Hybrid Excitation Synchronous Motor Current Optimization Control

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Abstract

A hybrid excitation synchronous machine is a a new type of motor with the combination of modern science and technology, which is capable of high-speed operation while maintaining the efficiency of the motor under the premise of the motor topology changes, and helping regulate motor control of the main magnetic field. It has a certain practical significance for improving motor speed and driving performance.Currently, hybrid excitation synchronous motor with its fundamental strengths of easy magnetic adjustment and wide speed range had gained industrial and military attention. It has certain prospects. This article will conduct an in-depth analysis of the hybrid excitation synchronous motor current optimal control.

Keywords

Hybrid Excitation Synchronous Motor; Current Control; Optimization.

1. Preface

Hybrid excitation synchronous motor is a new type of wide speed motor established on the basis of permanent magnet synchronous motor. Under normal circumstances, the air gap magnetic field of hybrid excitation synchronous motor is mainly the magnetic field generated by the permanent magnet, with the support of the field generated by the excitation current and through the effective adjustment of the excitation current and the d-axis current, it hybrid with the air gap magnetic field in the maximum range of the excitation synchronous motor to conduct the adjustment in order to realize the basic characteristics, i.e. the wide speed control, of hybrid excitation synchronous motor.In the manufacturing process of hybrid excitation synchronous motors it integrated the fundamental strengths of the permanent magnet synchronous motors and electrical excitation synchronous motors, and by virtue of these advantages it had won the attention by the fields of aerospace, industrial manufacturing and CNC machine tools .

2. Building the mathematical model of hybrid excitation synchronous machine

Figure 1 shows the constitution of the hybrid excitation synchronous motor drive control experimental system.

In the building of a hybrid excitation synchronous machine mathematical model, it needs to fully consider the generality of hybrid excitation synchronous motors, and ignore the impact on the inside of hybrid excitation synchronous motors caused by the phenomenons such as the temperature changes, the iron losses, stray losses and magnetic saturation, and maintain the fact in all time that the excitation current produced by hybrid excitation synchronous motors and the air gap magnetic field produced by the permanent magnet to producing the consistent phase.At the same time, we should adhere to the basic principle of vector control theory, and use the rotor field oriented approach to build a dq coordinate system, in order to form the basic equations of hybrid excitation synchronous machine mathematical model [1], the specific formula equations is shown in Table 1 below:

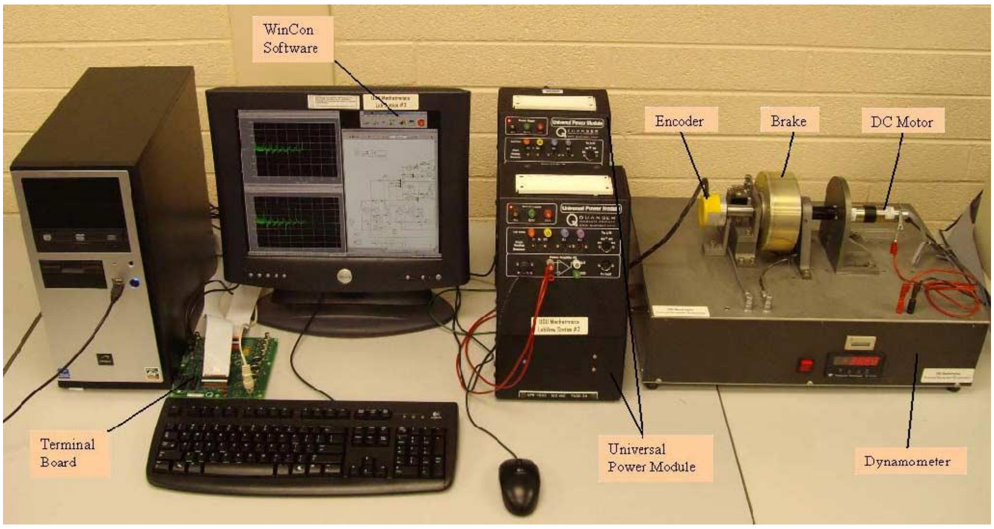


Fig. 1 The constitution of a hybrid excitation synchronous motor drive control experiment system

Table 1. Hybrid excitation synchronous machine mathematical model basic equation

Flux equation	$[\Psi_d]=[L_d\ 0\ M_{sf}][i_d]+[\Psi_{pm}]$
	$[\Psi_q]=[0\ L_q\ 0][i_d]+[0]$
Torque equation	$Te=3/2P[\Psi_{pm}+i_d(L_d-L_q)+M_{sf}i_f]$

Figure 2 is the model of hybrid excitation synchronous motor control system.

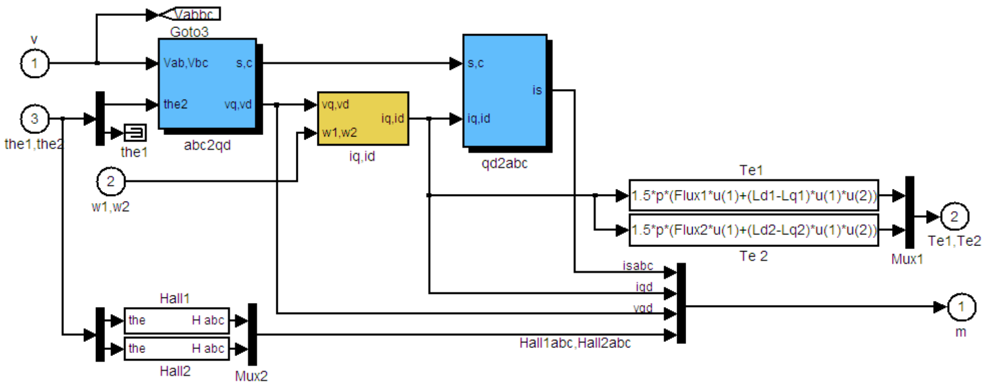


Figure 2. The model of hybrid excitation synchronous motor control system

3. The optimization control of hybrid excitation synchronous motor current

There are two types of hybrid excitation synchronous motor current control methods in this study, the first is the smallest copper consumption control method, the second is the conventional current control method.

Through the analysis of the electromagnetic properties of hybrid excitation synchronous motor, we can summarize the relationship between the electromagnetic torque reference value of the hybrid excitation synchronous motor and the reference current. The main purpose of this paper is to achieve the most optimized control of the hybrid excitation synchronous motor current, in order to achieve this goal, it requires that the hybrid excitation synchronous motor copper loss minimum efficiency optimization method be set as a constraint, to have a more accurate control over the hybrid excitation synchronous motors [2].The equations involved in this process are shown in Table 2:

Table 2. Hybrid excitation synchronous motor current control formula

Relationship between the electromagnetic torque reference value of hybrid excitation synchronous motor and the reference current	$T=3/2pi[\Psi_{pm}+i(L_d-L_q)+Mi]$
Copper consumption equation of hybrid excitation synchronous machine	$P=3/2R(i_d^2+i_q^2)+Ri_f^2$

Wherein T stands for the output of the speed controller in Figure 2, p stands for the number of pole pairs, Ψ pm stands for the permanent magnet flux

In the synchronous motor hybrid excitation current allocation process, if the hybrid excitation synchronous motor runs at low speeds, the back EMF does not change with the rising of magnetization operation, in the course of the current controlled it will not be limited with the voltage limi ring.However, when the hybrid excitation synchronous motor is running, if its speed is faster than the rated speed, the maximum electromagnetic torque of the hybrid excitation synchronous motor will decrease as the speed increases, the linear relationship between the two will be then presented [3].

If you do not consider the issue of hybrid excitation synchronous motor copper loss control, we can also use the most conventional manner to conduct current control, the process is relatively simple and easy to control; the specific formula is:

$$T=3/2pI\Psi_{pm}$$

In order to more clearly see the practical effect of conventional method of current control, the author used MATLAB software to establish a hybrid excitation synchronous motor control system simulation model. Through in-depth analysis of the simulation model, we found that the conventional hybrid excitation synchronous motor current control method is although relatively simple in operation, its efficiency is the lowest.Figure 3, Figure 4 is a conventional method of controlling the current changes in the different variables.

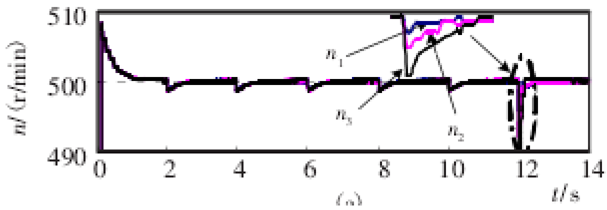


Figure 3. Conventional method of controlling the current changes in the different variables

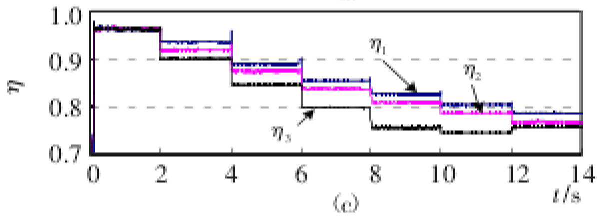
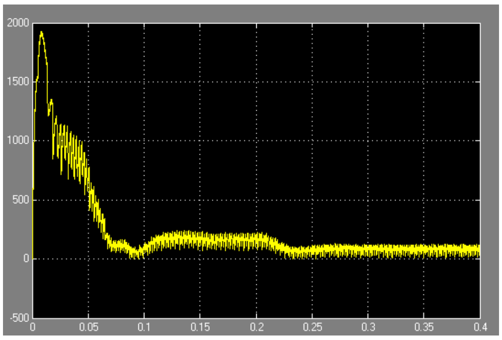
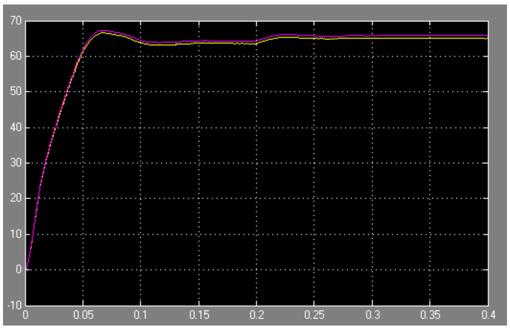


Figure 4. Conventional method of controlling the current changes in the different variables



(a)



(b)

Figure 5. Comparation of conventional method of controlling the current changes in the different variables

Through a series of analysis, we conclude that the conventional current control method is not very good in the performance of the hybrid synchronous motor excitation current control, compared with the minimum copper loss controlling method its actual efficiency is relatively low, but it does have the basic feature of being simple and easy to operate.That is, during the hybrid excitation synchronous motor current control, the optimized method is the minimum copper loss control method [4].

4. Conclusion

The above analysis shows that, in order to optimize hybrid excitation synchronous motor current control, this paper analyzed on the basis of the principle of hybrid excitation synchronous motor structure and electromagnetic properties. It made a total of two optimization hybrid excitation synchronous motor current control methods, which are respectively the minimum copper loss control method and the conventional current control method.Through a series of experiments to control both the ability and effectiveness of current, in the comparative analysis we found that both methods are able to improve the static and dynamic performance of hybrid excitation synchronous motors to a certain extent, and maintain the low speed high torque mode of operation.Wherein the minimum copper loss control method has a relatively high efficiency, while the conventional current control method is simple and easy to operate, but its actual performance is is not good as the minimum copper loss control method.Thus, the minimum copper loss control method is capable to perform the most optimized control over hybrid excitation synchronous motor current, which has a very high practical value in the fields of aerospace and automobile manufacturing.

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