Environmental Qualification of F insulation class Formwound Motor Winding using Vacuum Pressure Impregnation

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1. Introduction

Usually, the large motors important to safety for NPPs located outside containment in PWRs. Though they work important part to safety function, they don't have to environmentally qualified because they are located in mild conditions. But the large motors in PHWRs, important to safety, must be environmentally qualified according to IEEE Standard 323 due to their location, inside containment[1].

Type test is recommended qualifying method for electric equipments, carried out type testing to qualify F insulation class formwound motors for totally enclosed type F insulation class formwound motors and open type F insulation class formwound motors both[4].

The type testing to qualify F insulation class formwound motors for totally enclosed type and open type were passed for more than 40 years in PHWRs environment parameters[4].

To use the type testing result for identical or similar motors, the motor windings must be replaced with the tested type winding in case of open type F insulation class formwound motors because they are not the same formwound windings even if they are same F insulation class.

For motors, winding is the most important component and the price of this component is more than half of total cost. It is not reasonable to rewind motor to qualify open type F insulation class formwound motors instead of buying new one.

To solve this problem, I tried to qualify open type F insulation class formwound motors not by rewinding but by re-VPI(Vacuum Pressure Impregnation) for used motors.

In this paper, I'd like to introduce the type testing result of the VPI and no-VPI F insulation class formwound motor windings.

2. Methods and Results

2.1 Purposes

The purpose of this test is to compare VPI and no-VPI F insulation class formwound motor windings to use the qualification method instead of rewinding for used motors.

2.2 IEEE Standard application for formwound motor winding

IEEE Standard 334-2006 describes criteria for qualification of continuous duty Class 1E motors, located in mild and harsh environments in nuclear power generating stations in order to demonstrate their ability to perform their intended safety functions under all required conditions[2].

The type test sequence is described in section 5.3.3 of IEEE Standard 334-2006. During the type testing, functional tests of the sample to establish base line performance and sufficient data shall be taken to verify operability under load at the extremes of the motor's operational characteristics[2].

2.3VPI Introduction

VPI(Vacuum Pressure Impregnation) process is a vacuum cycle followed by high positive pressure that forces epoxy resin into all components of the wound stator. The stator is preheated prior to VPI to drive off any moisture that might be present and baked afterwards to cure the resin. VPI can be used in a wide range of applications from insulating electrical coil windings to sealing porous metal castings. The advantages of VPI are deeper resin penetration, void-free insulation that minimizes corona, improves heat transfer and provides greater bond strength and protects against moisture, dirt and corrosive chemicals. Figure 1 shows the VPI process pictures.

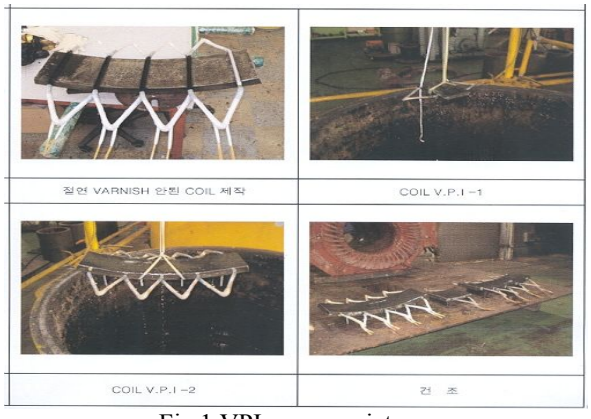

Fig.1 VPI process pictures

2.4 Test specimen preparation

For the purpose of this test to compare this test is to compare VPI and no-VPI F insulation class formwound motor windings, I designed 3 phase(4 times) winded winding can check the insulation to each phase(R-S, S-T, T-R). Figure 2 shows the design drawing of the specimen.

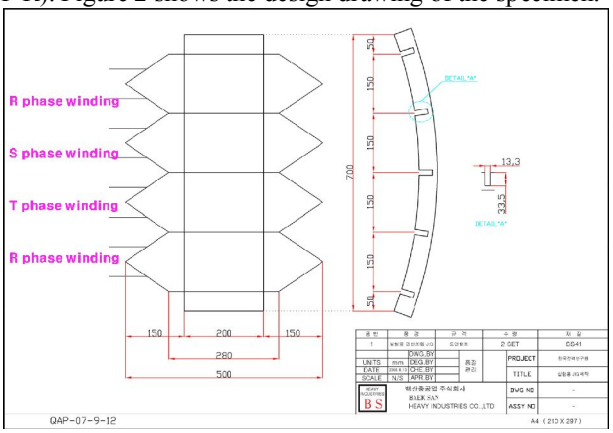

Fig. 2 the design drawing of the specimen

I prepared the VPI and no-VPI F insulation class formwound windings to compare their insulation ability at the same time. VPI material is used DVB-2122S type is useful for rust preventing and moisture proofing for the specimen will be exposed in high pressure and temperature condition during the test. Figure 3 and 4 shows VPI and no-VPI specimen.

Fig. 3 VPI specimen

Fig. 4 no-VPI specimen

2.5 Test result

Type test were implemented according to IEEE Std 323-2003(1983, 1974) and IEEE 334-2000(1994). After preparing two specimen, baseline function test, normal radiation exposure test, thermal aging test and accident radiation exposure test were implemented. Right after all test step, function tests were implemented to verify the performance deterioration. Function tests are IR(insulation resistance) test for each phase to phase and IR test for each phase to ground. Before the DBE(design basis event) simulation test, both specimen showed almost the same insulation ability compared to the baseline function test results[3].

DBE simulation test was implemented for the two specimen. During the DBE simulation test, VPI specimen showed strong insulation ability in higt pressure, high temperature and almost 100% steam condition. On the other hand, no-VPI specimen showed radical decline of insulation ability ends to short for phase to phase and phase to ground. Figure 5 shows the picture of DBE simulation chamber installed specimen.

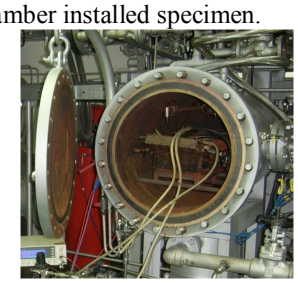

Fig. 5 DBE simulation chamber installed specimen

3. Conclusions

EQ type testing were implemented for VPI and no-VPI F insulation class formwound motor windings.

VPI F insulation class formwound motor winding maintained its insulation ability for all the test process even in DBE simulation test.

Even though no-VPI F insulation class formwound motor winding maintained its insulation ability before DBE simulation test, the specimen showed insulation failure during the DBE simulation test.

VPI F insulation class formwound motor winding with VPI material DVB-2122S is environmentally qualified.

The test result shows VPI can improve insulation ability for F class formwound motor windings and the specimen will be normally operable in the DBE steam environment for open type motors.

This result can be used to qualify F insulation class formwound used motor windings. It will be reasonable to perform VPI than rewinding the used open type motor.

REFERENCES

[1] IEEE Standard, “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations”, IEEE Std 323-2003

[2] IEEE Standard, “IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations”, IEEE Std 334-2006

[3] IEEE Standard, “IEEE Recommended Practice for Testing Insulation Resistance of Rotating”, IEEE Std 43-2000

[4] K.H.Park, “Determination of the Minimum Acceptable Value of Insulation Resistance for Formwound Motor Winding EQ Test” KEPCO RI, Korean Nuclear Society Spring Meeting, 2009