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Short Circuit Fault Simulations in an HTS Wind Generator with Different Mechanical Conditions

X. Huang, Z. Huang, A. Zhao, B. Zhu and Z. Jin

Shanghai Jiao Tong University, China

Introduction

1) Performances of a 2.5 MW HTS wind generator **under short circuit fault conditions** are studies by **coupling finite element method (FEM) model** and **equivalent circuit model**.

2) This study aims to find **the influence of different mechanical conditions** on simulation results of fault model, and **provides a criterion** to set the mechanical conditions.

3) Three different methods are used to set the mechanical conditions: **constant rotation speed method**, **constant torque method** and **constant power method**.

4) The influence of **moment of inertia** on **field current** is researched to find a way to protect the HTS winding during fault.

Three methods

1) Constant rotation speed method

The rotor rotates **at the rated speed constantly** after the fault occurs.

2) Constant torque method

Considering **rotation speed variation**, the governing equation is:

$$T_m - T_e = J\frac{d\omega}{dt}$$

where T_m **stays constant** after the fault occurs.

3) Constant power method

Considering **rotation speed variation**, the governing equation is:

$$\frac{P_{in}}{\omega} - T_e = J\frac{d\omega}{dt}$$

where T_m **stays constant** after the fault occurs.

Short circuit model

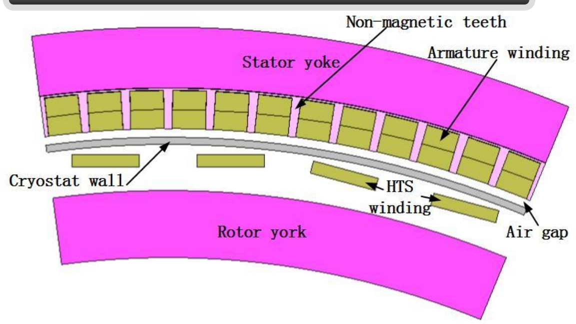

Fig. 1. Illustration of a one-pair-poles segment of 2.5 MW HTS wind generator

Parameter	Value
Power	2.5 MW
Voltage	690 V
Speed	14.5 rpm
Frequency	2.9 Hz
No. of pole-pairs	12
Outer radius	2180 mm
Active axial length	642 mm
Width of HTS tape	12 mm
No. of layers per coil	2
No. of tapes per layer	350
Operating temperature	30 K
Operating current	575 A

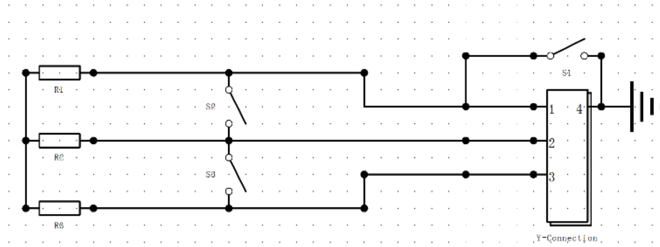

Fig. 2. Equivalent circuit of short circuit fault in the HTS wind generator

Short circuit fault type	S1	S2	S3
Three-phase fault (L-L-L)	0	1	1
Two-phase grounding fault (L-L-G)	1	1	0

Field current

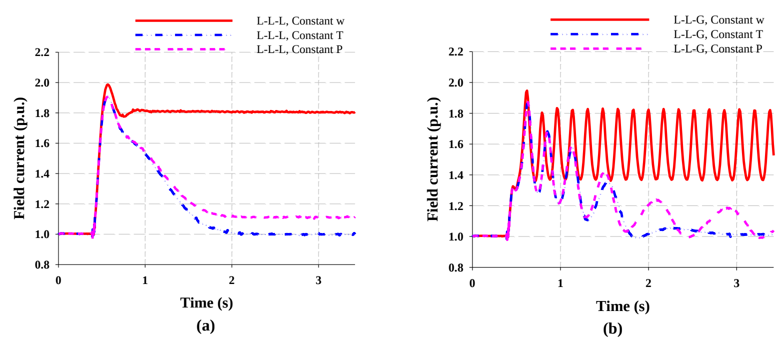

Fig. 6. Field current waveforms of the HTS wind generator under (a) L-L-L; (b) L-L-G short circuit fault conditions

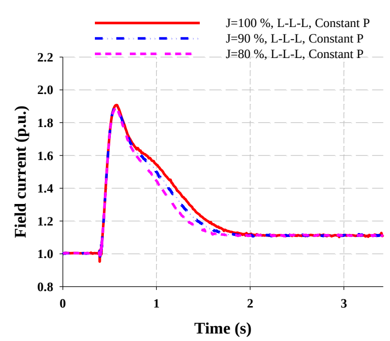

Fig. 7. Field current waveforms of the HTS wind generator with different moments of inertia

Rotation speed

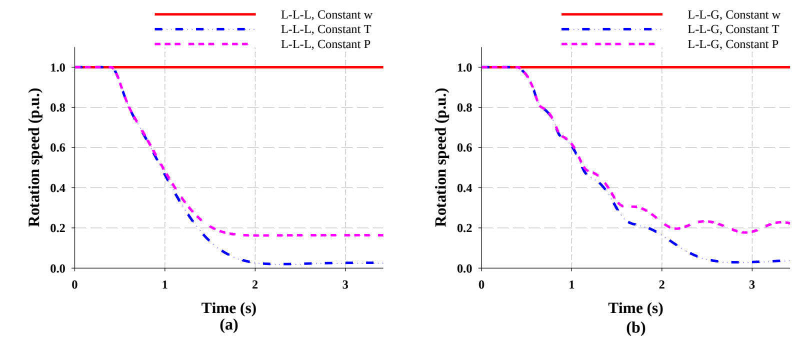

Fig. 3. Rotation speed waveforms of the HTS wind generator under (a) L-L-L; (b) L-L-G short circuit fault conditions

Electromagnetic torque

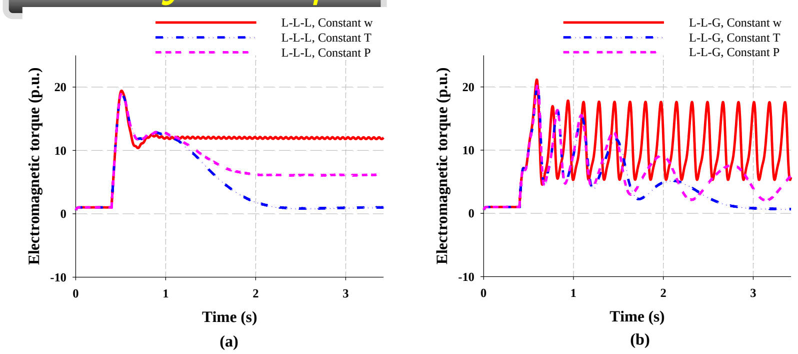

Fig. 4. Electromagnetic torque waveforms of the HTS wind generator under (a) L-L-L; (b) L-L-G short circuit fault conditions

Phase current

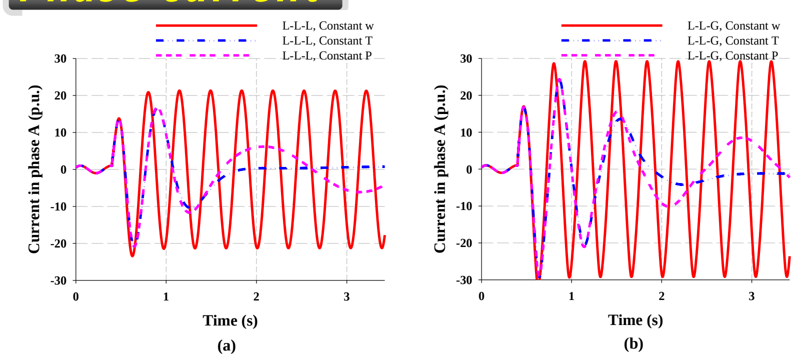

Fig. 5. Current waveforms in phase A of the HTS wind generator under (a) L-L-L; (b) L-L-G short circuit fault conditions

Conclusion

1) The short circuit fault models in three methods result in **similar peak values** in transient processes, then **different mechanical conditions take effect** and lead to **different final states**. Based on this finding, the optimal method can be chosen to model an HTS wind generator under short circuit fault conditions depend on simulation time, that is, **any one method** for **transient peak values**, but **the constant power method** for **the whole process**.

2) **Decreasing the moment of inertia** to **decelerate the rotor more rapidly** during the fault is effective on protecting the HTS winding by **shortening the pulse width** of field current

上海交通大學 SHANGHAI JIAO TONG UNIVERSITY