Karlsruhe Institute of Technology

Institute for Technical Physics (ITEP)

Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

CFD analysis of the cryocooler regenerator performance under different accelerations

Yuzhe Lin[1,2,*], Jiuce Sun[1], Holger Neumann[1,*], Shaowei Zhu[2]

[1] Karlsruhe Institute of Technology (KIT), 76344, Eggenstein-Leopoldshafen, Germany
[2] Tongji University, 201804, Shaihai, China
* Email: yuzhelin90@gmail.com; holger.neumann@kit.edu

Background

- High temperature superconducting (HTS) can scale the offshore wind turbines (WT) up to 10 MW with the Reduction of the size and head mass
- A cryogen free system with a cryocooler is put forward for cooling the HTS system.
- The cryocooler of this system is operating under a rotating condition, the regenerator performance may be influenced

Simulation model

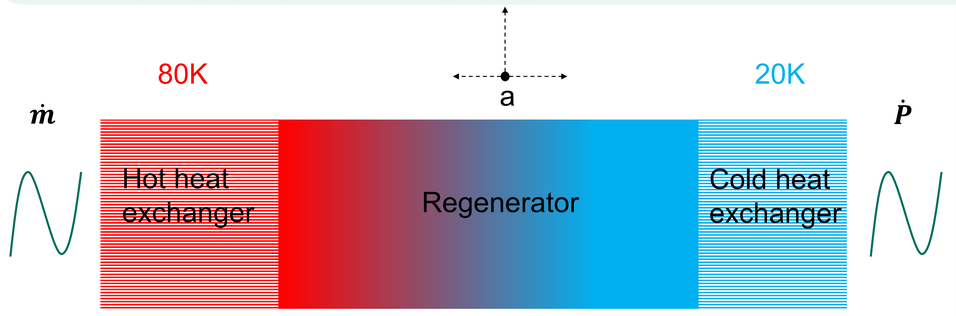

Fig.1 The sketch map of the regenerator model

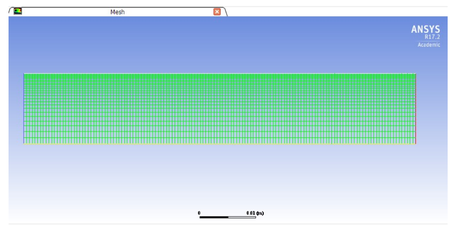

Fig.2 The meshes of the model

Tab.1 The parameters of the model

Components	Diameter (mm)	Length (mm)
Hot heat exchanger	25	15
Regenerator	25	40
Cold heat exchanger	25	15

Model details

- Gambit is used for generating meshes
- ANSYS Fluent 17.2 is used
- K-ω viscous model
- The material properties are based on NIST Database
- PISO coupling scheme
- Second order spatial discretization
- Every cycle has 360 time steps

Case settings

- ***a*** is the acceleration. And **g** is the gravity which is 9.8m/s^2
- In this simulation, ***a*** has different direction and different values. The operating frequency and porosity of the regenerator are also changed.

Simulation results

The influence on temperature field

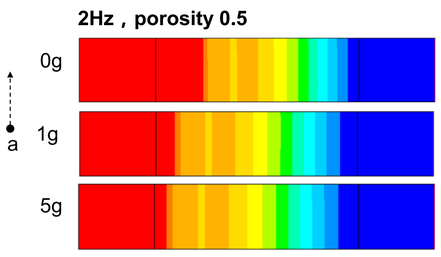

Fig.3 Temperature field

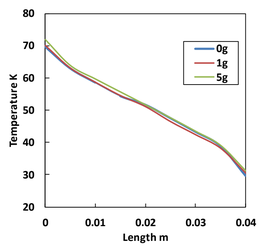

Fig.4 Temperature distribution

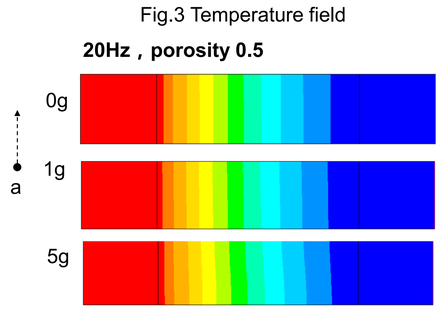

Fig.5 Temperature field

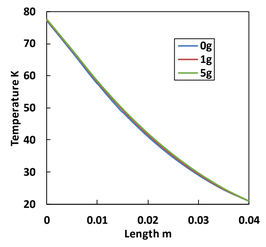

Fig.6 Temperature distribution

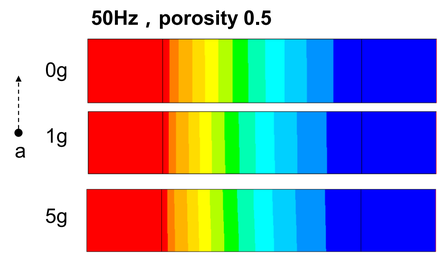

Fig.7 Temperature field

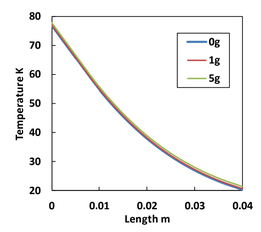

Fig.8 Temperature distribution

- Fig.3-Fig.8 show that with the increasing of the acceleration, there is slightly change of the temperature profiles. The operating frequencies also have a small effect.

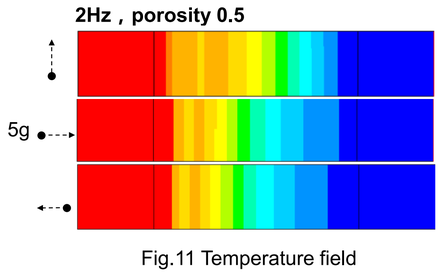

Fig.11 Temperature field

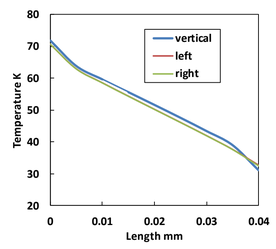

Fig.12 Temperature distribution

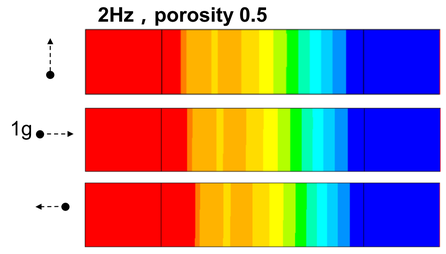

Fig.9 Temperature field

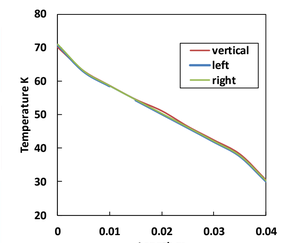

Fig.10 Temperature distribution

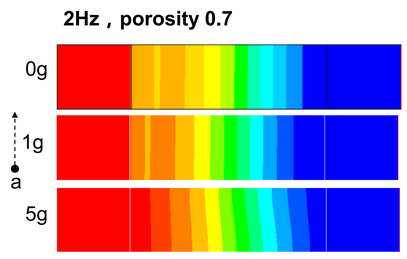

Fig.13 Temperature field

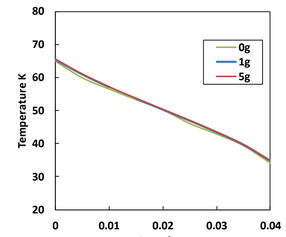

Fig.14 Temperature distribution

- Fig.9–Fig.12 show the temperature field temperature distribution different acceleration directions.
- Fig.13 and Fig.14 show the temperature field temperature distribution when the porosity is changed to 0.7.

The influence on pressure field

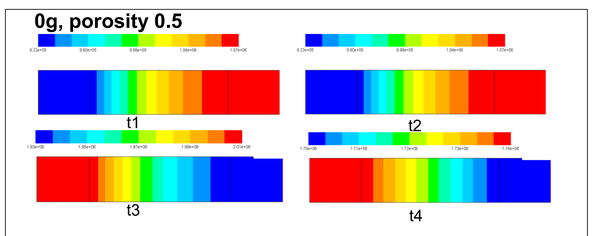

Fig.15 Pressure field

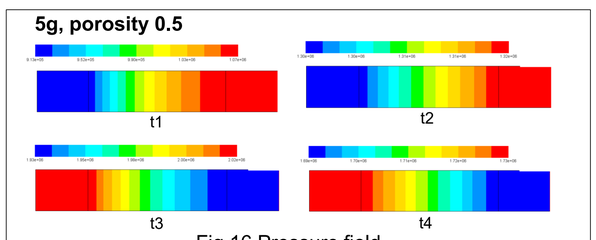

Fig.16 Pressure field

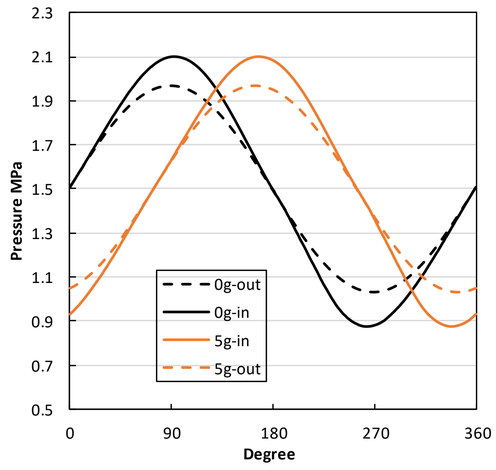

Fig.17 Pressure waves at the inlet and outlet of regenerator

- Fig. 15, Fig.16 and Fig.17 show the pressure field and the pressure wave at the inlet and outlet of the regenerator.

Conclusion and outlook

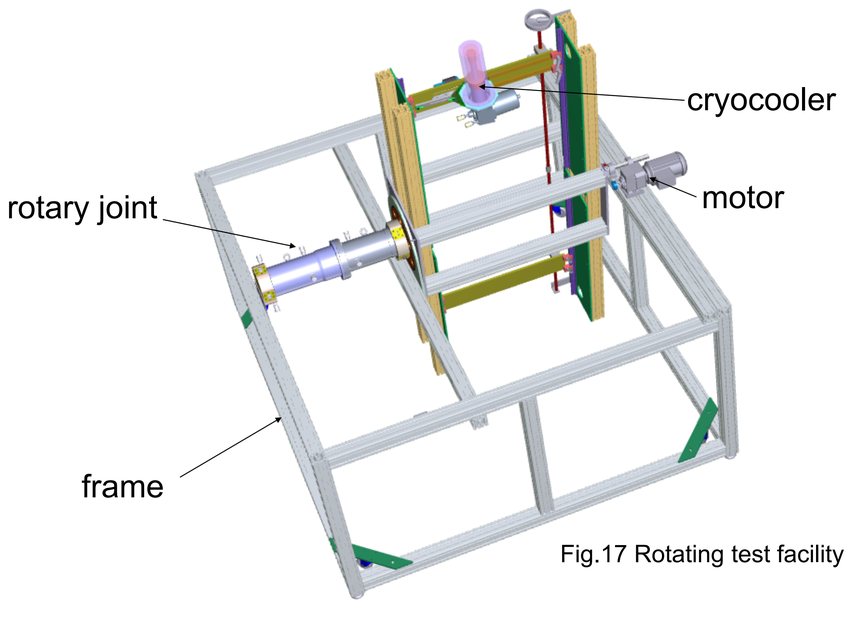

Fig.17 Rotating test facility

- With the help of ANSYS Fluent 17.2, the regenerator model operating under different accelerations are simulated.
- With the increasing of the acceleration, there is a slightly influence on the temperature field of the regenerator. The temperature field change has no relation with the operating frequency. With a higher porosity, the transformation of the temperature field is more obvious. But the temperature distribution in the regenerator solid part has no much difference. The pressure field is influence less than the temperature file. So we can say that the acceleration has a very limited influence on the performance of the regenerator.
- But this study is only about the regenerator. When the cold head system operating under the rotating condition, there should be some influence on the performance of the cryocooler. So we also build a facility to test the cryocooler with different accelerations, as shown in Fig.17. The test results will be published in the future.