Electrical Insulation Test on Mock-up Helium Circulator for HTR-PM

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INTRODUCTION

As the world's first pebble-bed type modular HTGR commercial demonstration plant, High-temperature Gas-cooled Reactor Pebble-bed Module (HTR-PM) is under construction in Shidao bay of China. It is expected to begin generating electricity in two years.

Helium circulator is one of most important components of HTR-PM. As the unique rotating part in primary loop, it would circulate helium and transport heat through the reactor core and steam generators. The layout of helium circulator is vertical, and its rotor is supported by active magnet bearings (AMBs). The main design parameters are shown in table I [1]. Since it integrates lots of advanced designs with new technologies, experiment study is urgently required.

TABLE I. Main Rated Parameters of Helium Circulator

Parameter	Unit	Value
Working fluid	-	helium
Inlet Temperature	℃	243
Inlet Pressure	MPa	7.0
Mass flow rate	kg/s	96
Pressure rise	kPa	200
Rotation speed	r/min	4000
Speed range	%	20~105
Motor power	kW	4500
Motor voltage	V	6000

A mock-up of helium circulator was manufactured, completely same as the real machine for the plant [2]. Meanwhile, Engineering Test Facility-Helium Circulator (ETF-HC) was built in Institute of Nuclear and New Energy Technology (INET) for the tests, as Fig. 1.

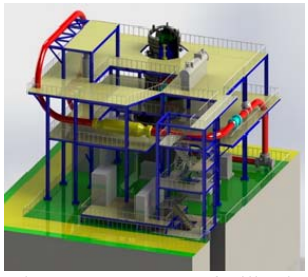

Fig. 1. ETF-HC test facility layout

ELECTRICAL INSULATION TEST

After successful factory test, the mock-up was tested on ETF-HC. Characteristics tests, endurance test [1], and 50 service cycles test were conducted. More than 500 operation hours were accumulated.

During 50 service cycles test, the insulation resistance of AMBs' windings were measured every 5 service cycles. One service cycle simulates the operation modes for nuclear power plant in a year. Fig.2 illustrates the motor parameters of one service test. Triple cold startups and stop, triple working operation mode with varying load, and triple hot trip stop and triple hot startups were included in one cycle. Thus, every 5 service cycles represented 5 years aging. The whole test was taken for almost one year. Fig.3. showed the measured results. The resistance value didn't change much, and it meant that the electrical insulation aging conditions of AMBs were good enough to continue the test.

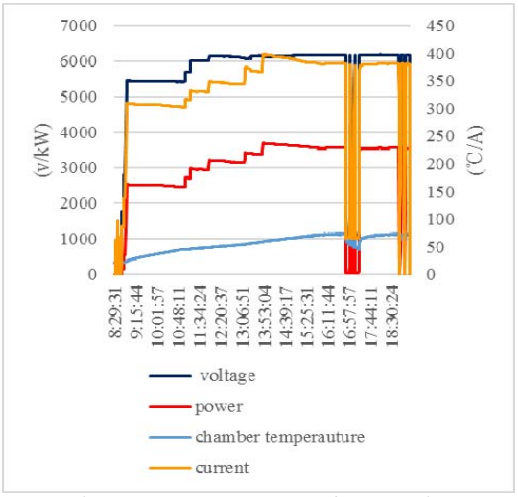

Fig. 2. Motor parameters of one service test

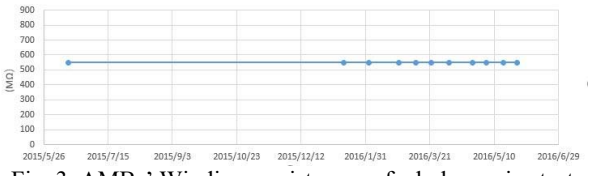

Fig. 3. AMBs' Windings resistances of whole service test

Then performance tests under abnormal conditions were taken [3]. The last one was electrical insulation test. The impact for electrical insulation when NPP is running under 1MPa helium condition, with room temperature.

Before tests, the helium pressure of main loop was adjusted to 1 MPa. The electrical insulation properties of motor and AMBs were measured. Then the mock-up was started at room temperature, until it run by 4000 rpm. All parameters were monitored for emergency case.

The whole test continued for more than 1 hour and the parameters were steady during the tests. After the tests, electrical insulation properties of motor and AMBs were measured again.

RESULTS

The test was successful. Throughout all tests' results, operation experience was accumulated and the helium circulator performance was clearly proved to meet the design requirements. It is very significant for safe and reliable operation of HTR-PM plant in the future.

REFERENCES

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