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Theoretical and Experimental Estimation of the Skin Effect on the Asynchronous Machine

The paper presents an experimental method to determine the skin effect in comparison to the theoretically one and the influence on the rotor parameters of the asynchronous machine with short-circuited rotor winding.

***Keywords**: skin effect, method, asynchronous machine*

1. Introduction

In case of the alternative current machine, cause of the jumping-up current effect, reflected in a growing up of the resistance in the alternative current circuits in comparison to those in continue current, additional lost appear. The windings resistance, in this case those for the short-circuited rotor, are computed based on the Volt – Ampere method, but this get changed cause of the skin effect, depending on the frequency value of the induced rotor voltage. The experimental and theoretical estimation of this effect, presents the objective of this paper.

2. Theoretical and experimental method

The skin effect influence the value of the rotor resistance R_R, depended on the frequency [3]. Cause of the skin current, the wire section is just partial used from the alternative current component, because, once the frequency increase, and the current gets shallow in the rotor wire.

The deepness bite of the current depending on the frequency [7] is computed with the relation:

$$d = \sqrt{\frac{1}{2\pi f_{RR}\mu_0\sigma_{Al}}} \tag{1}$$

where d – deepness bite; f_{RR} – rotor frequency; μ_0 – magnetic permeability; σ_{Al} aluminums conductivity.

Based on the grid frequency and the mechanical speed, the rotor currents frequency can be computed through:

$$f_{RR} = f_{Grid} - \frac{\omega_{mec}\, p}{2\pi} \tag{2}$$

To compute value of the rotor resistance R_R we suppose the "classic" form of the transversal section, as shown in figure 1.

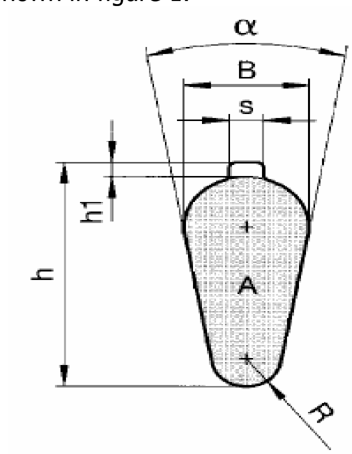

Figure 1. Notch of the rotor

The section is formed through a half circle in the superior part [2], [5] trapezium and a half circle in the inferior part, figure 2. Depending on the deepness bite, a certain percent of the section is used. Starting from the moment on that the section surface reduces, the rotor resistance modifies too.

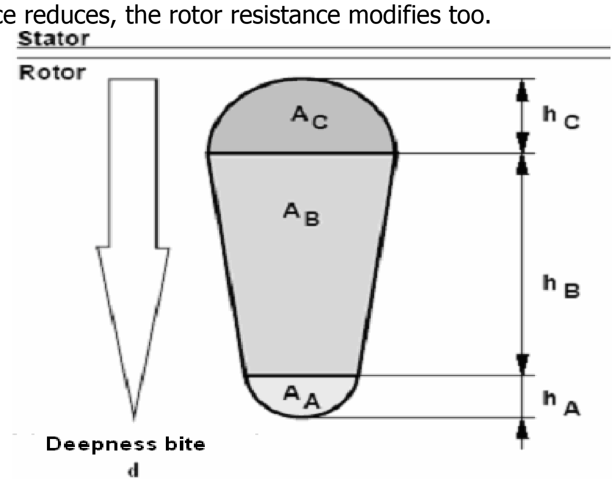

Figure 2. Analyze of the rotors notch section

Another variant that makes allowance for the skin effect influence the rotor parameters are through implementing their dependence on the slide [6].

The rotor resistance change once with the frequency of the rotor currents f_2, with the motors rev [1], principle from $f_2 = 0$ by idle stroke to $f_2 = 50$ Hz (starting).

The floating resistance with the slide s ($s = f_2/f_1$) can be expressed as being linear, figure 3,

$$R_2 = R_{20} + a_1 s \tag{3}$$

where R_{20} – the rotor resistance by idle stroke (s=0).

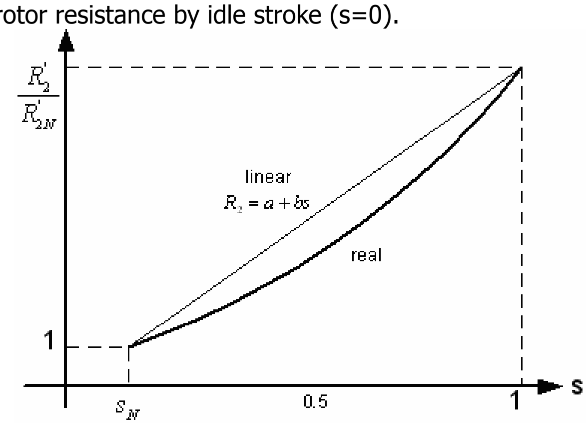

Figure 3. Rotor resistance depending on slide

The values for the constants R_{20} and a_1 are obtained from the nominal and the starting values, building the equation system:

$$\begin{aligned} R_{2N} &= R_{20} + a_1 s_N \\ R_{2P} &= R_{20} + a_1 1 \end{aligned} \tag{4}$$

where R_{2N} – rotor resistance in nominal regime ($s = s_N$) and R_{2P} – the rotor resistance when the process starts (s = 1).

3. **Implementation in Matlab / Simulink**

To implement the theoretical method we use the relation that expresses the dependence of the rotor resistance deepness bite (R_{Rd}) with the rotor resistance (R_R) and the notch's surface (A_{notch}) and the notch surface with the deepness bite (A_{notch_d}).

$$R_{Rd} = R_R \frac{A_{notch}}{A_{notch\_d}} \tag{5}$$

To assure an efficient processing of the useful notch surface, in function of the deepness bite, will be lineared of portion [4] and the values introduced in the so called 'look-up table' of Simulink, figure 4.

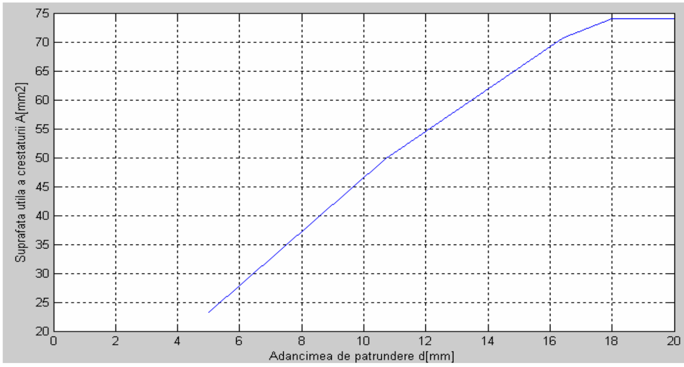

Figure 4. Usefull notch surface

Equations (1) (2) and (5) will be implemented, figure 5, and complete the general model of the asynchronous machine

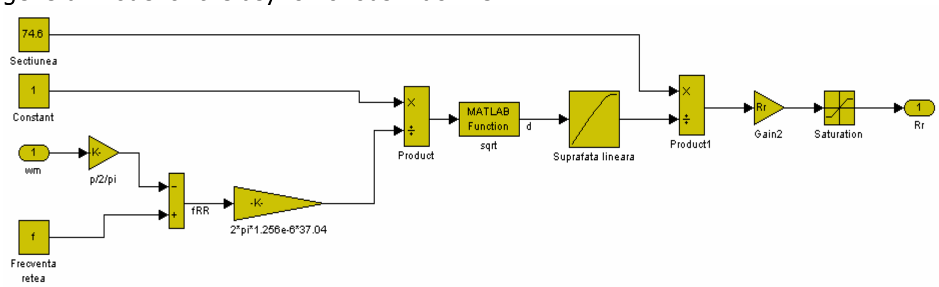

Figure 5. Implementetion of the efekt skin on the value of the rotor resitance

The proposed experimental method, equation (3) and (4) will be also implemented in Matlab / Simulink, figure 6, and, for the same numerical values, compared with the results obtained in the theoretical one.

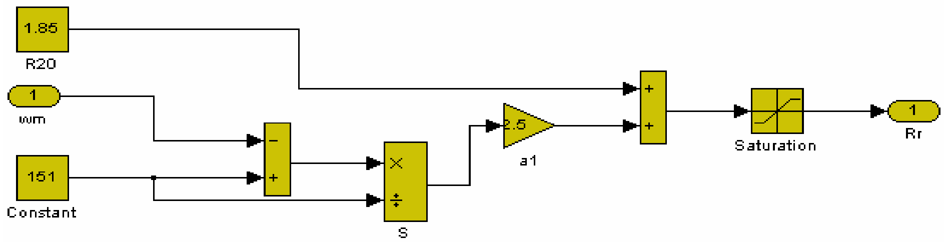

Figure 6. Dependence of the rotor resistance variation with the slide, implemented in Matlab / Simulink

As next, we present a comparison of the results for the current, figure 7, and the rotor speed [7], figure 8, evolution depending on the two implementation methods of the skin effect (blue line – theoretic; black line - experimental) on the rotor resistance, as well the evolution of current and rotor speed, without skin effect (red line - ideal).

It has been observed, based of the implementation of these two methods, that where the influence of the deepness bite is considered, the simulation needs a higher computing volume and, normally, a higher time to run, but a more precise result to the practical behavior.

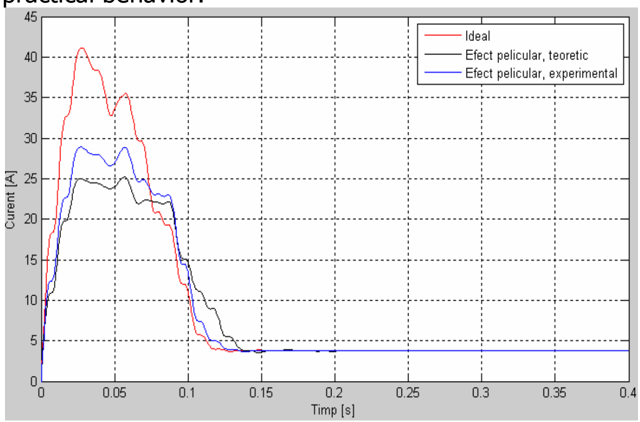

Figure 7. Time evolution for the situations: ideal, skin effect computed theoretic, skin effect experimental estimated

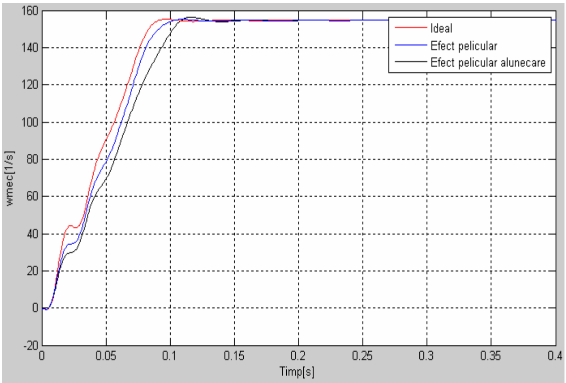

Figure 8. Time evolution of the rotor speed for the situations: ideal, skin effect computed theoretic, skin effect experimental estimated

4. Conclusion

The present paper presents an original computing method of the rotor resistance floating with the slide and her implementation in Matlab – Simulink, with direct practical applications in the control of the asynchronous machine as motor drive.

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