

Experimental Study Progress on Mock-up Helium Circulator with Dry Gas Seal

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INTRODUCTION

As the first module plant of HTGR in the world, High-temperature Gas-cooled Reactor Pebble-bed Module (HTR-PM) is of global concerns. Helium circulator is the key component for the project, which transports helium and heat in the primary loop. An external type of helium circulator with dry gas seal is designed as an alternative for HTR-PM. To investigate its characteristics, a full size mock-up machine was manufactured and tested on the Engineering Test Facility - Helium Circulator.

A series of experiments were designed, including mechanical and aerodynamic performance tests, durability tests and many special tests for seals.

Now the mechanical tests had been held. The mock-up worked and run smoothly under helium environment at 4 MPa and room temperature. The tests would continue at design working pressure as 7 MPa and with rated inlet temperature as 243 °C.

BACKGROUND AND DESIGN

High-temperature Gas-cooled Reactor Pebble-bed Module, which is called HTR-PM, has been under construction in Shidao Bay, Shan Dong, China. There would be two nuclear plants and one steam generator with 211MW electrical power. Expected to generate electricity in two years, its development is of global concern.

Helium circulator plays a key role of HTR-PM. Working under 243 °C, 7MPa helium condition, it is the unique rotating component and transports helium and heat in the primary loop. Its performance would significantly affect the reliability of HTR-PM.

It consists of a vertical driving motor, a high-speed large-scale one-stage circulator, and some strutting pieces. An external type of helium circulator is designed for HTR-PM. Motor of this circulator is set out of a containment, where sliding bearings are used and shaft seal such as dry gas seal is applied as the pressure boundary of primary loop. Fig.1. showed its model.

Dry gas seal is widely used in other industry but first used in HTGR. Thus, there would be lots of uncertainty. To investigate its characteristics, a full size mock-up was manufactured. A research platform, which is called Engineering Test Facility - Helium Circulator (ETF-HC) has been established. The mock-up is mounted on ETF-HC to conduct performance test.

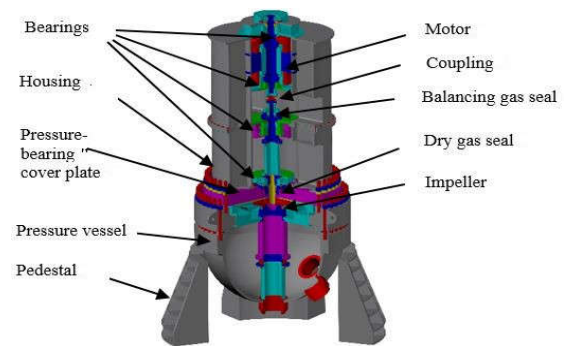


Fig. 1. Helium circulator with dry gas seal

In order to simulate most normal and abnormal operating conditions of helium circulator in HTR-PM, tests were carefully designed, including mechanical and aerodynamic performance tests, durability tests and many special tests for seals.

EXPERIMENTAL PROGRESS

After one-year installation and commissioning, mechanical tests were successfully taken.

Firstly, the sliding bearings and lubricating oil systems for circulator and motor were put into operation. It was done under room temperature and ordinary pressure with air. Systems were running smoothly. Oil stations for the motor and for the circulator were both tested. The interlock and protection functions were just proven perfect. Every instruments and meters was in good condition. It meant that the lubrication and ordinary bearing systems were ready for all tests.

Secondly, vibration monitoring and dynamic balance test was done. The rotation speed was gradually increasing to 4,000 rpm. And monitor results showed that the vibration met the requirement of customers and field balancing was used.

After above tests, dry gas seals were installed. Then dry gas seal system commissioning test were held. Helium were filled into the whole loop of ETF-HC, and the chamber pressure was 4.0 MPa, which is the minimum working pressure of dry gas seal. And the gas supply pressure was 4.2MPa. Under static pressure, the leakage rates of main gas seal and balancing gas seal were measured, which met the original requirement.

Under the circumstances, mechanical running tests were held. They were under 4.0MPa helium condition and

room temperature. The characteristics of helium circulator were tested under 20%-100% rotation speed. The results illustrated the good performance of mock-up helium circulator with dry gas seal.

Running tests under 7.0MPa, 243 °C would be taken next. Aerodynamic performance tests, service tests and durability tests would go on in sequence. Cold and hot states performance under normal conditions would be recorded and abnormal conditions such as emergency shut down, without cooling water of pressure-bearing plate were designed. Special tests for dry gas seals would also be conducted. Then 500h durability test, which would verify the whole system, would be in process.

These tests would show the features and performance of helium circulator with dry gas seal, and finally verify its feasibility and reliability.

RESULTS

Since lack of experience for NPP, a Mock-up helium circulator with dry gas seal was manufactured. And a research platform for it has been established. All tests could be taken on this platform. Nowadays, mechanical tests had been done and showed good performance. Lots of further tests would be held in sequence and its feasibility and reliability for HTR-PM would be verified.

ACKNOWLEDGMENTS

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