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STARTING PROPERTIES OF SINGLE-PHASE LINE-START PERMANENT MAGNET SYNCHRONOUS MOTOR

The papers deals with investigation into starting properties of single-phase PMSM. In Maxwell software ver. 16.0 circuit-field model of two-pole single-phase PMSM, based on the single-phase IM type SEh 80-2B stator, was built. During analyses resultant torque, braking torque and asynchronous torque were examined.

1. INTRODUCTION

Permanent magnet synchronous motors have very favorable running properties and average starting properties [2], [8], [10]–[12], [16]. The reason of weakening starting properties of this type of motors are permanent magnet-excitation which is impossible to switch-off. In case of single-phase PMSM this situation is even more unfavorable due to elliptical revolving magnetic field. The negative component of the magnetic field causes negative torque which diminishes the resultant motor torque. Phenomena during single-phase PMSM starting must be well-known to ensure successful starting and synchronization.

2. SINGLE-PHASE PMSM MODEL

In Maxwell software ver. 16.0 single-phase line-start two pole permanent magnet synchronous motor model was built. The field part of the model is presented in Fig. 1.

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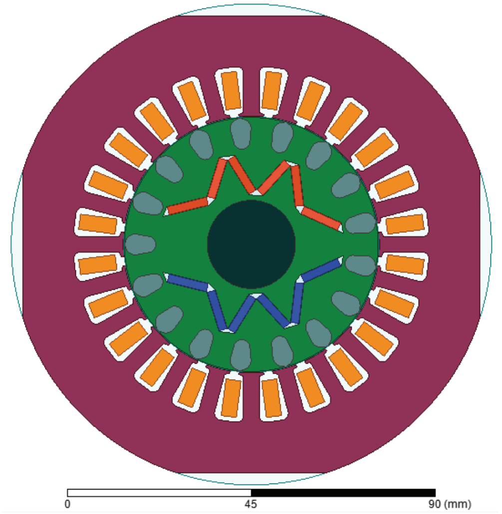

Fig. 1. Field part of the single-phase PMSM model

The motor contains permanent magnets in *W* shape. The permanent magnets shape was matched to obtain the maximum value of the back EMF and minimum value of the EMF THD. Rated parameters of the motor are: U_n = 230 V, P_n = 1.4 kW, n_n = 3000 rpm, $T_n = 4.52\ Nm$. Squirrel-cage is made of aluminum. Permanent magnets type is N42SH. Number of main winding turns z_{main} = 43.

2. STARTING PROPERTIES INVESTIGATION

During investigation into the influence of the capacitor capacitance, number of auxiliary winding turns, moment of inertia were examined.

Figure 2 shows influence of the capacitor capacitance on the resultant torque curve. According to the Fig. 2 only capacitor capacitance $C = 190\ \mu F$ ensures successful starting. Increase of the capacitor capacitance causes increase of the resultant motor torque.

Figure 3 shows influence of the capacitor capacitance on the braking torque curve. Increase of the capacitor capacitance causes increase of the braking torque. Braking torque for low speed is proportional to the motor speed, and capacitor capacitance has almost no influence on the braking torque, and reaches its minimum for $n \approx 600$ rpm, then during speed increase braking torque slowly diminishes.

Figure 4 shows influence of the auxiliary winding turns on the resultant motor torque curve. According to the Fig. 4 increase of the winding turns causes increase of the motor resultant torque but up to achievement of the maximum. After that increase of the winding turns causes decrease of the resultant torque for high speed and increase of the resultant torque for low speed. It improves starting properties of the motor and simultaneously deteriorates synchronization properties of the motor.

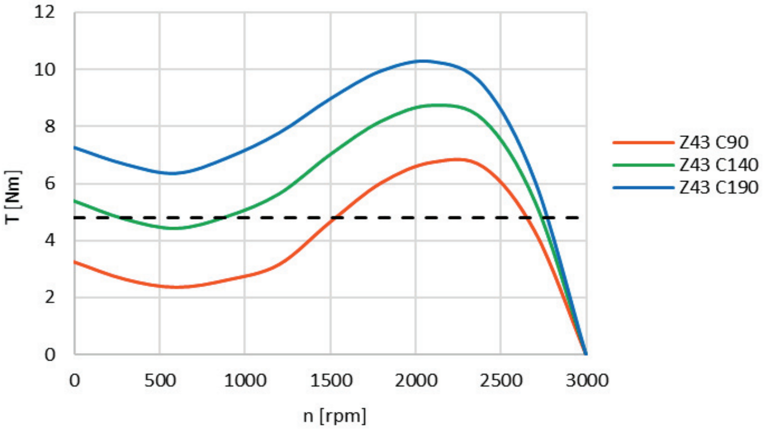

Fig. 2. Influence of the capacitor capacitance C on the resultant torque curve. The number of the auxiliary winding turns $Z = 43$ *turns*

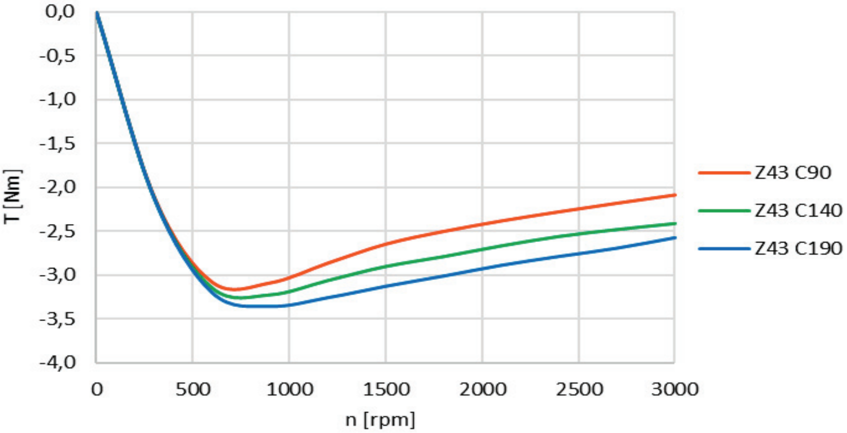

Fig. 3. Influence of the capacitor capacitance C on the braking torque curve. The number of the auxiliary winding turns $Z = 43$ *turns*

Figure 5 shows resultant motor torque, braking torque, asynchronous torque, sum of braking and asynchronous torque curves for $C = 190\ \mu F$ and $z_{main} = z_{aux} = 43$ *turns*. The sum of braking torque and asynchronous torque is not equal to the resultant motor torque because of saturation phenomenon. The sum is a little bit lower than the resultant torque.

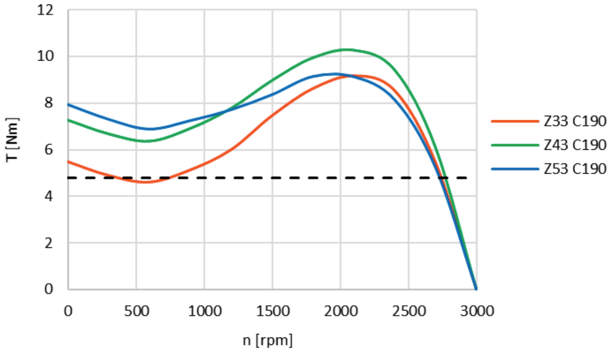

Fig. 4. Influence of the auxiliary winding turns *Z* on the resultant motor torque curve. The capacitance of the sum of running and starting capacitors $C = 190\ \mu F$

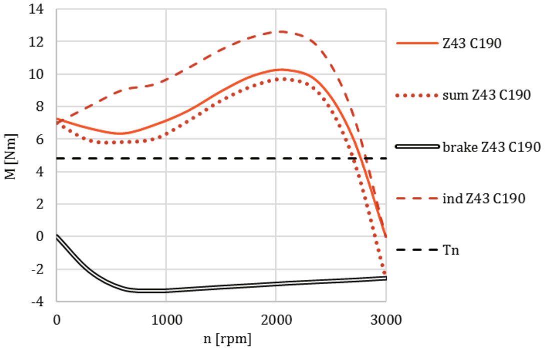

Fig. 5. Resultant motor torque, braking torque, asynchronous torque, sum of braking and asynchronous torque curves

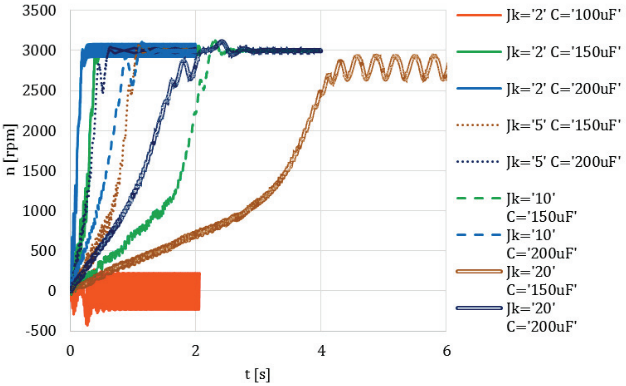

Fig. 6. speed curves during starting of single-phase PMSM for various values of the capacitor *C* and moment of inertia factor *Jk* for $T_{\mathrm{load}} = T_n$

Figure 6 shows speed curves during starting of single-phase PMSM for various values of the capacitor C and moment of inertia factor Jk. Factor Jk is a ratio of the whole drive system moment of inertia to the motor rotor moment of inertia. According to the obtained results, increase of the capacitor capacitance improves starting and synchronization properties of the motor. For extreme value of the moment of inertia (20 times higher than J_{rotor}) the motor is unable to synchronize so moment of inertia of the drive system constrains application of this type of motors.

4. CONCLUSIONS

Permanent magnets in single-phase line-start permanent magnet synchronous motor cause braking torque which diminishes the resultant motor torque. Moment of inertia of the drive system is a strong limitation of single-phase PMSM synchronization abilities. Starting and synchronization properties of the motor can be enhanced by increasing of the capacitor capacitance.

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WŁAŚCIWOŚCI ROZRUCHOWE JEDNOFAZOWEGO SILNIKA SYNCHRONICZNEGO Z MAGNESAMI TRWAŁYMI O ROZRUCHU BEZPOŚREDNIM

Artykuł przedstawia wyniki badań właściwości rozruchowych jednofazowego silnika synchronicznego z magnesami trwałymi o rozruchu bezpośrednim. W programie Maxwell wersja 16.0 zbudowano model polowo-obwodowy jednofazowego PMSM zaprojektowanego na bazie stojana jednofazowego silnika synchronicznego SEh 80-2B. W trakcie badań egzaminowano moment hamujący od magnesów trwałych, moment całkowity silnika i moment asynchroniczny od klatki wirnika.