

Effect of the Core Loss Resistance on the Steady State Performances of SEIG

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ABSTRACT

Thanks to its many advantageous, induction machine has more and more popular in the application of the autonomous production of the electrical power in the isolated areas. Like all system, self-excited induction generator suffers from same drawbacks like the poor voltage and frequency regulations. In order to overcome them, the first step is to determine the performances with a good accuracy. In the most published works, the core loss resistance is neglected which can degrade the accuracy of the determined results. In the present paper, we present the effect of the core loss resistance in the performances characteristics of the SEIG by comparing on a 0.8-KW induction generator the different performances with and without core loss. The computed results prove the effect of the core loss in the performance characteristic of the SEIG.

Keywords— Performances, Induction generator, core loss resistance.

I. INTRODUCTION

Recent studies have shown that the installed wind power generation capacity in the world has been increasing during the last few decades. Traditionally, synchronous generators are very commonly used in conventional large-scale power plants. Thanks to their relative advantageous features over the synchronous generators, induction generators are increasingly being used in generating systems based on alternative energy sources [1]. These features are rugged constructed, simple, robust, less expensive and require very little maintenance. Unlike synchronous machines, induction machines can be operated at variable speeds. They do not require external power supplies to produce magnetic flux for maintaining the desired voltage at the generator terminals. Hence, they are very much suitable for remote and isolated area applications [2-3].

As every system, induction generator suffers from same drawbacks. The major drawbacks in the use of self excited induction generators are the poor voltage and frequency regulations under prime mover speed and load perturbations [4-5]. In order to improve the efficiency of the presented system an imperative step is to evaluate with a good accuracy the different performances of SEIG.

In most published study, the different performances are determined with a neglected core loss resistance [6, 7, 8, 9]. This assumption is adopted to simplify the static study of the SGEI and hence the evaluation of these performances. Thus, the including of the core loss resistance introduces excessive complication in the resolution of the characteristic model of the generator [10, 11].

This paper present the effect of the core loss resistance on the performance of the self excited induction generator, this effect is explained by comparing the computed performances with and without taking account of the core loss resistance in the equivalent per phase circuit.

II. MATERIALS AND METHODS

Often, steady state performances of SEIG are based on per phase equivalent circuit [13, 14]. This latter, is shown in fig.1 where $R_1, R_2', R_f, R_L, X_{1s}, X_{2s}', X_c, X_m, X_L$ and g represent the stator resistance, rotor resistance (referred to stator), core loss resistance, load resistance, stator leakage reactance, rotor leakage reactance (referred to stator), excitation capacitor reactance, magnetizing reactance, load reactance and the generator slip respectively. All parameters are considered constant except the magnetizing reactance and the generator slip which vary respectively according to the saturation characteristic and the prime mover speed. Unlike the most of the published works core loss resistance is not neglected thus give more accuracy to the determined performances. In the present study, nodal admittance approach is used to analyze the self excitation process of the induction generator.

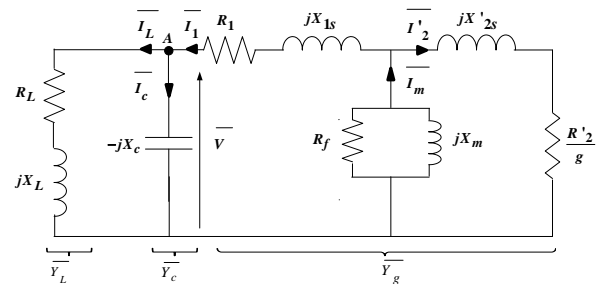


Fig1. Per phase equivalent circuit of SEIG

Where, \bar{Y}_g, \bar{Y}_c and \bar{Y}_L can be represented by using the equivalent circuit as follows:

$$\bar{Y}_g = \frac{1}{R_1 + jX_{1s}' + \left((R_f // jX_m) // (jX_{2s}' + \frac{R'2}{g}) \right)}$$

$$\bar{Y}_c = \frac{1}{-jX_c}$$

$$\bar{Y}_L = \frac{1}{R_L + jX_L}$$

At node "A" in Fig.1, the relation between \bar{I}_1, \bar{I}_L and \bar{I}_c can be written as:

$$\bar{I}_L + \bar{I}_c - \bar{I}_1 = 0 \quad (2)$$

The above equation can be expressed as follows:

$$\bar{V} (\bar{Y}_g + \bar{Y}_c + \bar{Y}_L) = 0 \quad (3)$$

Under normal operating conditions, the stator voltage $\bar{V} \neq 0$. Therefore, the sum of the admittances must be equal to zero.

$$(\bar{Y}_g + \bar{Y}_c + \bar{Y}_L) = 0 \quad (4)$$

This implies that both the real and imaginary parts of (4) would be separately zero.

$$\begin{cases} \text{Re}(\bar{Y}_g + \bar{Y}_c + \bar{Y}_L) = 0 \\ \text{Im}(\bar{Y}_g + \bar{Y}_c + \bar{Y}_L) = 0 \end{cases} \quad (5)$$

Resolution of (5) leads to find the values of F and X_m for fixed excitation capacitor, speed, and electrical passive load. Solution of equation (5) is not easy to achieve by conventional methods. In this work, resolution of equation (5) is achieved using a numerical MATLAB function which is explained in [ICEESA].

III. RESULTS

In this part, Performance analysis under no load, and loaded operation, variable prime mover speed and variable excitation capacitance operation were conducted on a three-phase, four poles, 50-Hz, 380-V, 2-A, 0.8Kw star/star connected wound rotor induction generator. Whose equivalent circuit constants are $R_1 = 8.21\Omega$, $R_2' = 6.73\Omega$, $R_f = 300\Omega$, $X_{1s} = 19.06\Omega$, $X_{2s}' = 19.06\Omega$. We note that in all figure the interrupted lines represents the performances with the adopted hypothesis (core loss resistance is neglected), and the continued lines represents the performance without the hypothesis (with core loss resistance).

Under no loaded operation, the variation of the terminal voltage and the frequency, against excitation capacitance for various prime mover speeds are shown in fig2 and fig3, respectively. Further, Stator phase voltage and Frequency, against prime mover speed for various capacitances are shown in fig4 and fig5, respectively.

At loaded operation, the variation of the terminal voltage, against load current for various excitation capacitances and speeds are shown in fig6 and fig9, respectively. The variation of the stator current as function of the load current and for different capacitance is shown in fig7. Furthermore, the variation of the frequency against load current and for various excitation capacitances firstly, and for various speeds secondly, are shown in fig8 and fig10, respectively.

In the different figures the performances captured with a neglected core loss resistance are different then the author calculated where we taking account of the core loss resistance this proves the limit of the adopted hypothesis in the most published studies. Consequently, the determined performances with the last hypothesis conducted in an error results and false interpretation.

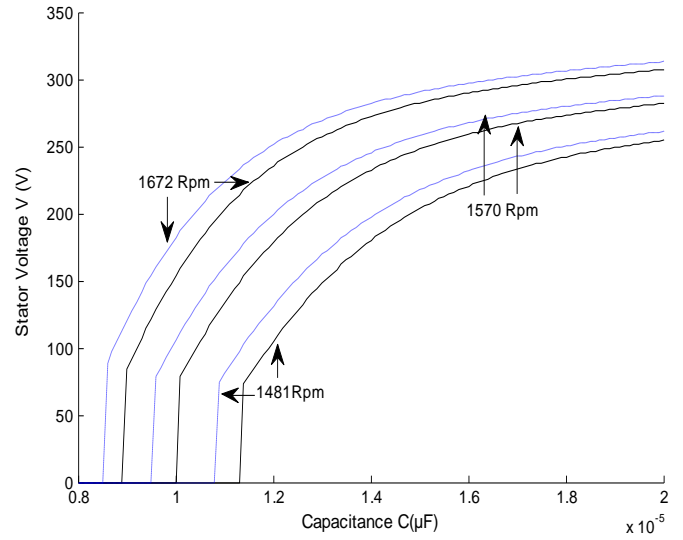


Fig.2 Stator voltage against capacitance for various prime mover speeds

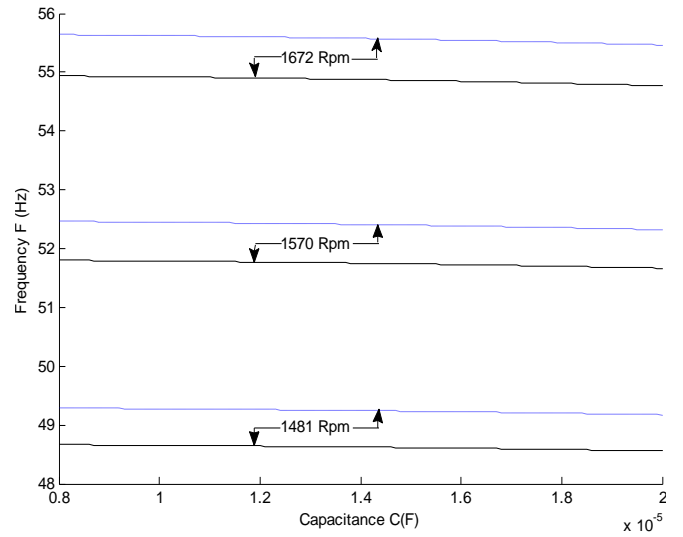


Fig.3 Frequency against capacitance for various prime mover speeds

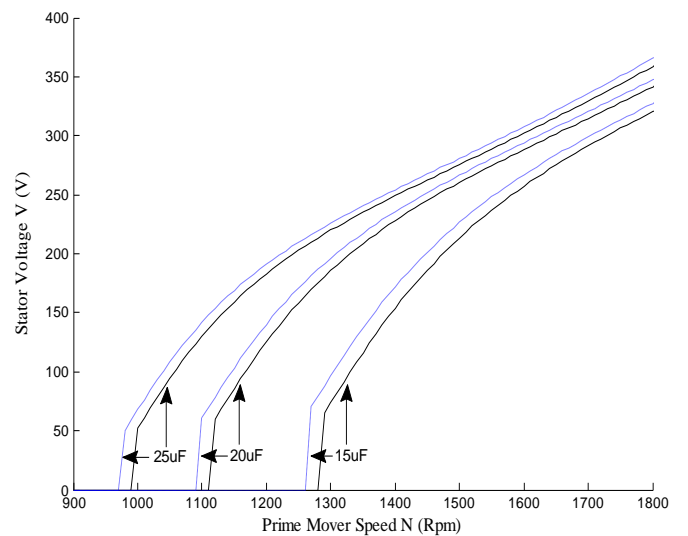


Fig.4 Stator voltage against prime mover speed for various capacitances

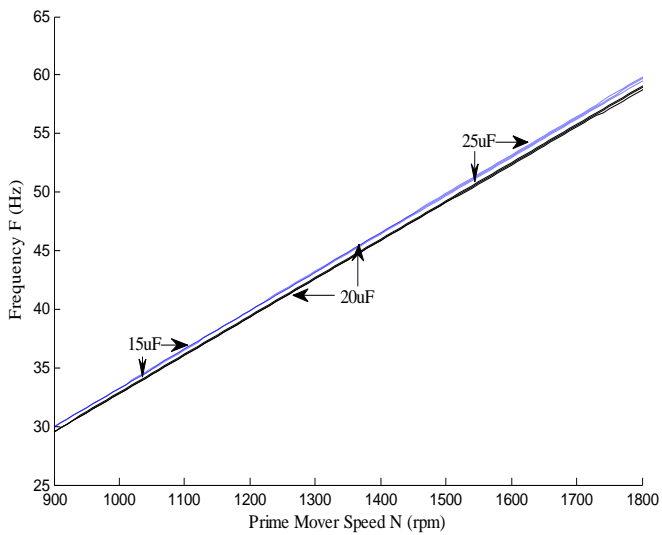


Fig.5 Frequency against prime mover speed for various capacitances

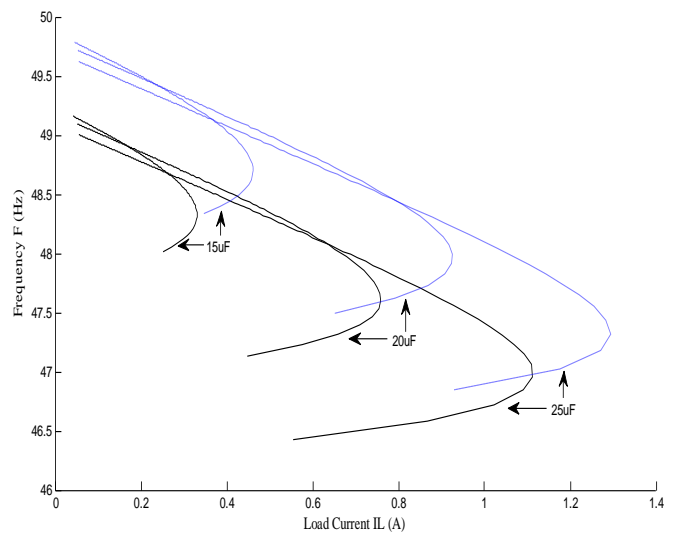


Fig.8 Frequency against load current for various capacitances

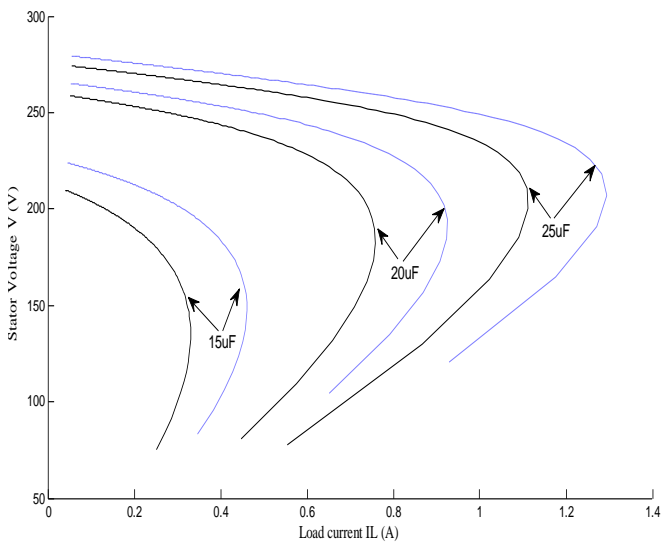


Fig.6 Stator voltage against load current for various capacitances

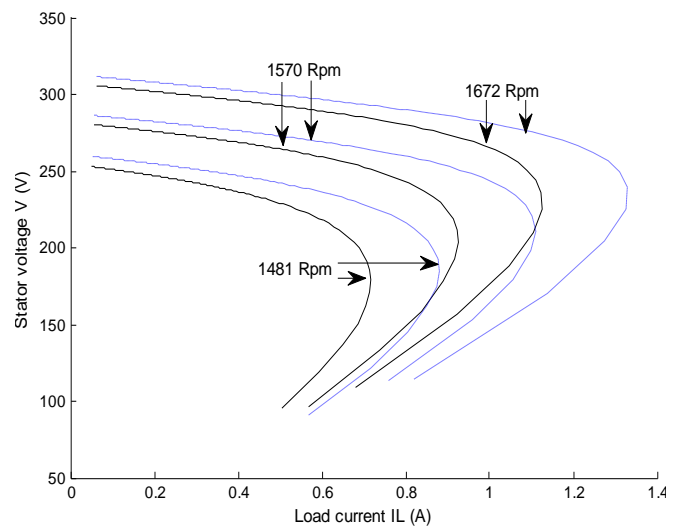


Fig.9 Stator voltage against load current for various speeds

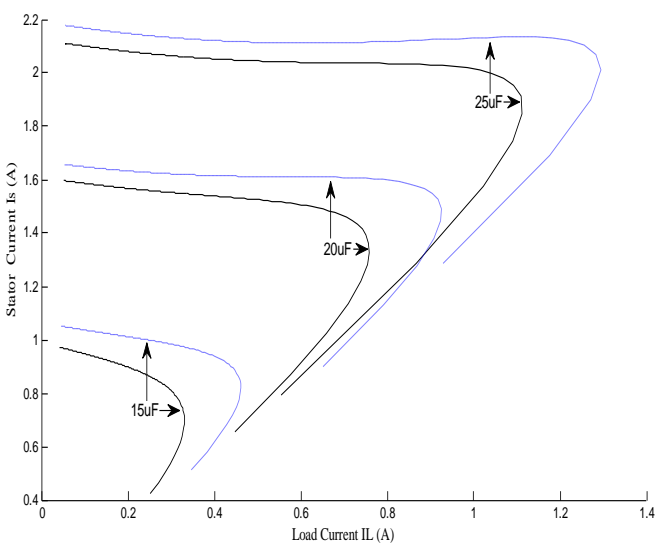


Fig.7 Stator current against load current for various capacitances

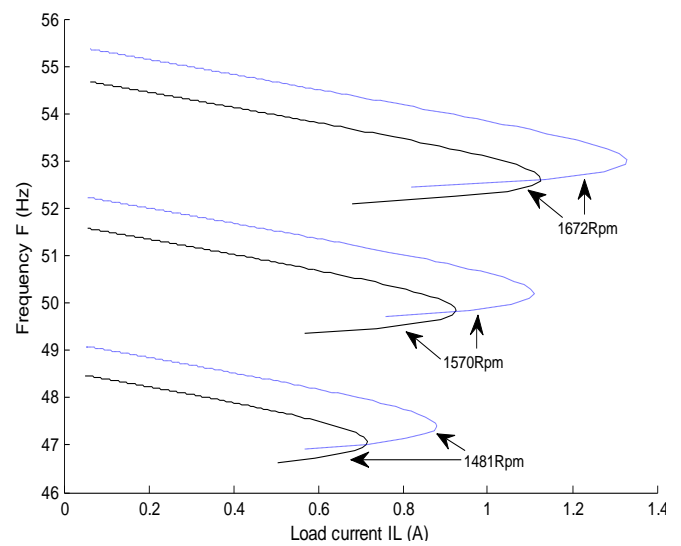


Fig.10 Frequency against load current for various speeds

IV. DISCUSSION

Under no loaded operation, a comparison between characteristics with and without a core-loss resistance of the evolution of the stator phase voltage and the the Frequency against the excitation capacitance and for three different prime mover speeds, 1481 rpm, 1576 rpm and 1672 rpm, is determined in fig2. and fig2., respectively . Thus, a comparison, with the same reasoning, for the voltage variation but this time against the prime mover speed and for various capacitance, 15 μ F, 20 μ F and 25 μ F, was conducted by the Fig 4. We note that in all performances characteristics a significant difference between that determined without considering the core losses resistance and with that calculated taking into account this last parametrs. In fig 2, we notice that the include of the core loss resistance introduce an increase, reaches approximately 0.25 μ F, in the capacity needed for initiating voltage buildup. Thus, the same remarque for the characteristic presented in fig3. Indeed, for a fixed capacity, include of the core loss resistance increase the minimum of speed required for the initiating voltage build up. Likewise, the presented variation of the frequency as fonction of the speed and the capacitance schow a difference between us calc ulated with and without core loss resistance.

Under loaded operation, the same comparison was made for the variation of the terminal voltage, the stator current and the frequency against load current and for various capacitances, 15 μ F, 20 μ F and 25 μ F, and it is mentioned in fig6, fig7 and fig8, respectively. Briefly, in the different cited characteristics an offset between the compared curves is observed. Then, the maximum injected current computed with the core loss resisyance is lower than that calculated with the adopted hypotthess.

therefore, these various no loaded and loaded performances prove the effect of the core loss resistance on the computed performances results of the self-excited induction generator.

V. CONCLUSIONS

In the present paper, the effect of the core loss resistance on the performances analysis of the self excited induction generator has been presented. However, this effect is mentioned in the different performances calculated under loaded and no loaded operation. The presented comparisons between the calculated performances with the core loss resistance and them without it prove consistent effect of this parameter on the accuracy of the determined results. The degradation of the accuracy performances due to the neglected core loss resistance leads, revilement, to false results and a bed interpretation and consequently ironed contribution for the drawbacks of the studied self excited induction generator.

VI. REFERENCES

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