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## The Influence of Air Gap Thickness between the Stator and Rotor on Nuclear Main Pump

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### Abstract

The canned motor pumps are commonly used as main pumps in nuclear primary circuit systems, because the typically outward leakage clearance in general centrifugal pumps does not exist in the canned motor pumps. The longer air gap thickness between the motor stator and the rotor, the more cooling liquid flowing through the air gap, which results the heat exchange becomes better between the motor and the cooling liquid and the temperature rise of the motor is lower. These are all good for improving the motor efficiency at the angle of the view, the temperature rise. From another angle of the view, the electromagnetism, the longer thickness between the motor stator and the rotor, the weaker interaction between the stator and rotor magnetic fields, which results the Lorentz force becomes weaker and the torque becomes smaller, and also the motor efficiency becomes lower. Therefore, there is an optimum value of the air gap thickness between the stator and the rotor, to balance the temperature rise and the electromagnetism interaction. In this paper with the case of 30kW canned motor, the coupled analysis of the heat exchange and the electromagnetic performance was studied. The influence of the air gap thickness on the motor temperature rise and on the electromagnetic performance was discussed respectively, and then the optimum value of the air gap thickness was given.

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### Keywords:

Canned pump; Air gap thickness; Electromagnetism interaction; Motor efficiency

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### 1. Main text

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### 1.1 INTRODUCTION

The traditional electric pump in the structure is the motor and pump through the coupling combination, so that the motor drives the impeller to rotate. As a result of this dynamic seal connection, resulting in serious leakage problems pump, which will not only cause the loss of working fluid, but also cause environmental pollution, or even direct harm to personal safety. With the rapid development of industrial production and the growing concern about environmental issues, the nuclear industry is increasingly urgent demand for non-leaking main pump. The canned motor pumps with no leakage characteristics, its technology development and application get more and more attention. Compared with the traditional pump, the canned pump has these advantages, such as high reliability, compact structure, and low noise, fully closed.

It is the trend of industrial development of pump applications. In order to prevent the working fluid corroding the motor and causing short circuit, stator and rotor of the motor each equipped with a shielding sleeve. This special structure of the motor is the canned motor. There is a great eddy current loss in the shielding sleeve. At the same time as the air gap is greater than the same power level of the general motor, excitation current is also large. For these reasons, when the canned pump is rated for operation, the motor rated current is large and winding loss is high, so that the overall loss of the canned motor is large. The larger power loss makes the canned motor temperature rise and temperature distribution is different from general motor. However, these differences have great significance for the motor life.

Yamazaki investigated the high temperature abnormal phenomenon caused by circulating current of canned motor at the end region, a 5000 k W canned induction motor is taken as an example. In that study, a mathematical model of 3-D electromagnetic and temperature field was established based on the electromagnetic field and temperature field theory. ERGENE established the mathematical model for 2D transient electromagnetic field analysis, and then analyzed magnetic flux lines and air-gap flux density by using circuit-field coupled time-stepping finite-element method. The obtained conclusion provides certain guidance for the designing of super high speed PM machine. In order to explore the effect of gap on the electrical insulation characteristics of winding insulation used in inverter-fed traction motor, BINNS simulated the electric field distribution characteristics in the air gap. The gap influence on the partial discharge characteristics of the inverter fed traction motor turn insulation under square impulse voltage was tested. Wang YUSHI and Yao Zhenjiang have analyzed the structure of canned induction motor within nuclear reactor coolant pump, and the expression of eddy current loss has been derived from the theory of electromagnetic eddy current combined with the finite element method. The shielding sleeve's eddy-current loss has been also analyzed and calculated by establishing two-dimensional eddy-current field finite element model. However, in their study, the coupling between heat transfer and electromagnetic performance is not considered. In this paper, 30kW canned motor is taken as the research object. Considering the influence of different air gap thickness on the electromagnetic performance and heat dissipation of the motor, the comprehensive performance of the motor under different air gap thickness is analyzed. The optimal value of 30kW shielded motor air gap thickness is obtained.

### 1.2 NUMERICAL SIMULATION

As shown in Fig.1, it is a typical canned motor structure. There are mainly 10 parts in the canned motor. There is an air gap between the rotor shielding sleeve and stator shielding sleeve. The working fluid flows through the air gap and takes away the heat from the canned motor. Therefore, its thermal performance is better than the general air-cooled motor. Meanwhile, the shielding sleeves bring additional eddy current losses.

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