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STATOR AND ROTOR CURRENTS ANALYSIS OF THE INVERTED ROTOR INDUCTION MOTOR

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ABSTRACT

A new approach for the design and construction of inverted rotor induction motor is presented. In this paper we propose a novel approach for constructing special induction motor. Stator and rotor current characteristics of an inverted rotor induction motor have been investigated. This motor has mechanical revolving characteristics both rotor and stator. The induction machine could be described as a three input, three output object either stator or rotor side. It is possible to make measurement for definition of the stator rotor parameters on this type construction. The objective of this paper is to propose three different type operation classification and comparison of them. By comparing three different experimental operation values are carried out and shown clearly. Experimental data have been recorded by using Fluke 434 Harmonic Analyzer device.

Keywords: *Stator Currents, Rotor Currents, Slip, Power Quality, Harmonic Distortion, Rotating Field, No-load test, Inverted Rotor Induction Motor, Blocked rotor test*

1. INTRODUCTION

This paper presents a unique induction motor. In which induction motor with mechanical revolving characteristics on the rotor and stator has been designed. Rotor and stator currents of this induction motor have been analyzed. Stator and rotor windings are wounded as two layers. Also measurement coils are placed in to same slots of the stator and rotor windings. Additional rotor rings are used for measurement coils connection in the rotor slots. This research and production technique will allow construction of induction motors with higher efficiency.

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Experimental data have been obtained while induction motor is being fed from the stator windings. Thus, rotor is being revolved.

2. STATOR AND ROTOR CURRENT ANALYSIS OF THE INVERTED ROTOR INDUCTION MOTOR

The terminals of the three stator phase windings are star-connected. Stator windings are connected to a balanced three-phase power supply. The stator currents flowing in each phase will be equal in magnitude and 1200 out of phase with each other. Inverted rotor induction motor is used experimentally in this research is depicted in Fig.1

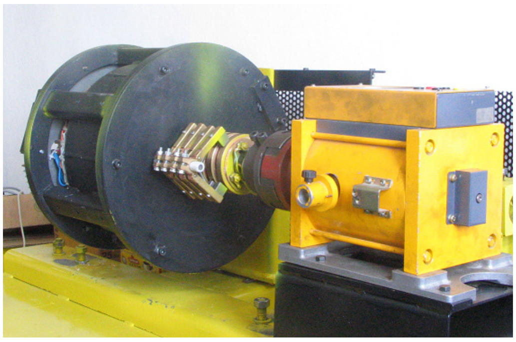

Figure 1. Inverted rotor induction motor

Equations of the voltages applied from the source to the motor can be written as follows:

$$
\begin{aligned}
v_a &= V_m.\sin \omega t \\
v_b &= V_m.\sin\left(\omega t + \frac{2\pi}{3}\right) \\
v_c &= V_m.\sin\left(\omega t - \frac{2\pi}{3}\right)
\end{aligned}
\qquad (1)
$$

Equivalent circuit diagram for an inverted rotor induction motor on a per phase basis referred to the stator is given in Fig.2. Rotor parameters are referred to the stator side in that equivalent circuit diagram.

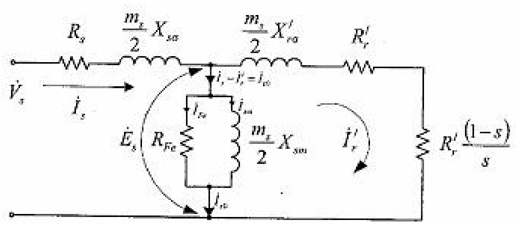

Figure 2. Equivalent circuit diagram for induction motor on a per phase basis referred to the stator.

Current waveforms have been investigated for no-load operation, load operation, blocked rotor operations of the inverted rotor induction motor. Measured values have been analyzed and evaluated. Harmonic components of the stator current wave form have been varied as odd components such as (n=3,5,7,..).

It is necessary to make standardization power quality and harmonics to pull down of the current harmonics to the certain level. Total harmonic distortion (THD) in the current can be calculated to that given by Eq. 2

$$
THD_i = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1} = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + I_6^2 + \ldots}}{I_1} \qquad (2)
$$

To quantify the distortion in the current waveform, a quantity called the total harmonic distortion is defined as Eq.3

$$
\%THD_i = 100 \times {}^{I_{dis}}\!/_{I_{s1}} \qquad (3)
$$

3. STATOR AND ROTOR CURRENT ANALYSIS FOR NO-LOAD OPERATION OF THE INVERTED ROTOR INDUCTION MOTOR

The rotor revolves at very nearly the synchronous speed of the stator field during the no-load operation. The difference in speed is just sufficient to produce enough current in the rotor to overcome the mechanical and electrical losses. Current waveform of the for no-load operation is given in Fig.3.

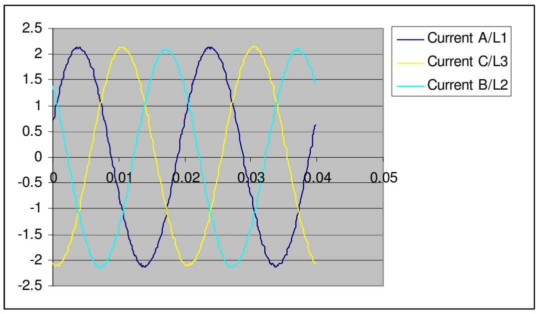

Figure 3. Stator current waveforms for no-load operation

Harmonic spectrum of stator current waveform is given in Fig.4.

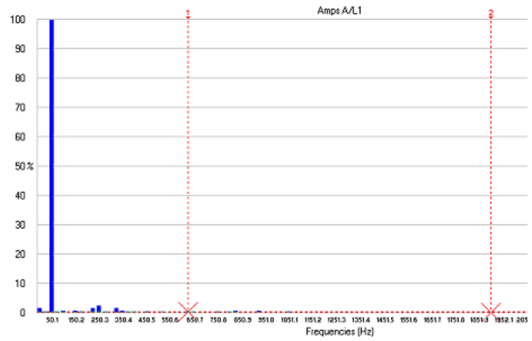

Figure 4. Harmonic spectrum of the stator current waveform for no-load operation

The rotor current waveform for no-load operation is shown in Fig.5. Because of the slip; rotor current frequency of the induction motor was 1 Hz. Harmonic spectrum of the rotor current waveform for no-load operation is shown in Fig.6.

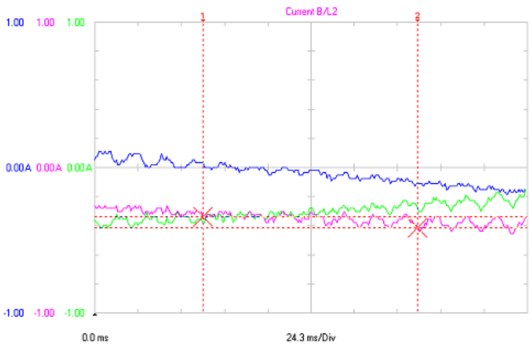

Figure 5. The rotor current waveform for no-load operation

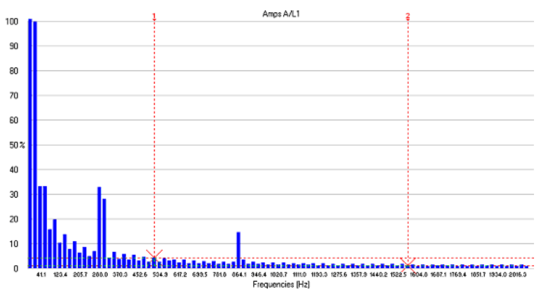

Figure 6. Harmonic spectrum of the rotor current waveform for no-load operation

Harmonic spectrum of rotor current waveform gives idea variations of the high order harmonics by taking into the consideration as a reference to the stator current waveform. High order harmonics of the rotor currents are more than the stator currents. Therefore, we should investigate the effects of the motor parameters. For this reason, we should have done load operation and blocked rotor operations of this motor. Harmonic analysis is performed by using these experimental values.

4. STATOR AND ROTOR CURRENT ANALYSIS FOR LOAD OPERATION OF THE INVERTED ROTOR INDUCTION MOTOR

The input power to an induction motor P_{in} is in the form of three-phase electric voltages and currents. The first losses encountered in the machine are I^2R losses in the stator windings (the stator copper loss P_{SCL}). Then some amount of power is lost as hysteresis and eddy currents in the stator *(P_{core})*. The power remaining at this point is transferred to the rotor of the machine across the air gap between the stator and rotor. This power is called the air-gap power P_{AG} of the machine. After the power is transferred to the rotor, some of it is lost as I^2R losses (the rotor copper loss P_{RCL}), and the rest is converted from electrical to mechanical form *(P_{conv})*. Finally , friction and windage losses $P_{F\&W}$ and stray losses *Pmisc* are substracted. The remaining power is the output of the motor P_{out} .

Stator current waveforms with harmonic contents for load operation are given in Fig.7.

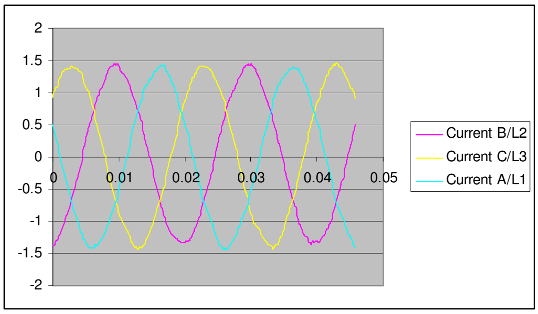

Figure 7. Stator current waveforms for load operation

Harmonic spectrum of the stator current waveform for load operation is given in Fig.8

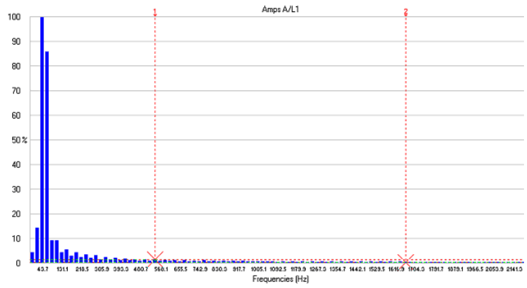

Figure 8. Harmonic spectrum of the stator current waveform for load operation

Rotor current waveform for load operation is seen in Fig.9. As load increases slip is increased. This causes increasing on the rotor current frequency. Rotor current frequency on the load operation is higher than the no-load operation. Harmonic spectrum of the rotor current waveform for load operation is shown in Fig.10

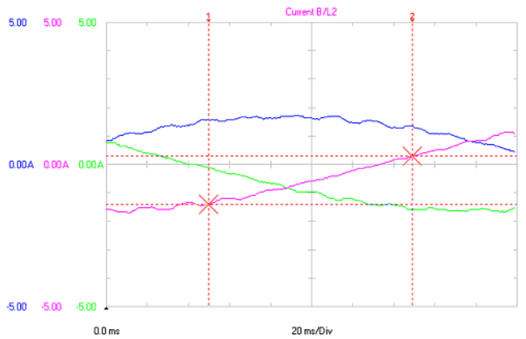

Figure 9. The rotor current waveform for load operation

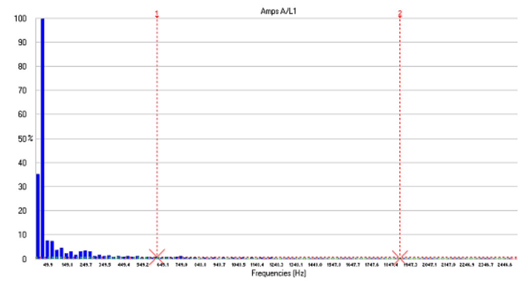

Figure 10. Harmonic spectrum of the rotor current waveform for load operation

High order harmonic value of the rotor current on the load operation is become more than no-load operation. In order to understand the harmonic increasing is related with slip or not; the blocked rotor operation has been achieved.

5. STATOR AND ROTOR CURRENT ANALYSIS FOR THE BLOCKED ROTOR OPERATION OF THE INVERTED ROTOR INDUCTION MOTOR

Since rotor can not turn, n_r =o and slip s = 1 or 100% for the blocked rotor operation. This corresponds to the condition at start up and we would expect currents that are five to six times their rated value. For this reason, as with transformers during the short-circuit operation, that the applied stator voltage is reduced to such a voltage, permitting rated stator current to flow. The input power to an induction motor losses encountered in the machine are I^2R losses in the stator windings and some amount of power is lost as hysteresis and eddy currents in the stator (P_{core}). There is no friction and windage losses $P_{F\&W}$ and stray losses during the blocked rotor operation. Stator current waveforms for the blocked rotor operation are given in Fig.11.

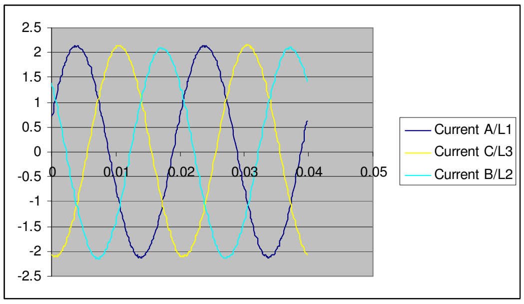

Figure 11. Stator current waveforms for the blocked rotor operation

Stator current waveforms are seem in sinusoidal shape don't contain any harmonic components. This result is verified by the harmonic spectrum of the stator current waveform for the blocked rotor operation as seen in Fig.12.

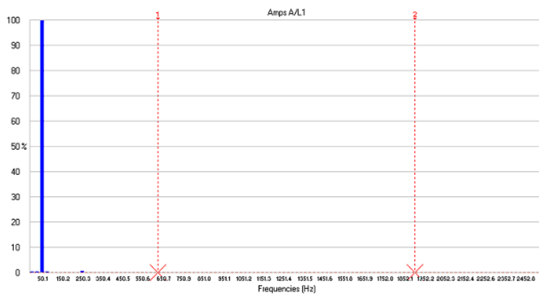

Figure 12. Harmonic spectrum of the stator current waveform for the blocked rotor operation

Since induction motor behaves like as transformers during the short-circuit operation, rotor current waveform looks like stator current waveform as seen in Fig.13. This result is verified by the harmonic spectrum of the rotor current waveform as seen in Fig.14.

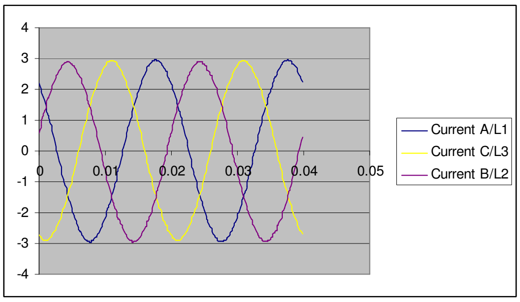

Figure 13. Rotor current waveforms for the blocked rotor operation

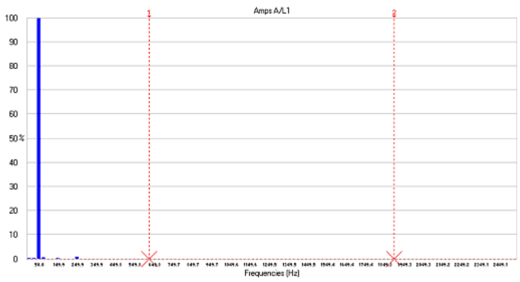

Figure 14. Harmonic spectrum of the rotor current waveform for the blocked rotor operation

There is harmonic difference between the blocked rotor operation wave forms and no-load operation or load operation wave forms.

6. CONCLUSION

All experiments performed with inverted rotor induction motor have always shown various harmonic effects on the stator and rotor currents. From stator and rotor currents its possible determines circuit parameters are nonlinear. Therefore, it is inevitable occurrence of the high order harmonics. On the other hand, from the stator and rotor currents harmonics are increased for no load and load operations. Incremental variation of harmonics on the stator and rotor currents is based on slip. Because as load increased harmonics are increased on the stator and rotor currents.

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