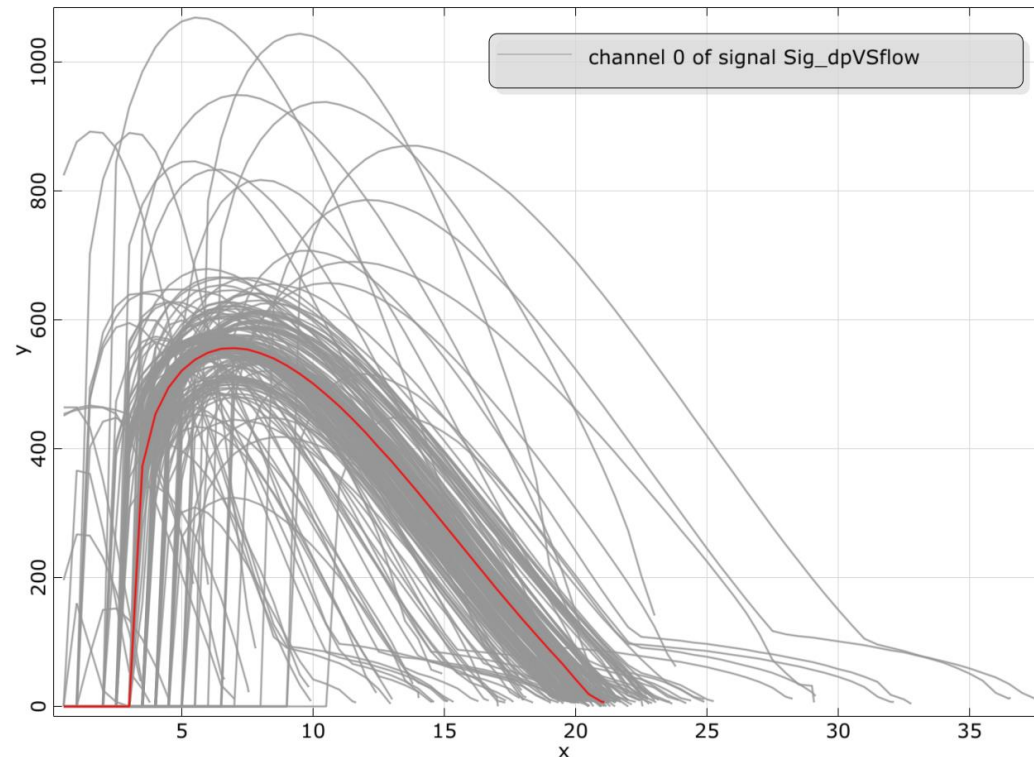
dp

- CPU Time ~ 3-4 minutes
- 261 Designs calculated

How to make this process accessible for many users?



channel 0 of signal Sig\_dpVSflow



# OPTIMIZATION - PROCESS



## Simulation Democratization

Democratize simulation to be used or consumed by many engineers in different stages of the development process

**Simulation Experts** → **All Engineers**

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## Democratize Workflows → Calculate & Postprocess in Web-App

**Simulation Expert** → **Programming Expert** → **optiSlang Novice** → **Non-simulation Expert**

**CONSULTING**

**Custom Programming**

- Expensive and time-consuming to develop
- Hard to maintain (ACT + scripting)

**GUI-based Workflow**

- No programming required
- Easy to learn and fast to develop
- Easy to host on network

**User-friendly Tool**

- No simulation experience required
- No need to have software installed
- Available on network

[Back to feature overview](#)

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New OptiSlang version offers:

- Way to publish workflows in a webapp
- Host a webservice
- Automated post processing of the results



Automated post processing not suited for our needs

- Project together with ANSYS to customize the webapp



# OPTIMIZATION - PROCESS



optiSLang

Login

Username

Password

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Ansys / OPTISLANG

Projects

Wizards

Administration

Sign out

**ANDRITZ**

Optimization Radial Fan

An optiSLang web application built with pyowa

Different "Wizards"



Ansys / OPTISLANG

Optimization Radial Fan

An optiSLang web application built with pyowa

User Input

Name	Value	Description
FANPGoal	500	Desired fan pressure rise (Pa)
FANRMax	1000	Maximum value for the outer fan radius (mm)
FANRMin	400	Minimum value for the inner fan radius (mm)
FANSpeed	500	Fan Speed (RPM)
FANVGoal	10	Desired fan volume flow rate (m <sup>3</sup> /s)

Project settings

Project name

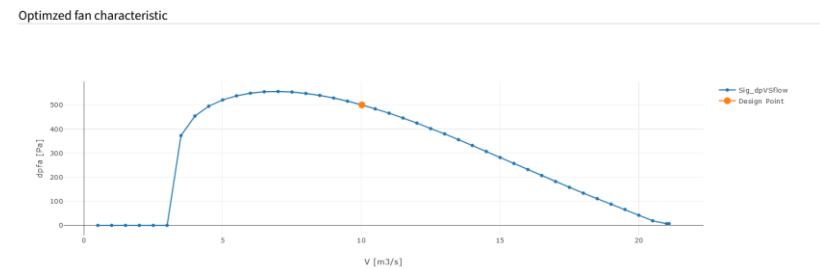
▶

User input



Optimized Geometry

Name	Value	Unit	Explanation
OptRInner	539.3	[mm]	Inner fan radius
OptROuter	854.3	[mm]	Outer fan radius
OptHeight	270	[mm]	Fan blade height
OptBlade_Number	8	[-]	Number of fan blades
OptB1	21.9	[°]	Leading edge angle
OptB2	25.4	[°]	Trailing edge angle



Results

# SUMMARY



- Optimization process based on existing layout tools for radials fans was developed
- To enable this process to as many engineers as possible a webapp was established
- Improvements of the optimization process were demonstrated by real application
- Next steps:
  - Introduce reduction of cost as optimization goal
  - Extend the workflow to axial fans