Dedication

To everyone who taught me letters in this mortal world.

To the pure spirit of my father.

To my dear mother.

To my dear husband and sons and daughters.

To all my loved family members.

To my colleagues and colleagues ,who have had a great impact on all obstacles and difficulties.

To all my honorable teachers who did not hesitate to extend a helping hand to me.

We ask God to make it a beacon for every student of knowledge.

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E	Electric field.
E	The Young's modulus.
E_d	d-axis emf voltage at steady-state.
E_q	q -axis emf voltage at steady-state.
F	Centrifugal force.
H	Magnetic field strength amplitude.
H_c	Coercivity of permanent magnet materials.
H_g	Magnetic field strength of the air-gap.
H_m	Magnetic field strength of the permanent magnet.
I	Phase current of the stator winding.
I	Inertia.
I_a	Current of the armature coils.
I_{base}	Base phase current.
Id	d-axis phase current at steady-state.
I_q	q-axis phase current at steady-state.
$\hat{I}$	Peak value of input current.
J	Current density in the elements.
L	Phase inductance of the stator windings.
L	The shaft length.
L_d	Phase inductance of d-axis.
L_q	Phase inductance of q-axis.
m	The Mass per unit length of shaft.
N_c	The disc natural frequency.
P	Real power per phase per pole-pair of the motor.
p	Number of the pole-pairs.

Q	Reactive power per phase per pole-pair of the motor.
R	Resistance of the stator windings.
r	Radius.
S	Complex power per phase per pole-pair of the motor.
T	Output torque.
T_{base}	Permanent magnet torque at I_{base}.
V	Phase voltage of the stator windings, electric potential.
V_t	Input phase voltage.
V_d	d-axis phase voltage at steady-state.
$V_t V_q$	q-axis phase voltage at steady-state.
W_c	Natural frequencies.
w	Angular velocity of rotor (rad/sec).
X	Synchronous phase reactance of the stator windings (=ωL).
X_d	Synchronous phase reactance of d-axis.
X_q	Synchronous phase reactance of q-axis.

Greek

γ	Slot pitch.
λ_{PM}	Flux-linkage produced by the permanent magnet.
δ	Voltage angle or torque angle.
ω	Synchronous angular speed (electrical speed).
ξ	Saliency ratio between L_d and L_q.
$\propto_n$	Numerical constant calculated by the Rayleigh method.
µ	Mass per unit length.
ψ	the flux linkage components.

Abstract:

High-speed electric machines (HSEMs) have been widely used in many of today's applications. The mechanical design of a high-speed electrical machine is a very responsible task because this type of machine is often designed to operate with a speed that is close to the flexural critical speeds. Errors in the prediction of these speeds can lead to unpleasant phenomena such as excessive acoustic noise emissions and catastrophic failures during operation. For high-speed machines, in particular, it is very important to accurately predict natural frequencies of the rotor at the design stage so as to minimize the likelihood of failure. The problem of reliable mechanical design of a high-speed rotor is more serious for a high-speed permanent-magnet (PM) machine because it has a more complex construction than a high-speed induction machine. The high-speed PM machines have some advantages over the high-speed induction machines like better utilization factors, higher power factors and higher efficiencies.

The main goal of this project is to contribute to the development of high-speed machines by examining the design issues and performance. For permanent-magnet synchronous motors driven by high-frequency drives, the rotor speed is normally above 30 000 rpm, and it may exceed 100 000 rpm. The choice in this project has been made for a 7-kw permanent magnet synchronous machine at 200,000 rpm.

3D finite element analysis (ANSYS WORKBENCH 15) was used to determine the natural frequencies and rotor patterns of a synchronous high-speed permanent magnetic motor, to assess the impact of leading design parameters, such as length, column diameter, span, bearings, material properties, and to compare the results of the finite element program with the results of analytical methods (i.e. critical speed).

الملخص:

تم استخدام الآلات الكهربائية عالية السرعة (HSEMs) على نطاق واسع في العديد من تطبيقات اليوم. يعد التصميم الميكانيكي للآلة الكهربائية عالية السرعة مهمة مسؤولة للغاية لأن هذا النوع من الآلات غالبًا ما يكون مصممًا للعمل بسرعة قريبة من السرعات الحرجة الخارجية. يمكن أن تؤدي الأخطاء في التنبؤ بهذه السرعات إلى ظواهر غير سارة مثل انبعاثات الضوضاء الصوتية المفرطة والفشل الكارثي أثناء التشغيل. بالنسبة للآلات عالية السرعة، على وجه الخصوص، من المهم جدًا التنبؤ بدقة بالترددات الطبيعية للدوار في مرحلة التصميم لتقليل احتمالية الفشل. تعتبر مشكلة التصميم الميكانيكي لدوار عالي السرعة أكثر خطورة بالنسبة لآلة مغناطيسية دائمة عالية السرعة (PM) لأنها تحتوي على بنية أكثر تعقيدًا من آلة الحث عالية السرعة. تتمتع آلات PM عالية السرعة ببعض المزايا مقارنة بآلات الحث عالية السرعة مثل عوامل الاستخدام الأفضل، وعوامل الطاقة الأعلى والكفاءة الأعلى.

الهدف الرئيسي من هذا المشروع هو المساهمة في تطوير آلات عالية السرعة من خلال دراسة مشكلات التصميم والأداء. بالنسبة للمحركات المتزامنة ذات المغناطيس الدائم التي يتم تشغيلها بواسطة محركات عالية التردد، تكون سرعة الدوار عادةً أعلى من 30000 دورة في الدقيقة، وقد تتجاوز 100000 دورة في الدقيقة. تم الاختيار في هذا المشروع لآلة متزامنة ذات مغناطيس دائم بقدرة 7 كيلو وات عند 200000 دورة في الدقيقة.

تم استخدام تحليل العناصر المحدودة ثلاثية الأبعاد لتحديد الترددات الطبيعية وأنماط الدوار لمحرك متزامن مغناطيسي دائم عالي السرعة، وتقييم تأثير معلمات التصميم الرائدة، مثل الطول، قطر العمود وتمديده والمحامل، وخصائص المواد. ومقارنة النتائج المتحصل عليها للسرعة الحرجة من (ANSYS WORKBENCH 15) بنتائج الطرق التحليلية.