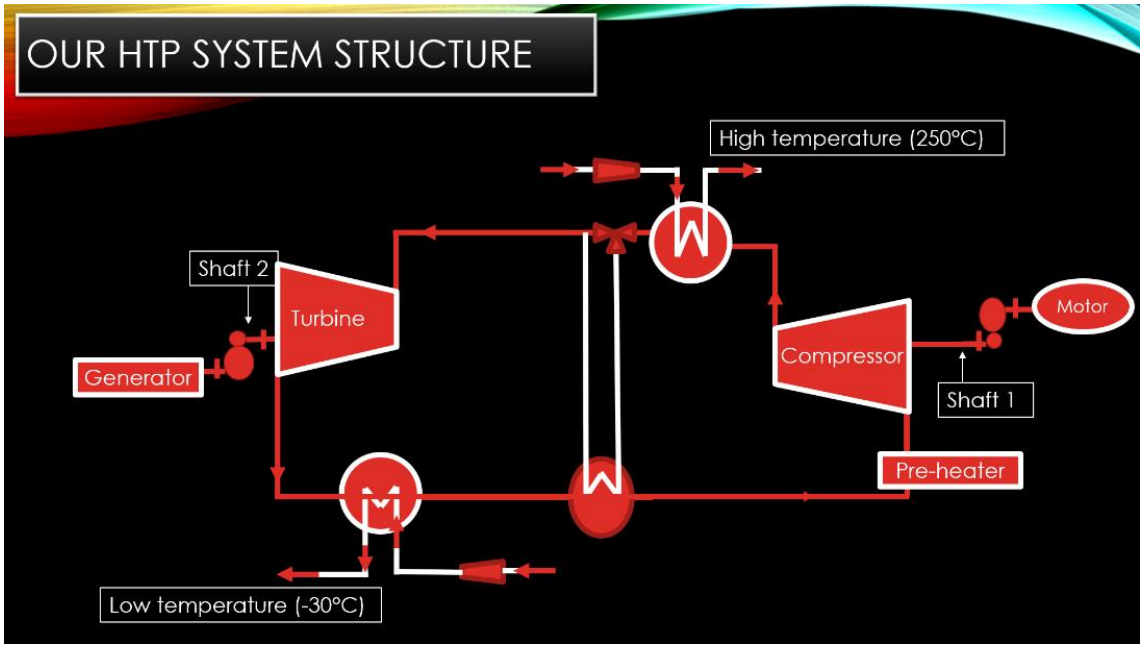
Nicolas Carnec

MY INTERNSHIP AT DLR

RESEARCH TOPIC: Linear model of a high temperature heat pump based on the closed Brayton cycle process

The objectives of the internship were to understand the short-term heat pump behavior and to develop a linear dynamic system of the form $\dot{\boldsymbol{x}}(t) = \boldsymbol{A}\boldsymbol{x}(t) + \boldsymbol{B}\boldsymbol{u}(t)$ which captures the dominant physical characteristics of the high temperature heat pump (HTP), as illustrated below, developed by the DLR Institute.



In order to realize the mentioned objectives, the following work stages were conducted:

1.) Linearization of nonlinear mass flows $\dot{\boldsymbol{m}}$ arising in turbomachines using Taylor series

2.) Extracting hydraulic state space model using 1.) to obtain $\dot{\boldsymbol{p}}(t) = \boldsymbol{A}\boldsymbol{p}(t) + \boldsymbol{B}\boldsymbol{n}(t)$ with pressure $\boldsymbol{p}$, motor shaft speed $\boldsymbol{n}$, state matrix $\boldsymbol{A}$ and control matrix $\boldsymbol{B}$

3.) Validation of dynamic model by DLR in-house software GTlab

Once this dynamic model has been developed, we could therefore establish the HTP approximate transient trajectory on a performance map. Exemplarily, the HTP transient response, between

$$\mathrm{OP}_3 \text{ and } \mathrm{OP}_8 \ (\mathrm{OP}_\mathrm{i} \text{ designates the } \mathrm{i}^{\mathrm{th}} \text{ operating point})$$

to either an increasing and decreasing ramp-up and ramp-down input is shown below:

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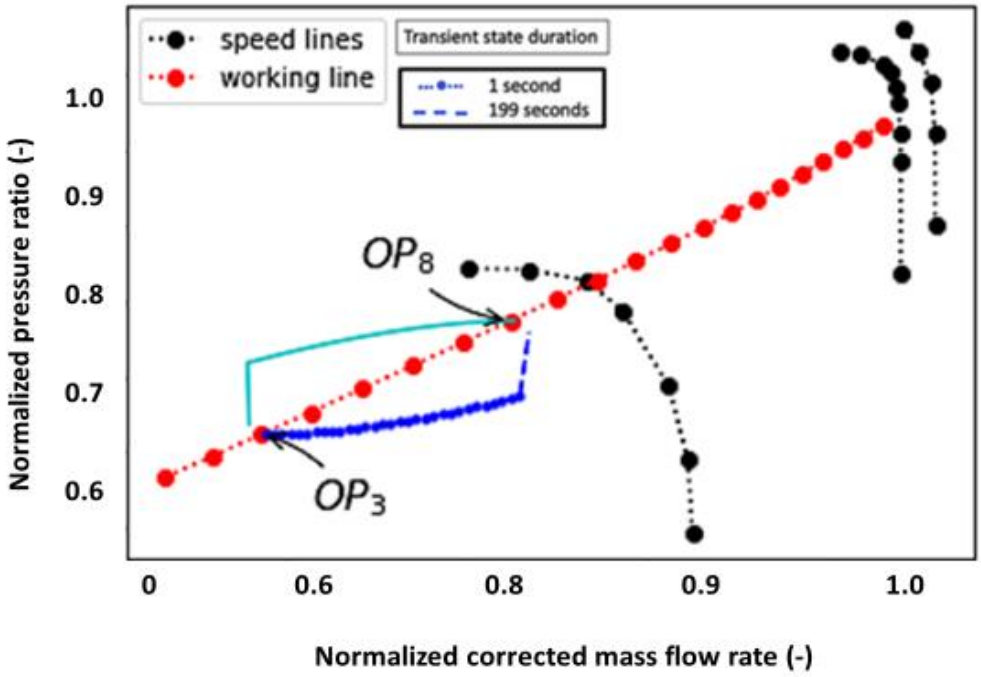

Let us mention that these results could not be compared with a reference model, and were therefore only validated on steady state solutions. However, they give us a first overview of how the HTP system would behave when we increase or decrease the motor shaft speed (the motor shaft speed is the control variable of the HTP system). In conclusion, the results obtained with this linear dynamic system satisfied the requirements of my institute's colleagues and it therefore follows that I really appreciated working in research and in particular in the Cottbus DLR institute. Ultimately, I would say that this internship has motivated me to work in the field of *decarbonized energy systems* or either in numerical modelling which aims to significantly reduce CO_2 and pollutant emissions in the future.