THE CURRENTS OF THE INDUCTION MACHINE DURING THE FAULT

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Abstract: This paper deals with calculation of the currents in the loaded induction machine during the fault. 2D model of the induction machine is created in the Maxwell program where the stator and rotor windings (cage winding) are created in the next step. These windings are supplied and connected by an external circuit of a Simplorer program. This program makes possibilities to simulate of different operating state such as are fault, short circuit, no load state, load state, start etc. The disconnection of the rotor windings (rotor bars) are simulated in this case.

Keywords: induction machine, state, bar, cage, fault current, Ansys Maxwell

1. INTRODUCTION

Many companies know that permanent magnets are very expensive and a rare earth fields are very limited. Due to this fact it is important to deal with the machine such as the induction machines (without permanent magnet). The aim of this paper is induction machine model creation with rotor bars coupling. This model makes possible to the state simulation of this machine such as a start, short circuits and faults of the rotor bars. There are simulated three states. The first state is without faults and the next two states are faulty. The four rotor bars (adjoining) are disconnected in the first case of the faults (hereinafter *Fault1*) and the fourteen rotor bars (adjoining) are disconnected in the second case of the faults (hereinafter *Fault2*). Time behaviors of stator currents, torques, speeds and core losses are results of magnetic analysis.

2. 2D MODEL OF THREE PHASE INDUCTION MACHINE

Program Ansys RMXprt is use for a model creation. This program sub-serves to analytical solution of a machine steady state. Next table (Table 1) shows nominal values of the simulated machine and material properties. A Draw of 2D model is not necessary because RMXprt makes possible to export 2D model to the Ansys Maxwell program.

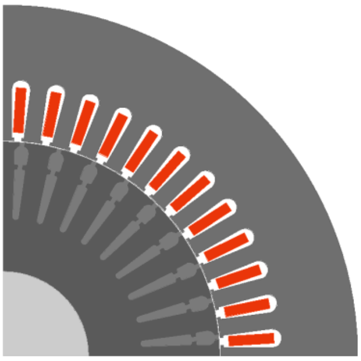
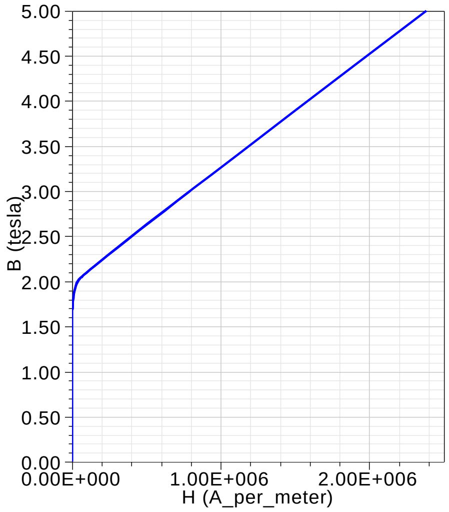


Figure 1 2D Model of Induction machine.

TABLE I

LIST OF PARAMETERS AND MATERIALS

Machine parameters		BH curve of M54 steel:	
P [W]	7500		
n [rpm]	1450		
2p [-]	4		
f [Hz]	50		
U [V]	400/D		
T [°C]	85		
STATOR		ROTOR	
Number of slots	48	Number of slots	36
Type	3 phase	Type	Double cage
Material	Cu/ Fe M54	Material	cast Al/ Fe M54
Hysteresis core loss coefficient		$k_h = 790$	
Eddy-current core loss coefficient		$k_e = 0,6$	
Excess core loss coefficient		$k_c = 0,3$	



3. ANALYSIS

Following analysis is done for nominal load and operating temperature 85°C. Transient simulations are analyzed from reason of currents, torques, speeds and core losses finding with the time duration 300ms. Results are analyzed in the next sections.

3.1. CURRENTS

When the subtransient and the transient state subsides the current steady state value is 14.88A (Fig. 2). A peak value of subtransient state is six times bigger than steady state value. The peak currents values are changing with a period during the Fault1 (Fig. 3). The current ripple is very loaded by the fourteen rotor bars disconnecting (Fig. 4).

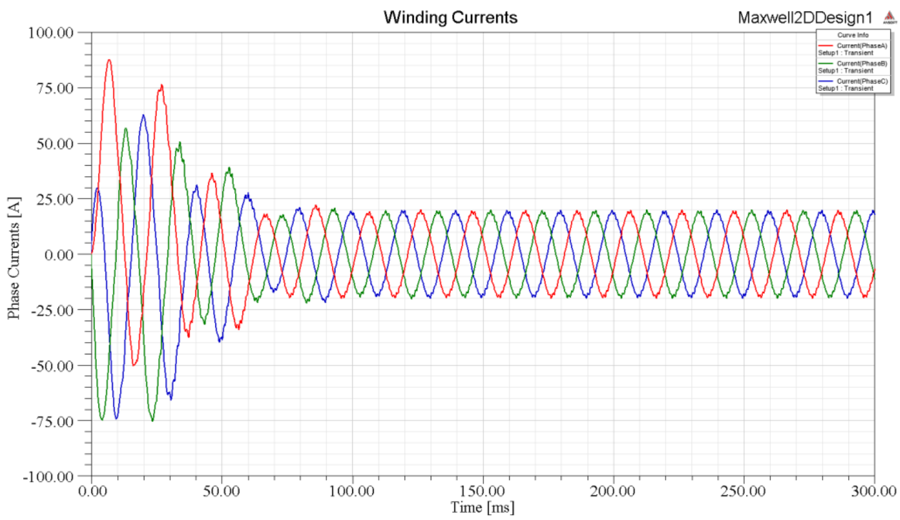


Figure 2 Three-phase currents in loaded induction machine.

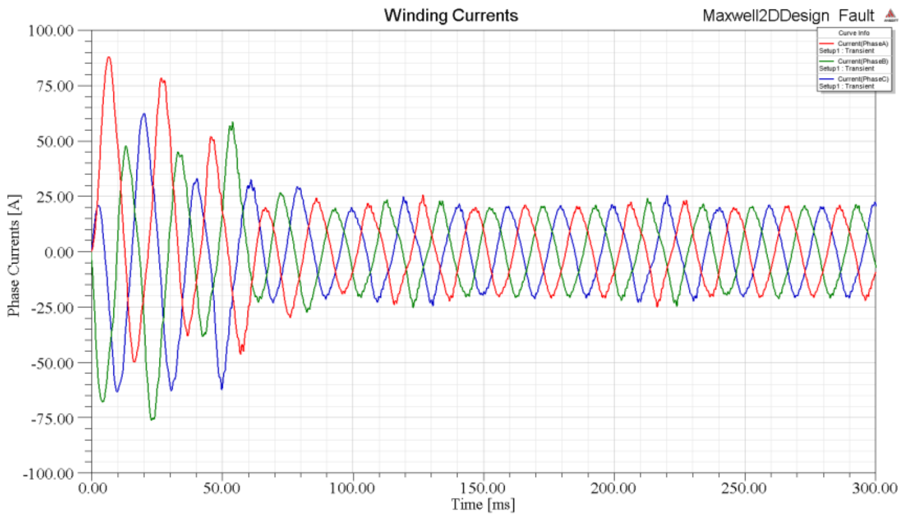


Figure 3 Three-phase currents in loaded induction machine during Fault1 – four bars are disconnected.

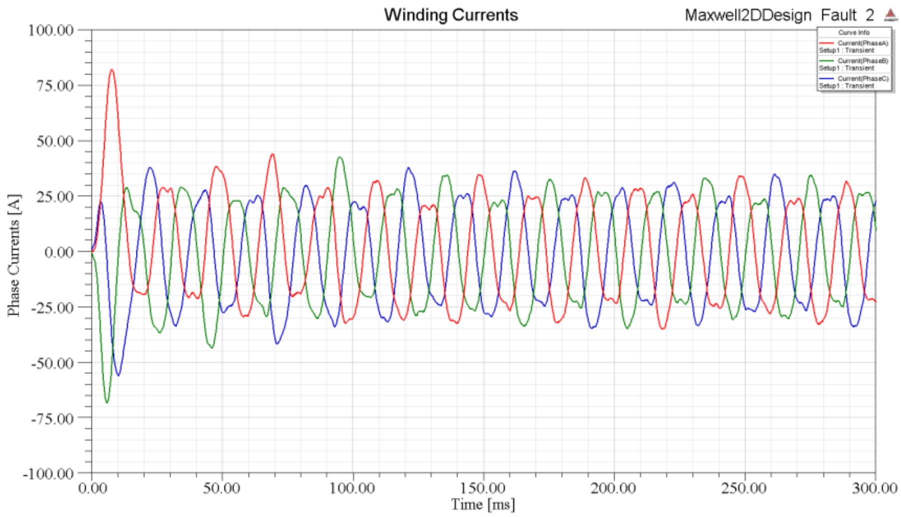


Figure 4 Three-phase currents in loaded induction machine during Fault2 - fourteen bars are disconnected.

3.2. COMPUTATION OF CORE LOSS FROM A SINGLE-FREQUENCY LOSS CURVE

A calculation of core losses is described in this part. The principles of the computation algorithm are summarized as follows. The iron-core loss is expressed as:

$$p_v = p_c + p_h + p_e = K_1 B_m^2 + K_2 B_m^{1,5} \tag{1}$$

Where the eddy-current loss is:

$$p_c = k_c (f B_m)^2 \tag{2}$$

The hysteresis loss is:

$$p_h = k_n f {B_m}^2 \tag{3}$$

And the excessive loss is:

$$p_e = k_e (f B_m)^{1,5} \tag{4}$$

Therefore:

$$\begin{gathered} K_1 = k_h f + k_c f^2 \\ K_2 = k_e f^{1,5} \end{gathered} \tag{5}$$

Where f is frequency and B_m is maximum of induction.

3.3. CORE LOSS, SPEED AND TORQUE

The time behaviors of the core losses are showed in Fig. 5. The core losses are biggest during The Fault2 from reason of current increasing.

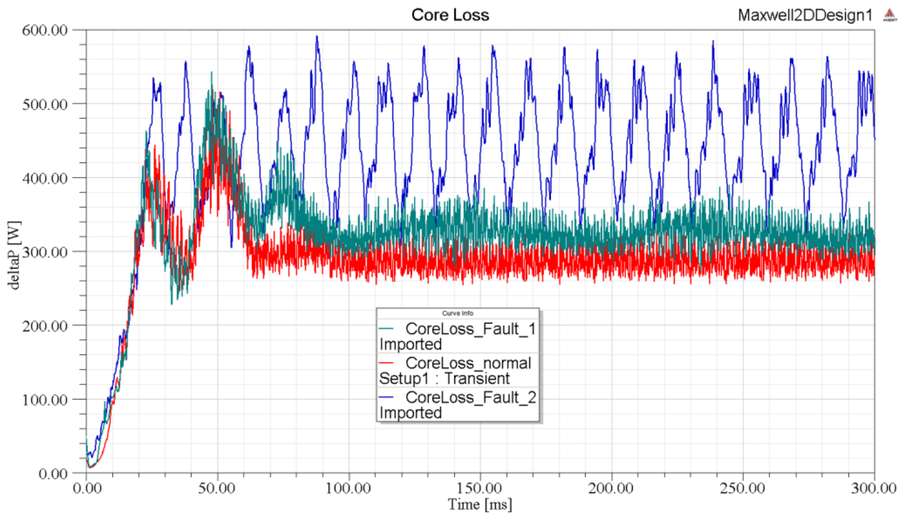


Figure 5 Core Losses in M54 material.

The steady state speed value is nominal but the speed is changing with the period during the Fault1. The steady state speed value is 400rpm during the Fault2 (Fig. 6). The machine is not able to right function in this state.

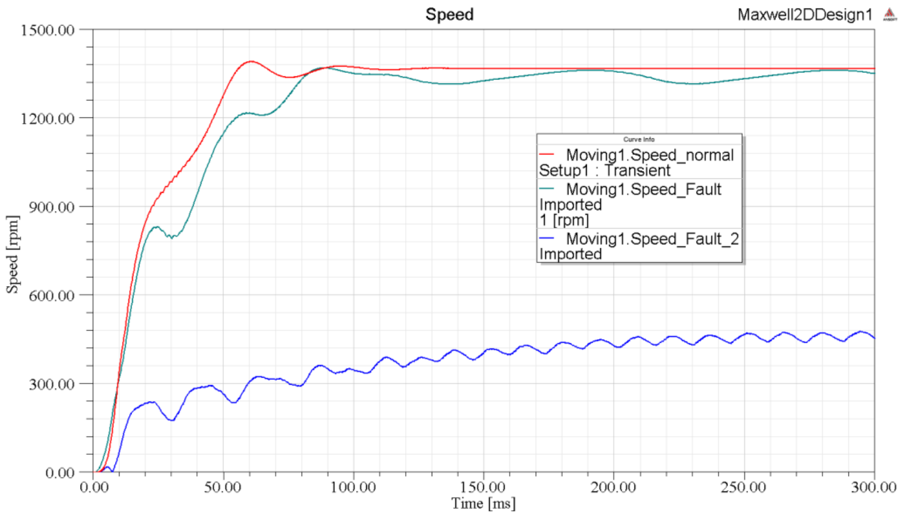


Figure 6 Speeds of all fault types.

The time behaviors of the all torques correspond with the speeds. The torque value is nominal during the state without the faults. The torques are changing with the period during the faults and the torque value is half during the Fault2 (Fig. 7).

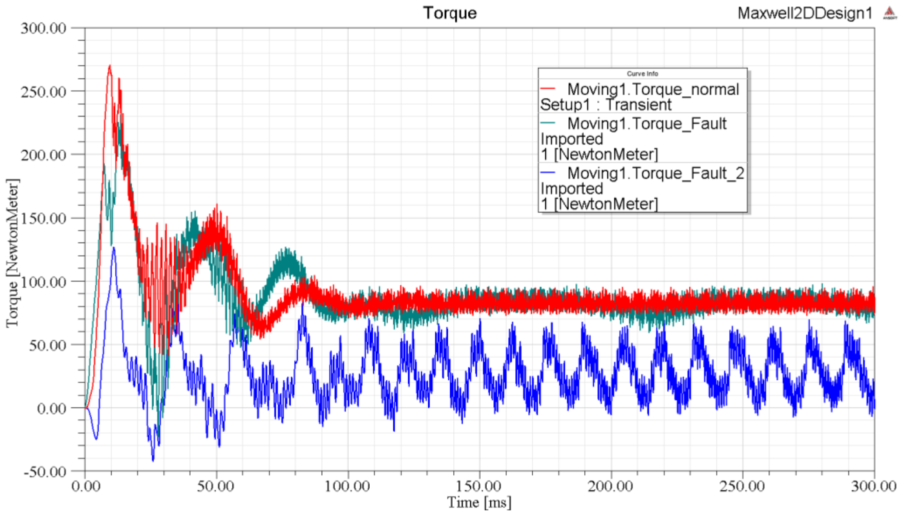


Figure 7 Torques of all fault types.

4. CONCLUSION

This paper deals with the 2D simulation of the faults in the induction machine with the cage winding. Program Ansys Maxwell is used to solve of the currents, the speeds, the torques and the core losses. The machine is solved in the three states. The first state is without faults and it sub-serves to the comparison with the fault states. The faults are a rotor bars disconnection here. Four bars are disconnected during the Fault1. The currents are little bit rippled (Fig. 3). The torque (Fig. 7) and the speed (Fig.6) are not steady too. Fourteen bars are disconnected during the Fault2. The current ripple is very high (Fig. 4) where difference of the maximum values is 16A between without faults state and Fault2 state. The speed and the torque are very rippled. The core loss is bigger from reason of the current increasing during the Fault2.

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