Analysis of Electrical Parameters of Generator Motor No-load Operation Fault

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Abstract. In the context of my country's full effort to build pumped storage power stations, my country has the ability to independently research and develop pumped storage power stations, and has set a development goal to manufacture pumped storage units with larger single-unit capacity and higher speed. Generator motors play an important role in the safe and stable operation of power systems, and have a significant impact on power grids and power stations. This paper establishes a physical model of the damping winding of the generator motor, simulates the change of electrical parameters when a short-circuit fault occurs in the no-load operation of the generator motor, and obtains and analyzes the change rule, which has great theoretical and practical significance.

Keywords: Generator motor, short circuit fault, electrical parameters.

1. Introduction
In the past 10 years, with the vigorous development of my country’s industry, my country has the ability to build large-scale nuclear power plants and can operate 600MW steam turbine generators. This has eased the pressure on my country’s power industry to a certain extent. However, due to the load of the power system The peak-valley difference is increasing [1- 4]. Therefore, it is of great significance to quickly build pumped-storage power stations, improve the power supply quality of the power system, increase the operating efficiency of pumped-storage units, and rationally use energy. In this paper, the short-circuit fault state of the generator motor is simulated and analyzed, and the changes of various electrical quantities before and after the motor failure are analyzed, and then the electrical parameter change law is obtained [5- 8].

2. Establishment of Physical Model of Damping Winding of Generator Motor
The rotor magnetic pole damper winding structure is shown in Figure 1.
In Figure 1, because the electromagnetic field calculation model in this paper is a symmetrical model of a twenty-fourth circle, in order to facilitate the analysis of the electrical parameter distribution of the damping winding at different positions, the structure of each part is clearly explained, and the pumped-storage generator motor in this article for a magnetic pole research object, the damping bars are now numbered, and the numbers are in a clockwise direction, and the size increases gradually. As can be seen from the figure above, there are 7 damping bars in total, set the damping bar number as $z_i$, $i=1, 2, 3, 4, 5, 6, 7$. The order is that the damping strips on the left side of the magnetic pole are numbered 1, 2, 3, 4 from left to right, and the right side of the magnetic pole is numbered 5, 6, and 7 from left to right.

3. Simulation Analysis of Electrical Parameters of Short Circuit Fault in No-load Operation

3.1. Electrical Parameters Change When Single-phase Grounding is Short-circuited.
When the motor is running under no-load conditions, the motor is running at rated speed at this time, and the excitation current is the rated excitation current. Set the stator side of the motor, and the phase A winding has a single-phase grounding short-circuit fault. The change curve is shown in Figure 2, Figure 3 and Figure 4.
As can be seen from the above figure, when the motor is running under no-load conditions under abnormal power generation conditions, the load current and back EMF will have a jump, which far exceeds the rated value of the motor, posing a serious threat to the operation of the motor.

3.2. Change of Electrical Parameters When Short Circuit between Phases
When the motor is under no-load conditions, set the stator side of the motor, A and B two-phase windings have a phase-to-phase short circuit fault. The change curve is shown in Figure 5, Figure 6, and Figure 7.

**Fig. 4** Single phase grounding short circuit torque variation curve under no load operation

**Fig. 5** Interphase short circuit current variation curve under no load operation

**Fig. 6** Interphase short circuit voltage variation curve under no load operation
3.3. Changes in Electrical Parameters when Two Phases are Short-circuited to Ground.

When the motor is under no-load conditions, set the motor stator side, A and B two-phase windings have a two-phase grounding short-circuit fault. The change curve is shown in Figure 8, Figure 9, and Figure 10.

![Interphase short circuit torque variation curve under no load operation](image1)

**Fig. 7** Interphase short circuit torque variation curve under no load operation

It can be seen from the above figure that when the motor is operating under abnormal power generation conditions, such as a phase-to-phase short-circuit fault, the load current and back EMF surge, and its value is the highest under the three short-circuit faults.

![Two phase grounding short circuit current variation curve under no load operation](image2)

**Fig. 8** Two phase grounding short circuit current variation curve under no load operation

![Two phase grounding short circuit voltage variation curve under no load operation](image3)

**Fig. 9** Two phase grounding short circuit voltage variation curve under no load operation
In order to compare and analyze the calculation results more intuitively, when the motor is running under no-load conditions, when a single-phase grounding short circuit, an interphase short circuit, two-phase grounding short circuit and other external short-circuit faults occur, the back EMF, short-circuit current and electromagnetic torque maximum values of torque parameters are shown in Table 1, and the effective values of electrical parameters after a stable fault are shown in Table 2.

**Table 1.** Comparison of maximum value of parameters of external short-circuit fault of generator/motor under no-load operation

| Failure form               | Single phase to ground short circuit | Short circuit | Two phases to ground short circuit |
|---------------------------|--------------------------------------|---------------|----------------------------------|
| $I_{\text{max}} / \text{kA}$ | 55                                   | 145           | 135                              |
| $E_{\text{max}} / \text{kV}$ | 21                                   | 19            | 8.1                              |
| $T_{\text{e max}} / \text{MNm}$ | 74                                   | 81            | 70                               |

**Table 2.** Instantaneous values of parameters for generation/motor under no load operation after fault stabilization

| Failure form | Single phase to ground short circuit | Short circuit | Two phases to ground short circuit |
|--------------|--------------------------------------|---------------|----------------------------------|
| $I_A / \text{kA}$ | 25.01                               | 30.52         | 23.91                            |
| $I_B / \text{kA}$ | 0                                   | 30.47         | 22.77                            |
| $I_C / \text{kA}$ | 0                                   | 0             | 0                                |
| $E_A / \text{kV}$ | 0                                   | 7.53          | 0.85                             |
| $E_B / \text{kV}$ | 14.55                               | 7.45          | 0.91                             |
| $E_C / \text{kV}$ | 14.37                               | 15.31         | 6.42                             |
| $T_e / \text{MNm}$ | 7                                   | 8             | 6                                |

When the generator motor is running under no-load conditions, an external short-circuit fault occurs at this time, and the back EMF, current, and torque fluctuate violently. After a period of transient state, it turns to a steady state. At this time, the back EMF, the stator current and the electromagnetic torque value tend to a constant value over time. Cross-comparing Table 1, Table 2 with the simulation results shows that the calculation results are similar to the actual operation conditions, which verifies the accuracy of the model establishment. It can be seen from the data in the table that when the motor has...
an external short-circuit fault, the effective value of the electrical parameters far exceeds its rated value, which is likely to cause motor vibration, overheating and other hazards, threatening the safe and stable operation of the motor.

When a single-phase short circuit occurs in the generator motor, the maximum current is 55 times the rated value, the maximum voltage is 14.65 times the rated value, and the maximum electromagnetic torque is 9.5 times the rated value, which will cause serious impact on the rotor core and shaft. Causes rotor eccentricity fault; in the case of a phase-to-phase short circuit of the motor, the maximum current is 145 times in the rated state. If the neutral grounding resistance is not taken into account, it is easy to cause overheating, burn the stator winding, and damage the insulation layer. The maximum voltage is the rated state 13.31 times, the maximum torque is 9 times in the rated state; the motor has a two-phase grounding short-circuit fault, the maximum current is 135 times in the rated state, the maximum voltage is 5.6 times in the rated state, and the maximum torque is the rated state Down 8.87 times. When the generator motor is put into actual operation, the neutral point grounding resistance can be used to suppress the peak current and control it within a safe interval to avoid danger.

4. Summary
This article concludes as follows:

When the generator motor is under no-load conditions, an external short-circuit fault occurs, which will seriously affect the safe and stable operation of the motor. When a single-phase short-circuit occurs, the maximum electromagnetic torque is 9.5 times the rated value, which will bring damage to the rotor core and shaft. Severe impact can easily cause rotor eccentricity failure;

The phase-to-phase short-circuit fault in the external short-circuit fault has a particularly serious impact on the motor. In the case of a phase-to-phase short circuit of the motor, the maximum stator side current is 145 times in the rated state, and the maximum back-EMF is 13.31 times in the rated state. Excessive current and voltage values can easily cause overheating of the stator side and eventually damage the insulation layer, even with the safety hazards of burning the stator windings.

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