Howden
A Chart Industries Company

Increasing the performance of steam turbines at partial load by optimising the control during operation

Revolving Around You™

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Howden Turbo GmbH

Location Frankenthal, Germany

1899: Foundation of the Frankenthal boilermakers and machine factory Kühnle, Kopp & Kausch

1909: Name change to >AG Kühnle, Kopp & Kausch< (AG KK&K)

2006: Siemens acquires 100 % of the company shares (Siemens Turbomachinery Equipment GmbH)

2017: Part of Howden Group (UK), Howden Turbo GmbH

2023: Howden Group part of Chart Industries (US)

Steam Turbines, Turbo Compressors and Turbo fans for industrial applications

- Development
- Sales
- Manufacturing
- Service

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Modular design of the Steam Turbine

Typical applications


food and beverage


mechanical drives


waste incineration


steel industry


petrochemistry


biomass, paper

- Energy-from-Waste plants
- Biomass incineration plants
- Sewage sludge incineration plants
- Combined heat and power (CHP)
- Waste heat recovery, e.g. glass-, steel- and cement industry
- Solar heat

- Mechanical drives like pumps, compressors and fans

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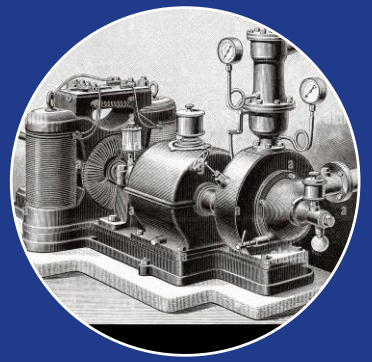
Motivation



Steam turbines have been in operation for centuries

Partial load operation is not new

The answer: nozzle group control

Voice of Customer

Request from the customer to further optimise turbine at partial load

In recent years: Online monitoring

How do you optimise operations for as many operating points as possible?

Digitalisation and electrically controllable valves open up new possibilities

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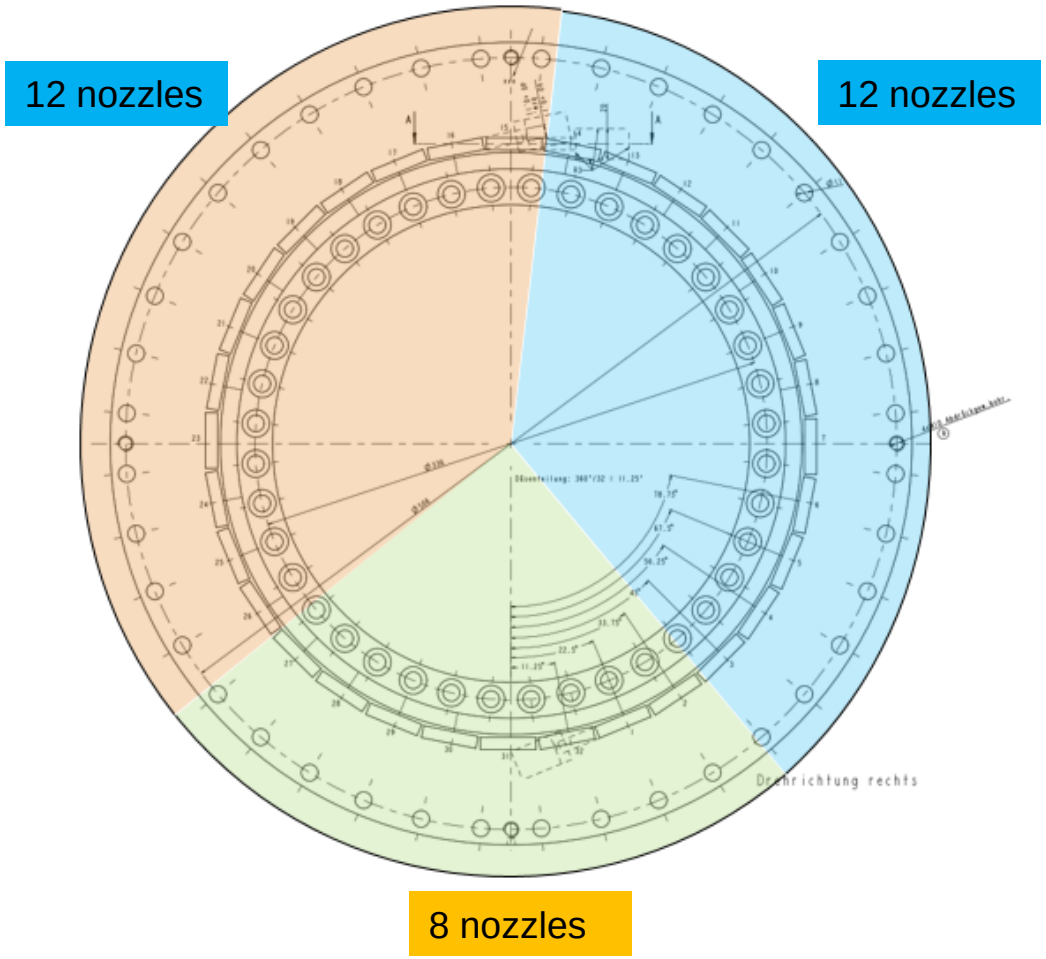
Design of a nozzle ring

Exemplary nozzle ring (AFA turbine)

Different numbers of nozzles = different fluid quantities per segment

The number of nozzles controlled should be be matched as closely as possible to the flow.

The nozzle ring does not necessarily have to be designed with 32 nozzles.



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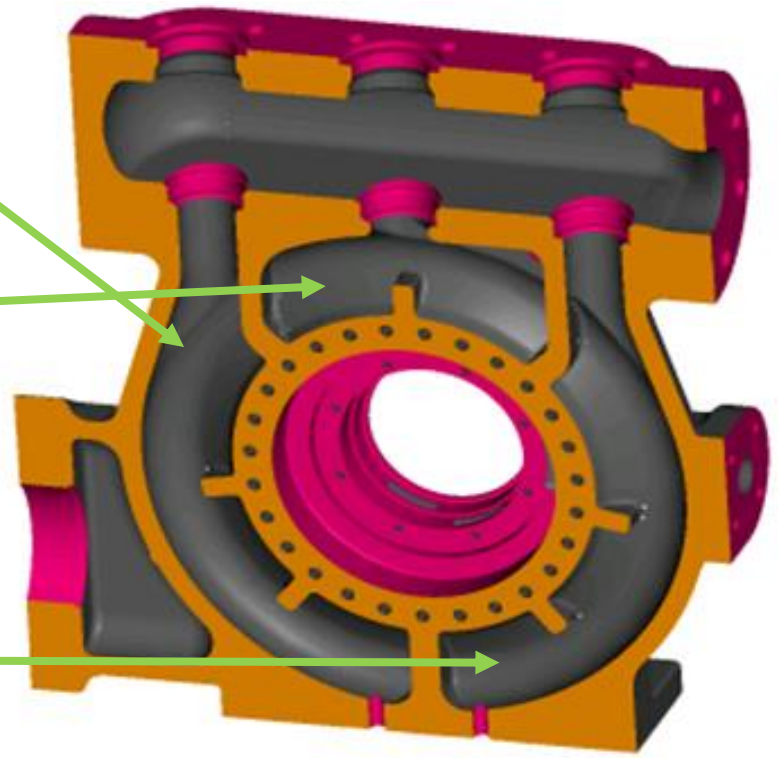
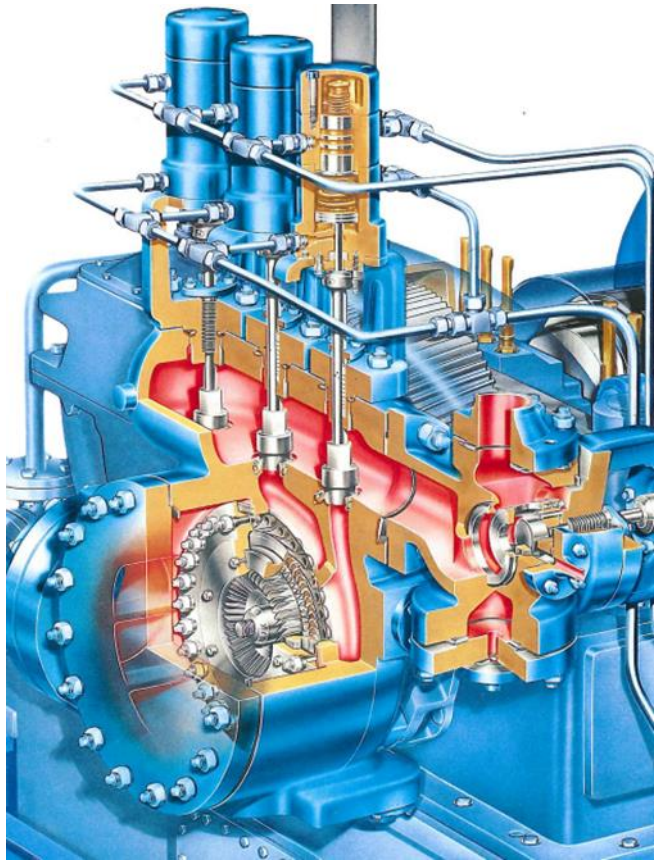
Design of a nozzle ring

Nozzle group 1

Nozzle group 2

Nozzle group 3





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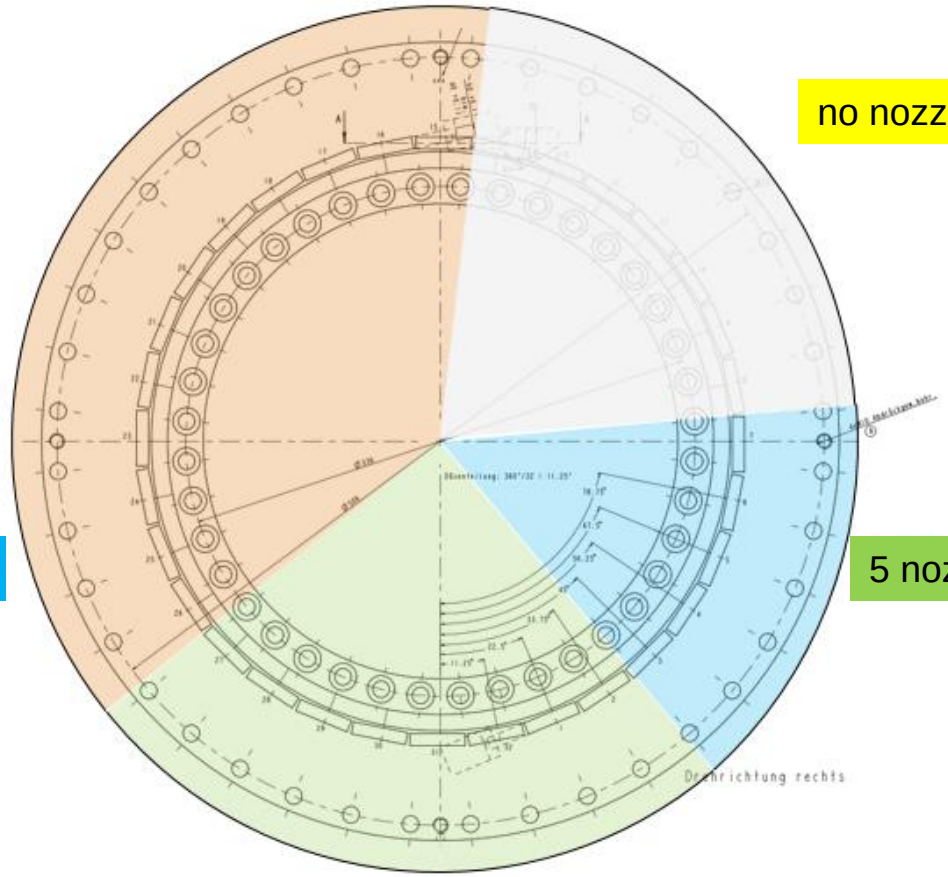
Design of a nozzle ring

Other variation ➔ more flexibility

(25 nozzles, for example)



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Design of a nozzle ring

Please note :

With most KK&K turbines it is possible to change the nozzle ring and thus adapt it to any changed operating parameters !!!!

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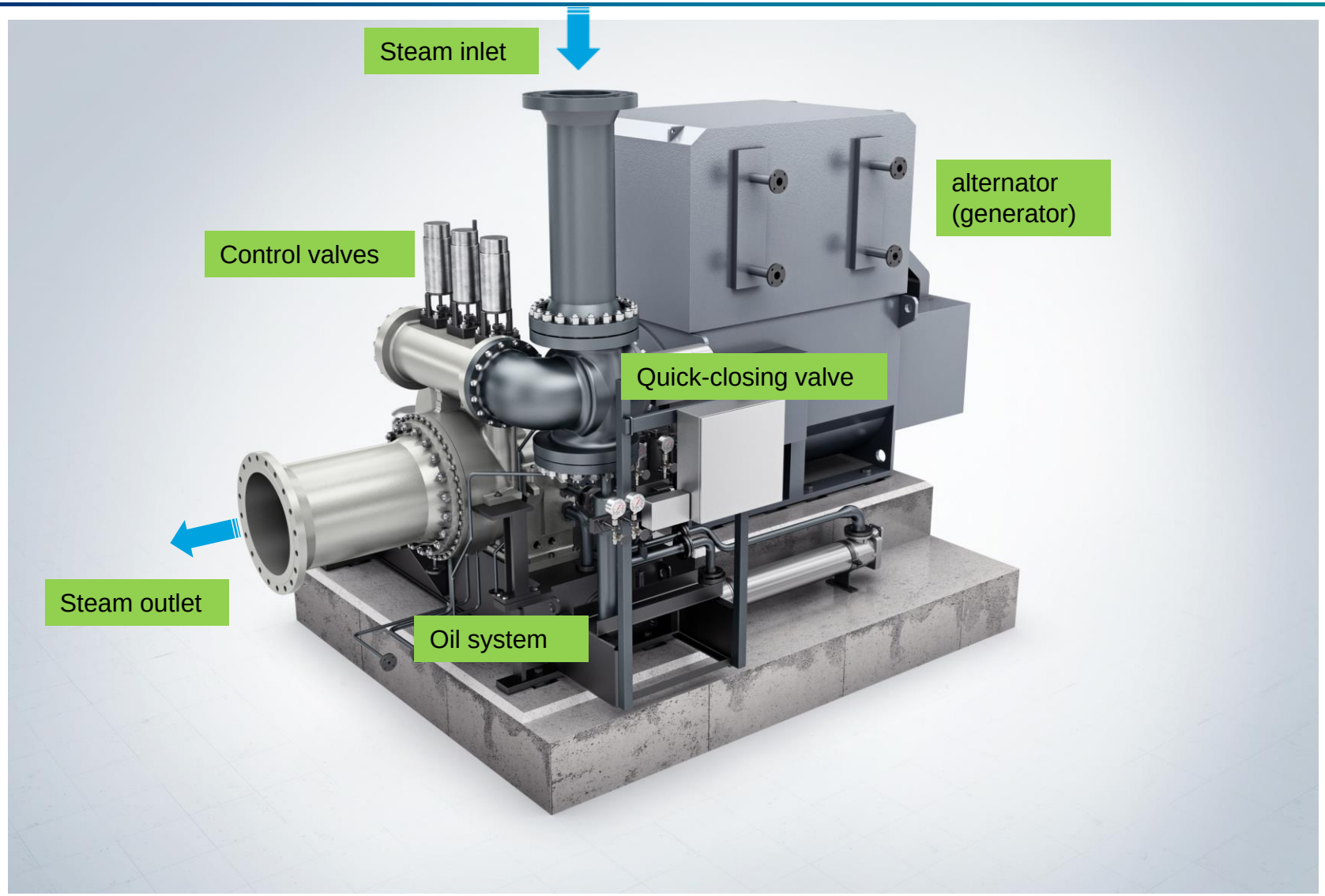
Modular design of the Steam Turbine

Principle structure



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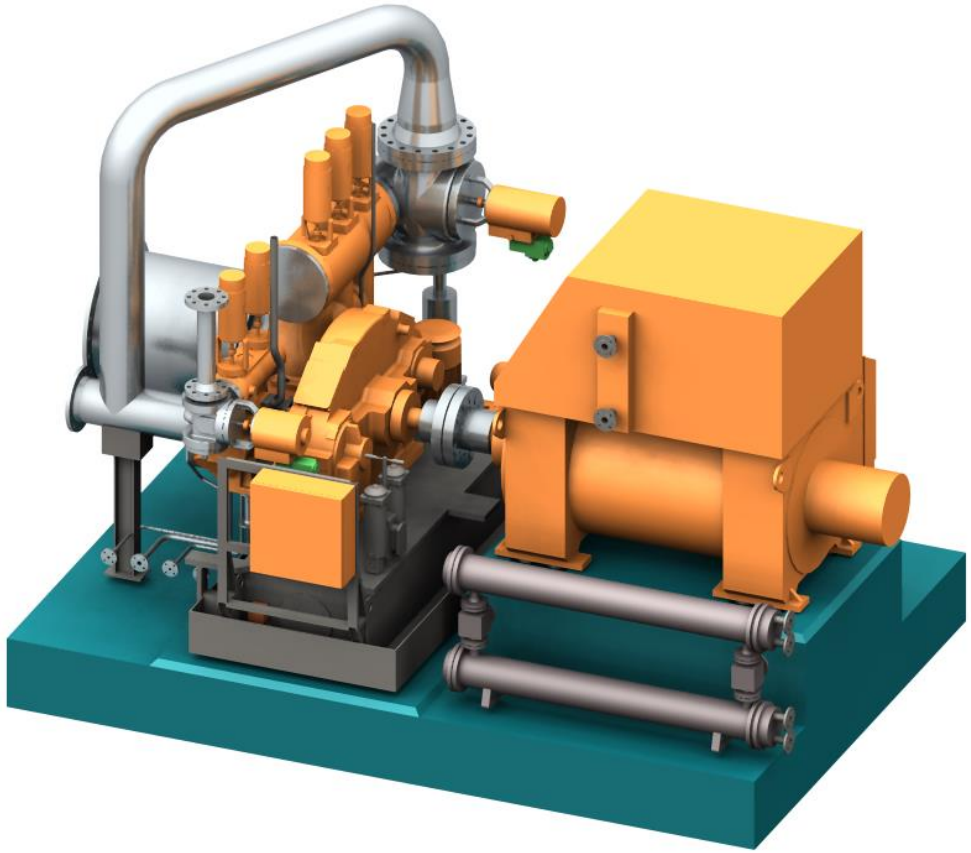
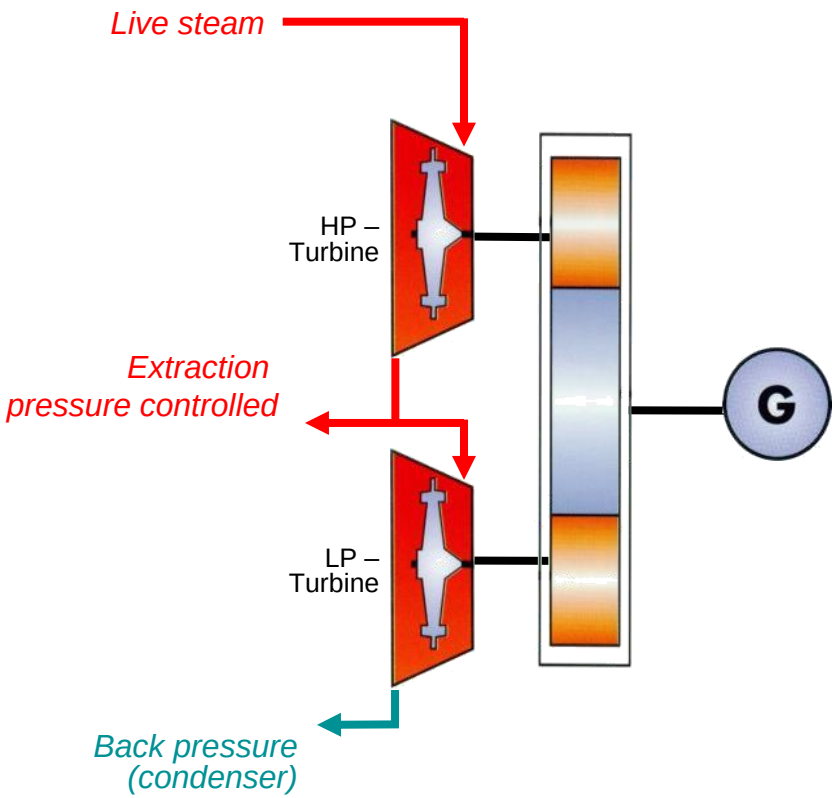
Modular design of the Steam Turbine

Principle structure





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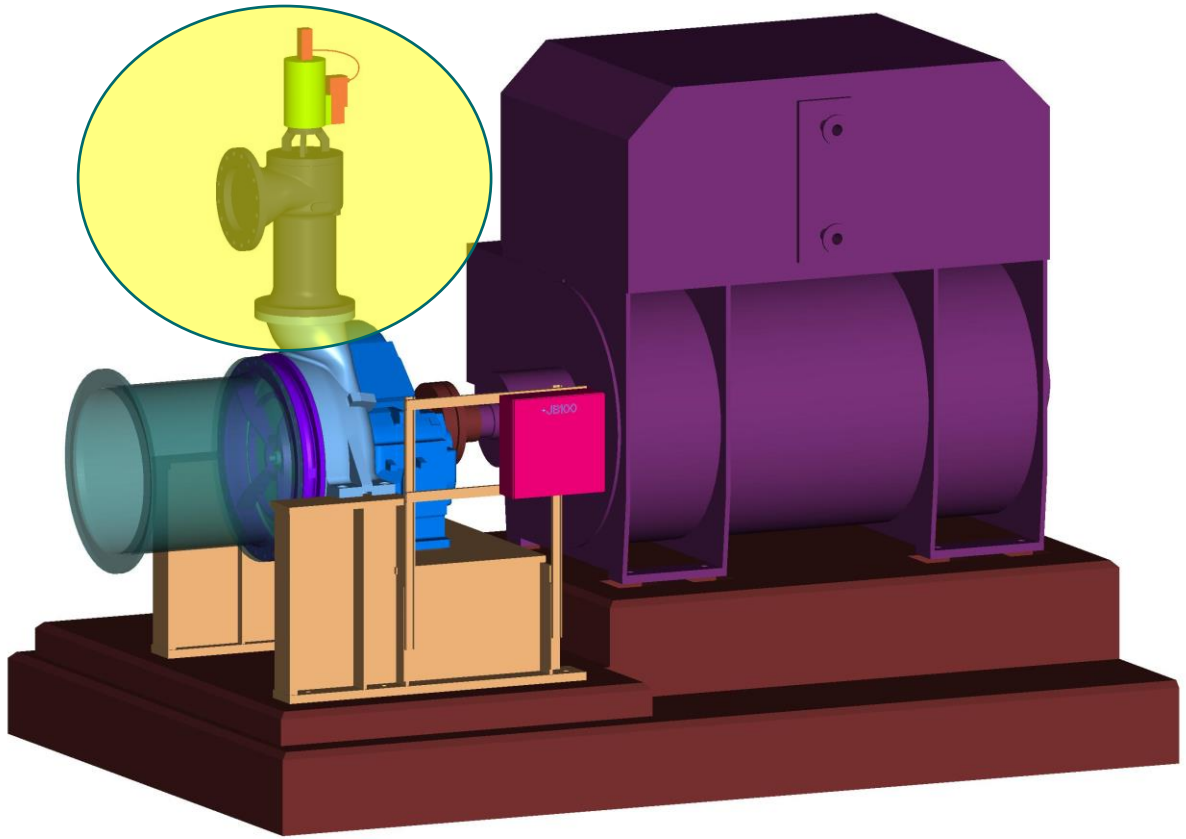
Modular design of the Steam Turbine

Principle structure



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Modular design of the Steam Turbine

Principle structure

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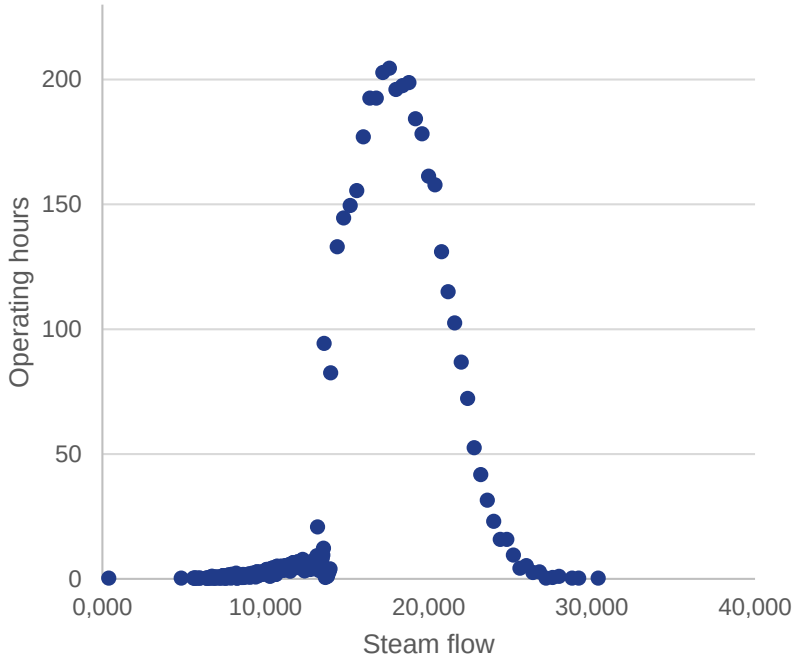
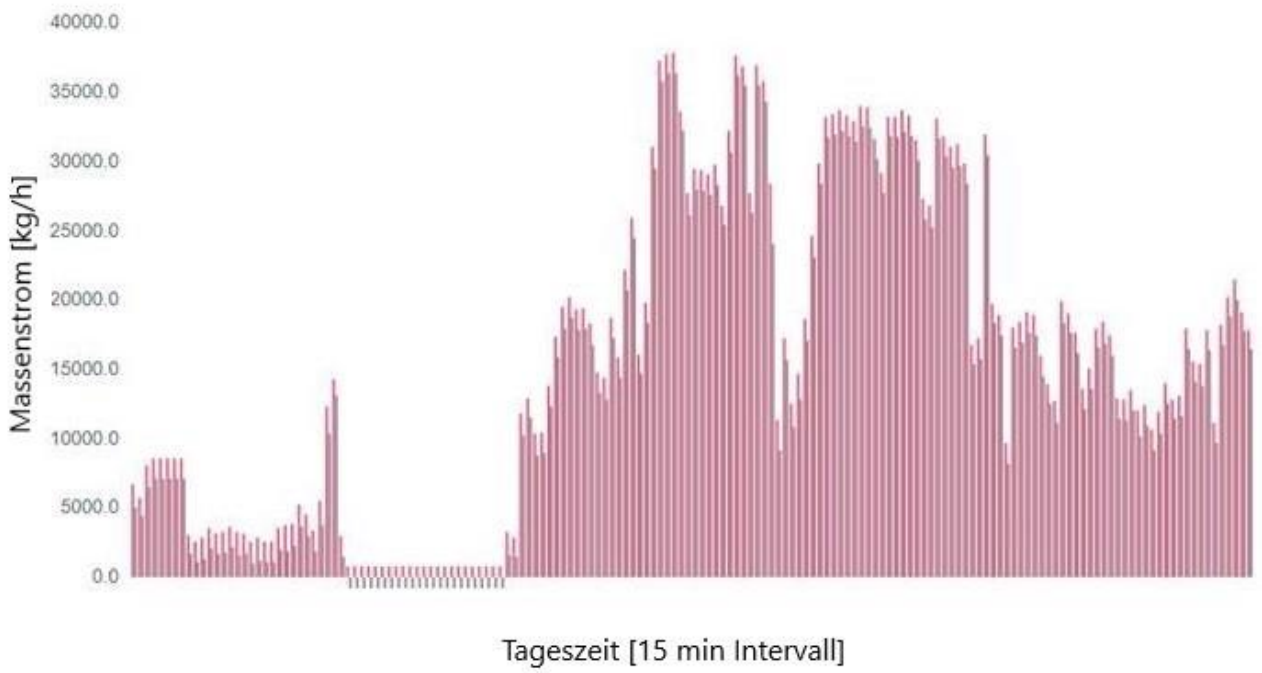
Operating behaviour of industrial steam turbines

Typical annual and daily variations

Distribution of operating hours



Fluctuations in daily load curve



→ High flexibility required

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Current operation mode

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Current operation mode

- **nozzle group control, better than only one valve at partial load.**
- **Used by many, but the valves are opened sequentially (in pre-set sequence)**

→ Potential for optimisation

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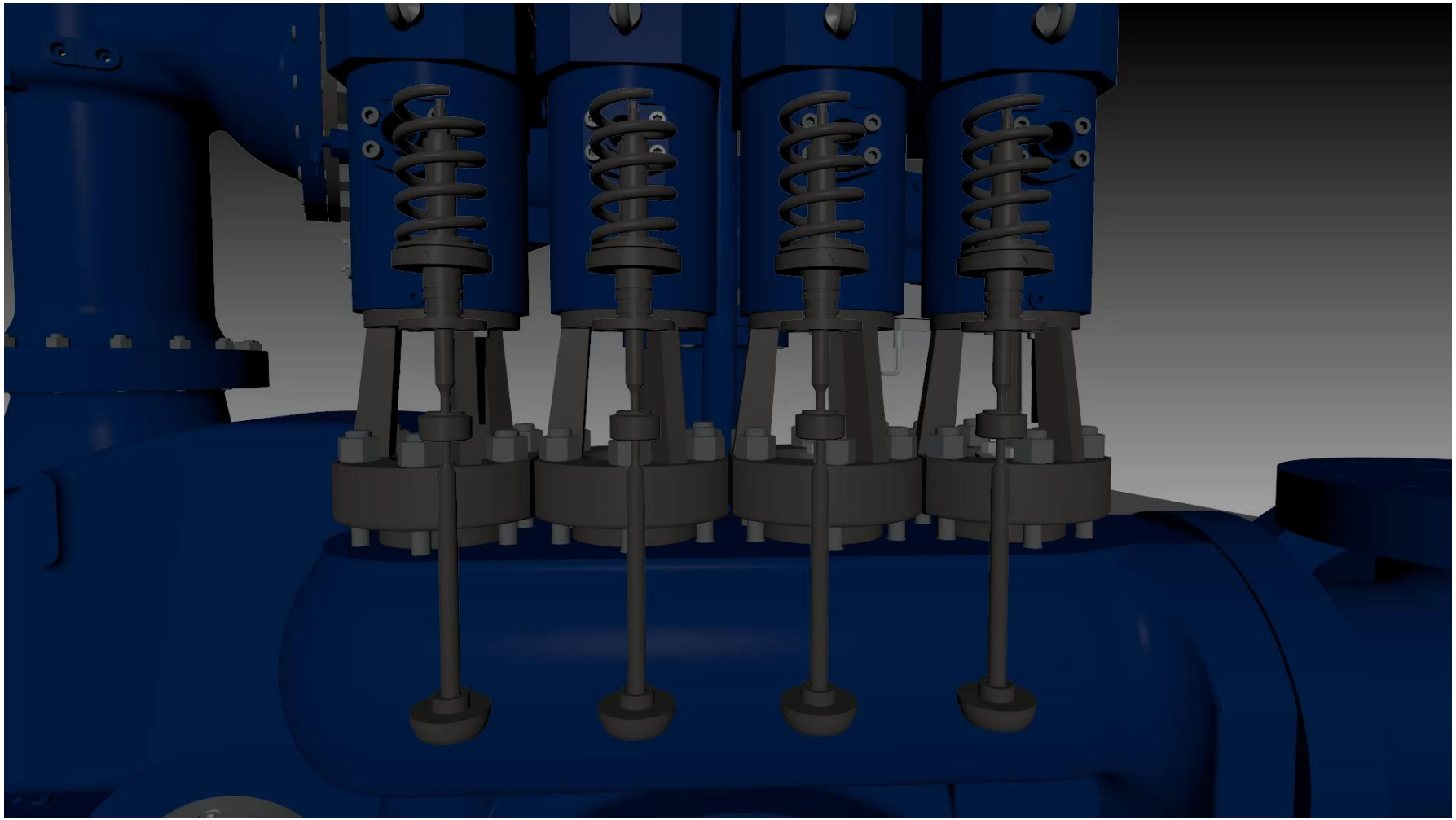
Current operation mode

Serial valve opening



4 nozzle groups,

CFR - turbine

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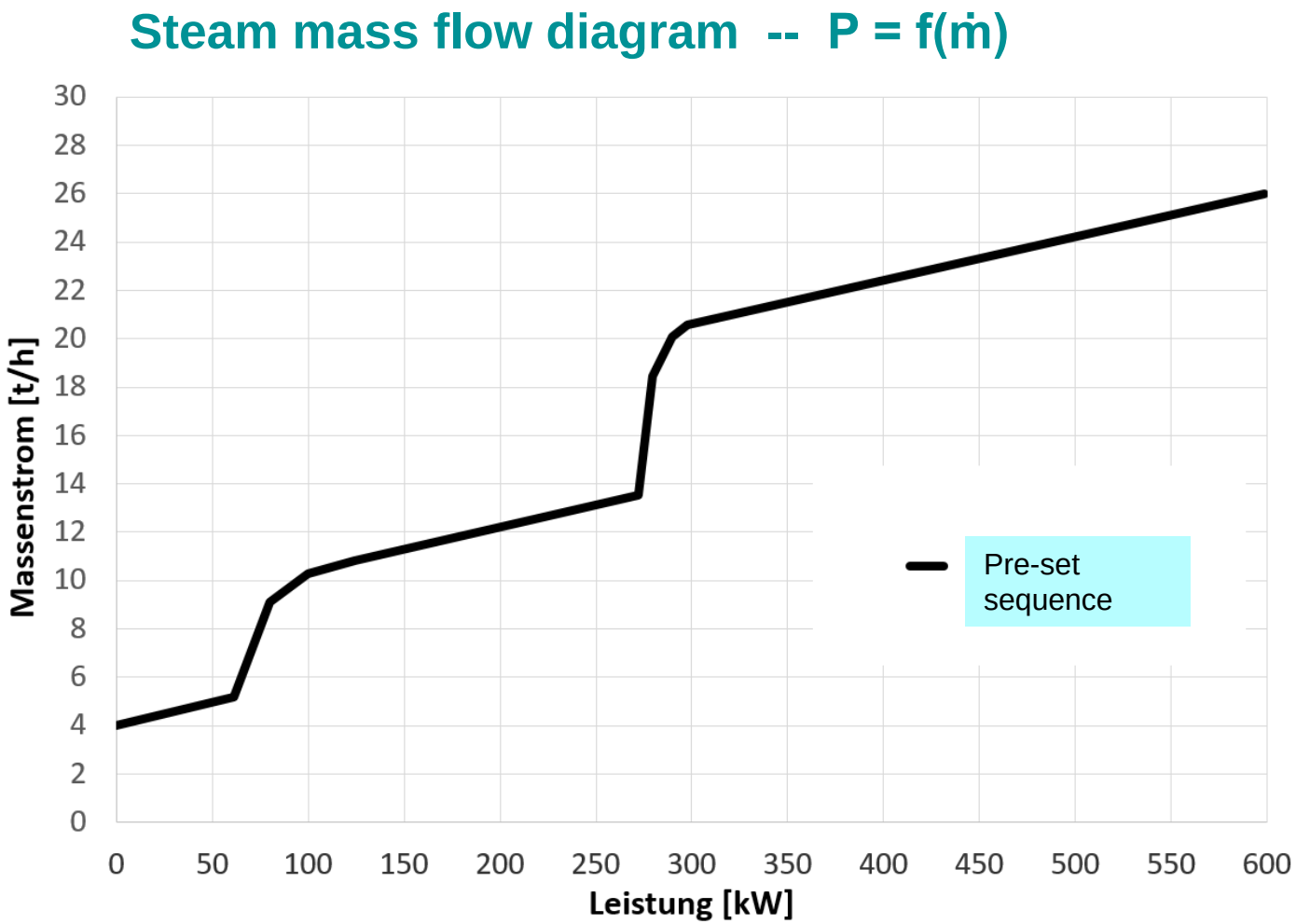
Current operation mode

Serial valve opening

- Control line shown in black
- Mass flow [t/h] plotted against power [kW]
- Serial opening of the valves
- Inefficient operation in valve opening points



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The dynamic valve coordinator

Simulation results

- Linear increase of the mass flow to simulation start
- Valve 1 is closed at different speeds after a prompt
- Valve 2 opens and takes over control
- Significant increase in performance after valve change

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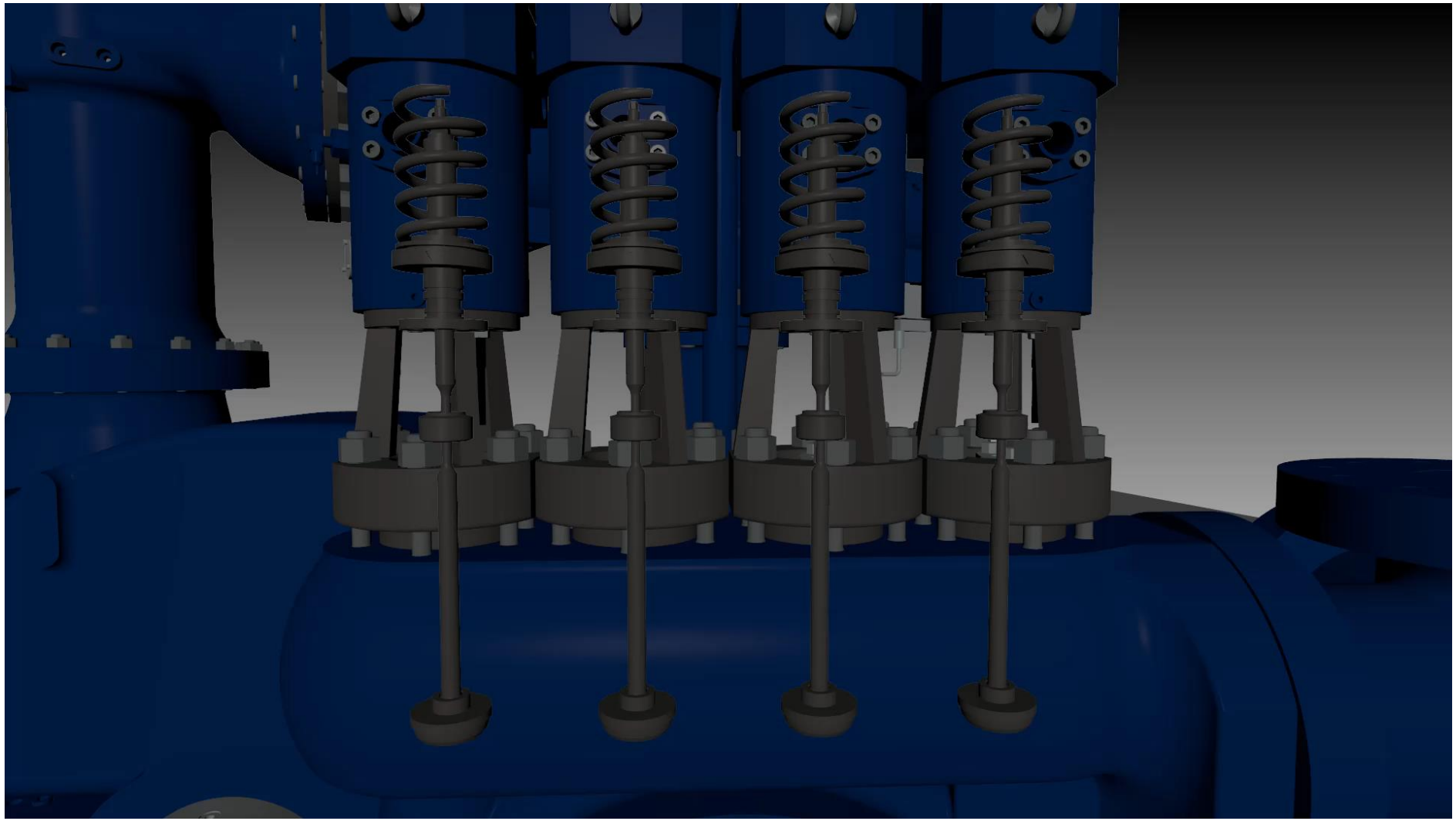
Result

Variable valve opening



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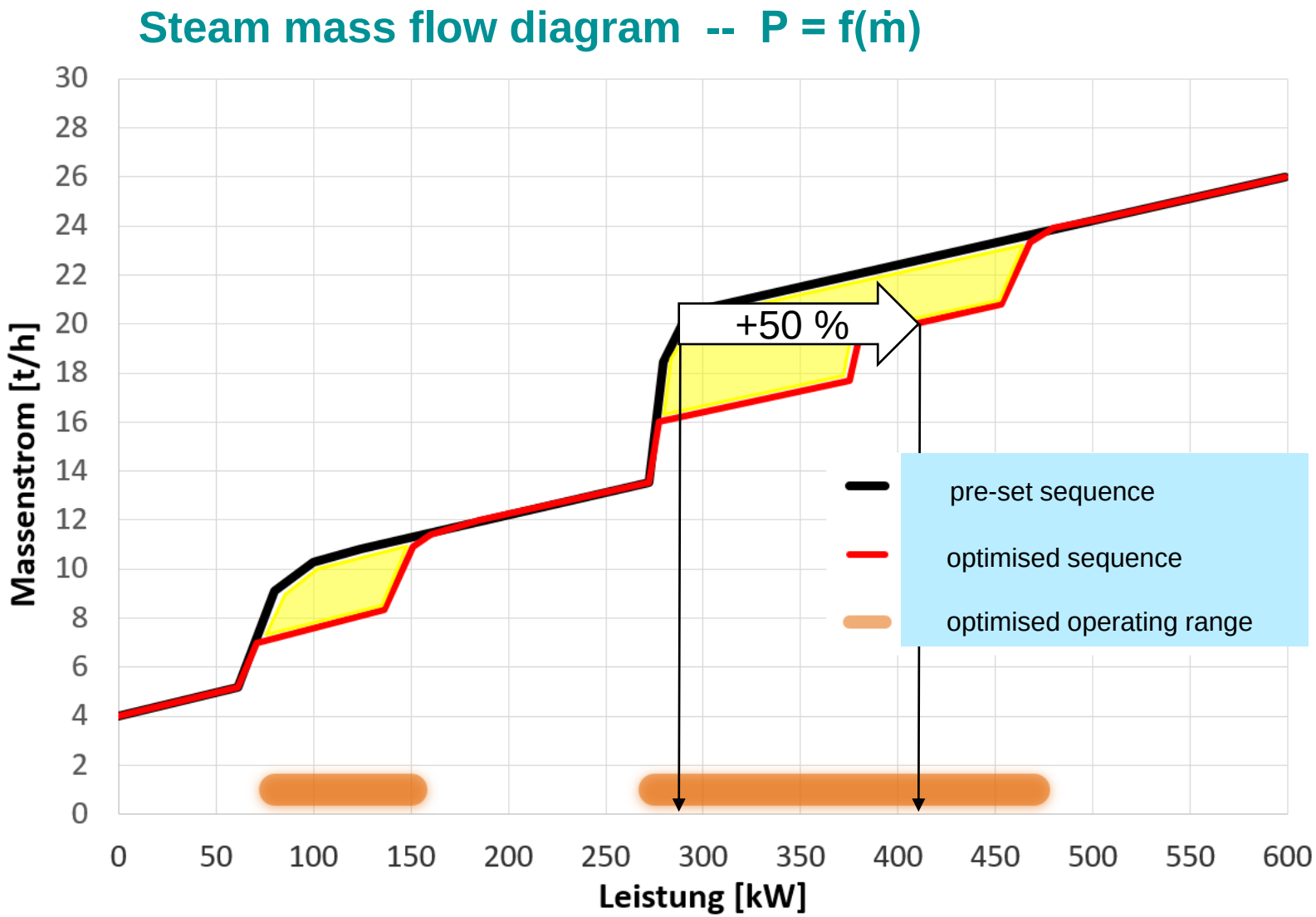
Result

Variable valve opening - optimisation potential

- Old control line shown in black
- Future control line shown in red
- Optimised area is marked yellow
- Up to 50 % performance increase



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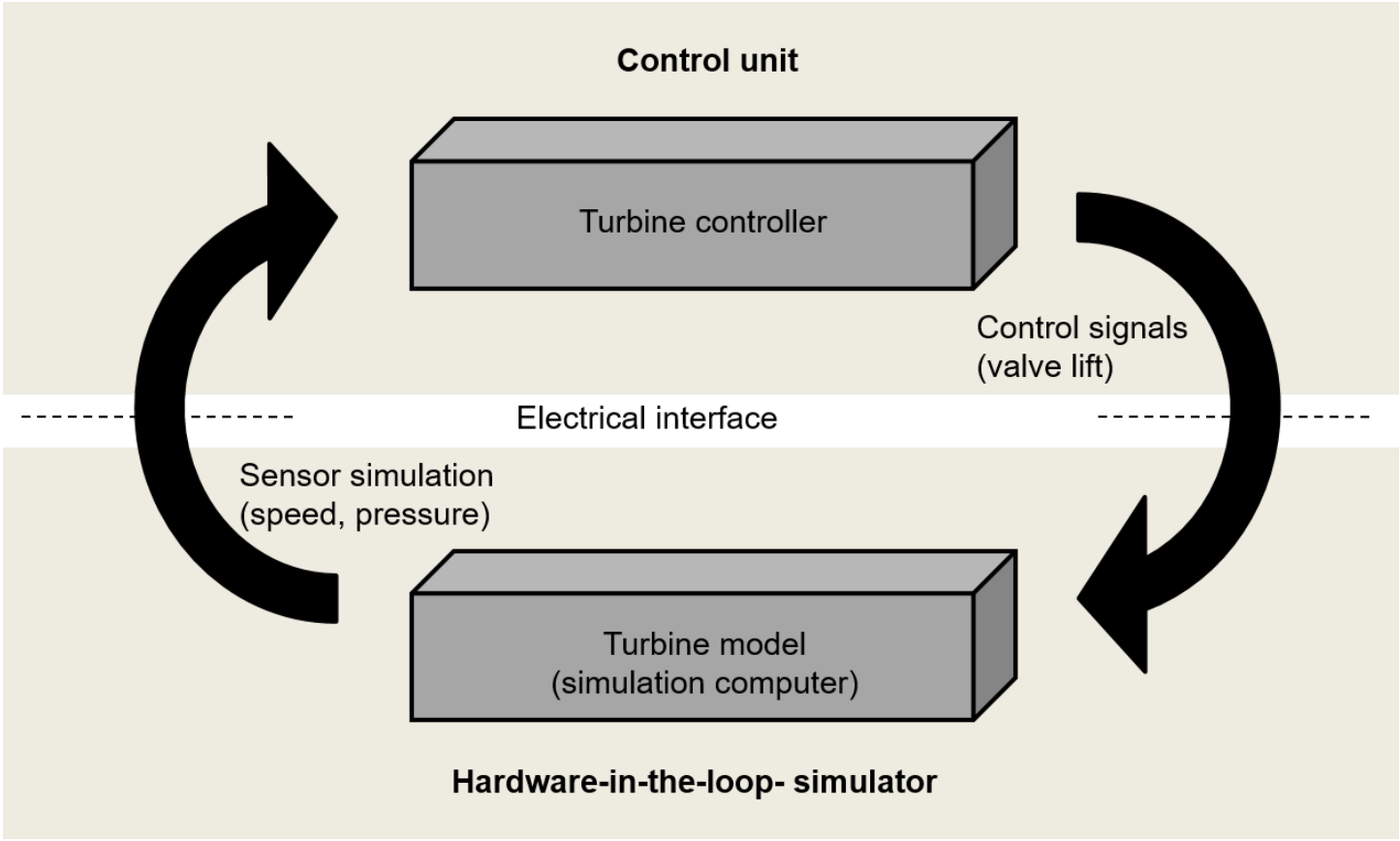
Simulations on the hardware-in-the-loop simulator

Variable valve opening

1. Initial setting of speed/valve lift
2. Turbine model calculates thermodynamic values
3. Control variables (speed, pressure) are passed on to the control unit
4. Control unit (turbine controller) processes input signal
   - Valve lift is output variable



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Result

Variable valve opening

Please note :

This optimisation requires control valves with position feedback, i.e. either electro-mechanical (so-called MOOG) valves or corresponding actuators for hydraulic valves (RE valves).

Whether a turbine already in operation can be converted, should please be clarified with our aftermarket.

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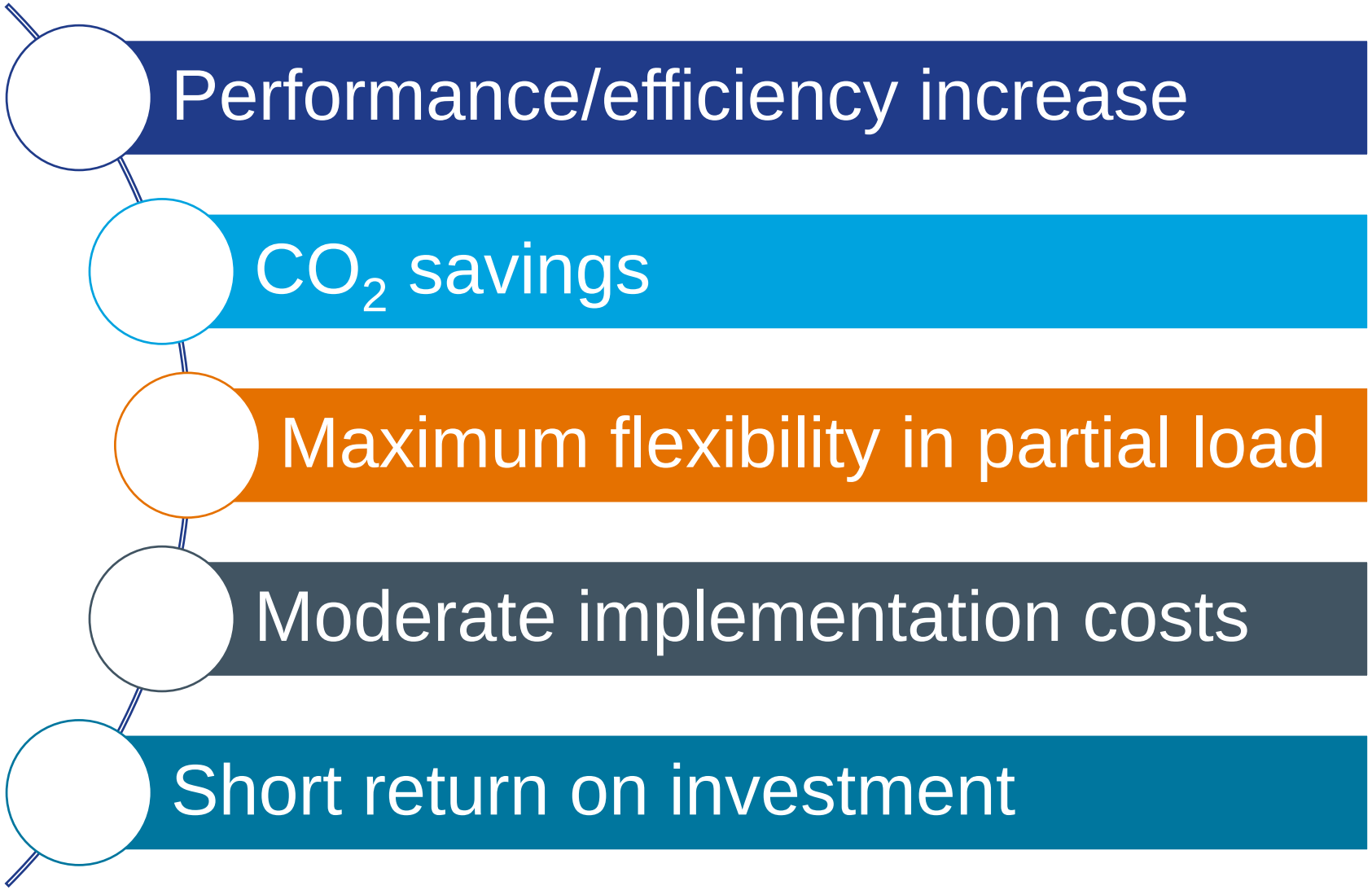
Summary

The advantages of the dynamic valve coordinator



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Thank you

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