E-Traction Motor Design for an All-Electric Urban Transport Vehicle

FORD OTOSAN

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ABSTRACT

In this project we worked together with the automotive company Ford Otosan to design an e-traction motor for an electric vehicle. The end goal of this project is to produce an e-motor that would meet the desired requirements. The most commonly used motors are permanent magnet motors; however, they use rare magnetic material which is non-renewable and expensive. To overcome this limitation, an AC induction motor is designed, which does not consist of permanent magnets. In order to design and simulate the motor, ANSYS Maxwell software is used.

INTRODUCTION

- Electric vehicles (EVs) don't have tailpipe emissions, they are more efficient and therefore they have lower operational costs compared to conventional vehicles. These advantages increase the demand for electric vehicles.
- In EVs, instead of an internal combustion engine, an electric motor provides traction.
- There are different types of electric motors that can be used in EVs: induction motor, permanent magnet (PM) DC motor and switched reluctance motor.
- PM motors use rare-earth magnets which have high costs due to increasing demand.
- Although switched reluctance motors have simple design, it is hard to control the motor without knowing the exact position of the rotor.
- AC induction motors are currently most promising option considering the disadvantages of other types.
- In order to simulate the motor, ANSYS Maxwell was used. ANSYS Maxwell is the electromagnetic field simulation software for the design and analysis of electric motors, actuators, sensors, transformers and other electromagnetic and electromechanical devices.

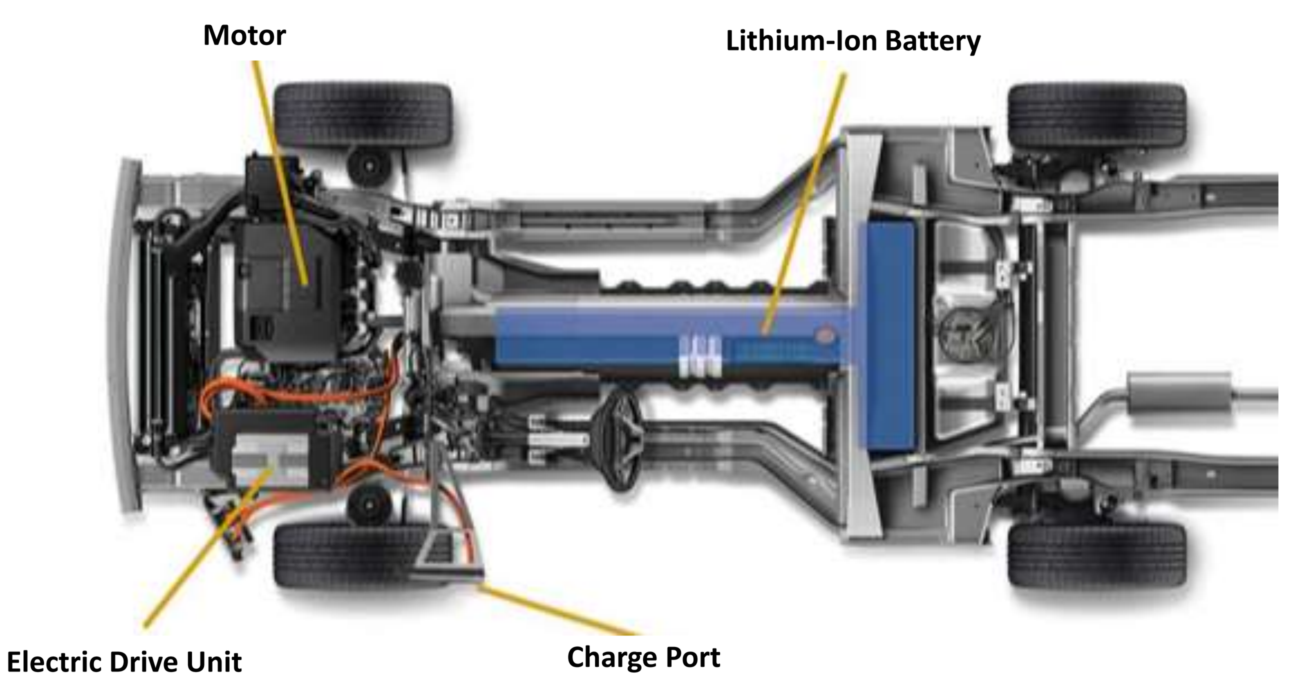

Figure 1. EV Powertrain

AC INDUCTION MOTOR

- An AC induction motor has two main parts: stator and rotor. Stator is the stationary part and rotor is the rotating part.
- Stator consists of a set of windings. When current is applied to windings, coils become electromagnets.
- Polarization of coils changes in every half-cycle due to alternating current.
- Rotor windings are induced by the rotating magnetic field and they create their own magnetic field.
- Interaction of these two magnetic fields creates torque on the rotor.

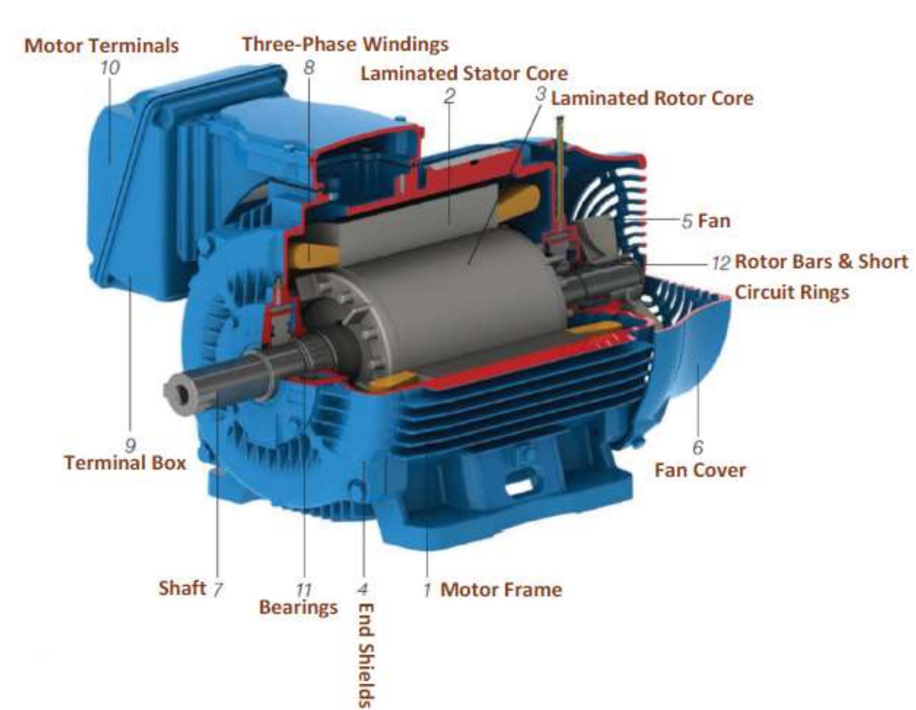

Figure 2. Components of an induction motor

PROJECT OBJECTIVES

To design an electric motor for a light commercial vehicle (LCV) satisfying the following requirements:

- Minimum efficiency of 94%.
- Peak power must be greater than 100 kW.
- Peak torque must be greater than 200 Nm.
- Maximum speed to base speed ratio must be greater than 2.
- Peak to continuous power ratio must be less than 1.7.
- Power to weight ratio must be greater than 1.6 kW/kg.
- Motor weight should be less than 65 kg.
- Motor type must be non-PM.
- Battery pack nominal voltage must be 360 V.

Figure 3. LCV for which the motor is designed

DESIGN

- The design stage started with the identification of design paramaters.
- Based on identified design parameters, dimensional calculations were performed.
- Calculated parameters were utilized do design the motor in ANSYS Maxwell .
- Final design parameters are provided in Table 1.
- Stator and rotor geometries are depicted in green and blue colors in Figure 4.
- Design steps are outlined in Figure 5.

Table 1. Designed Motor Parameters

Given Output Power	120 kW
Rated Voltage	360 V
Poles	4
Given Speed	4455 rpm
Frequency	150 Hz
Stator Outer Diameter	290 mm
Stator Inner Diameter	195 mm
Length	220 mm
Number of Stator Slots	36
Rotor Outer Diameter	193.5 mm
Rotor Inner Diameter	90 mm
Number of Rotor Slots	26

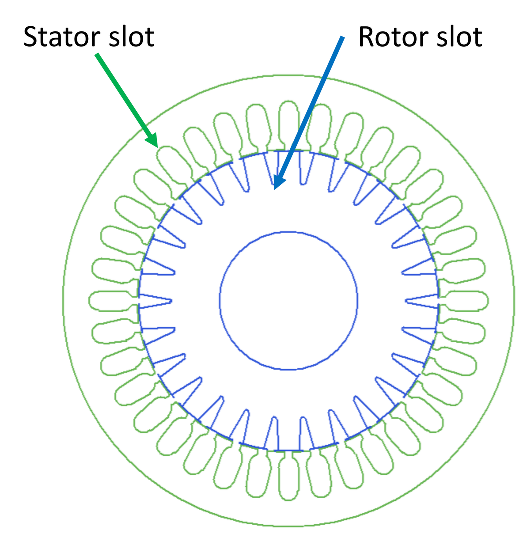

Figure 4. Designed motor geometry

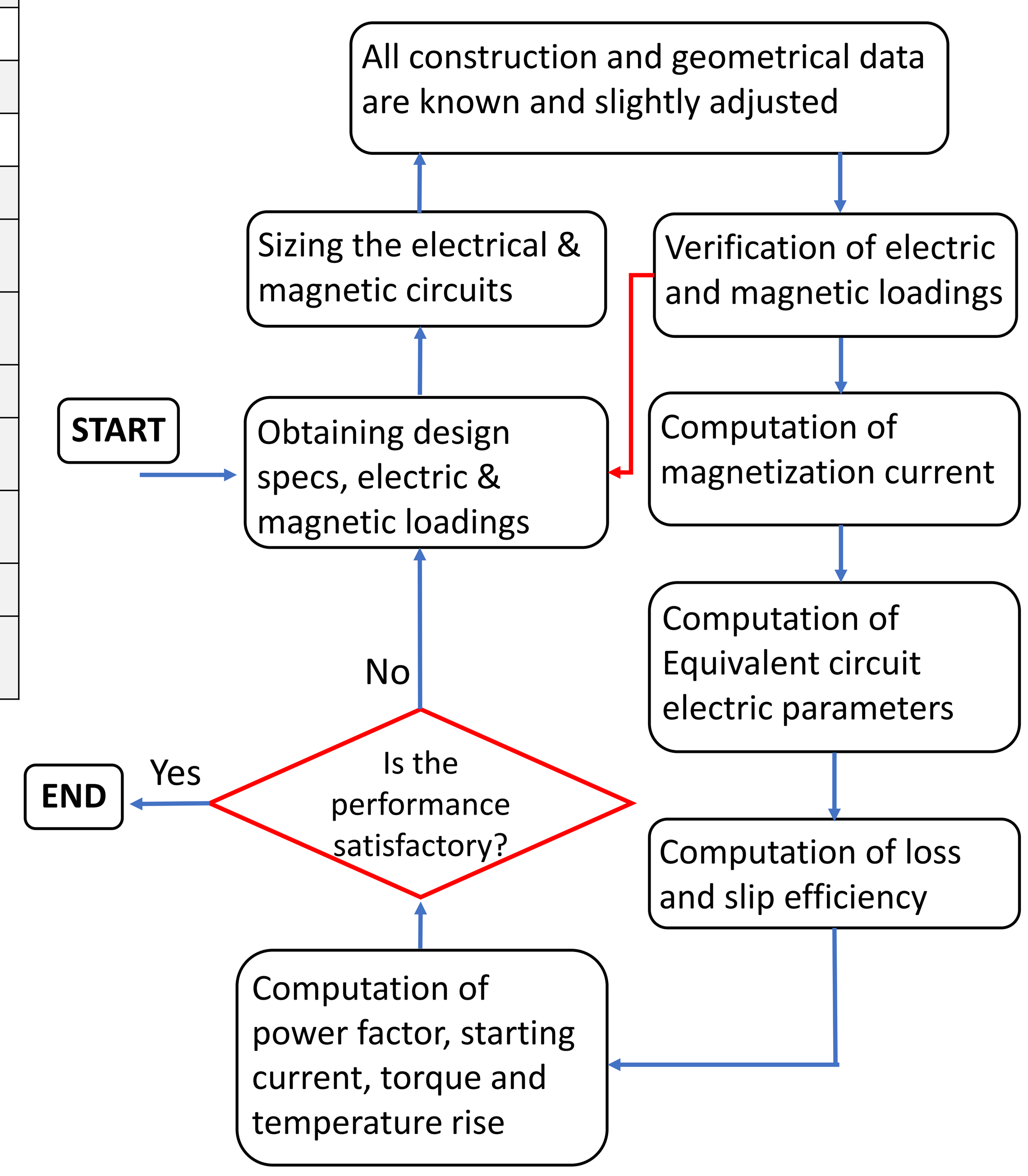

Figure 5. Design steps flow-chart

RESULTS

Current design has the following features:

- 95% peak efficiency as can be seen in Figure 6.
- 183 kW peak output power. Output versus speed graph is given in Figure 7.
- 85 kg motor weight.
- 450 Nm torque is obtained.
- 2.1 kW/kg power to weight ratio is achieved.

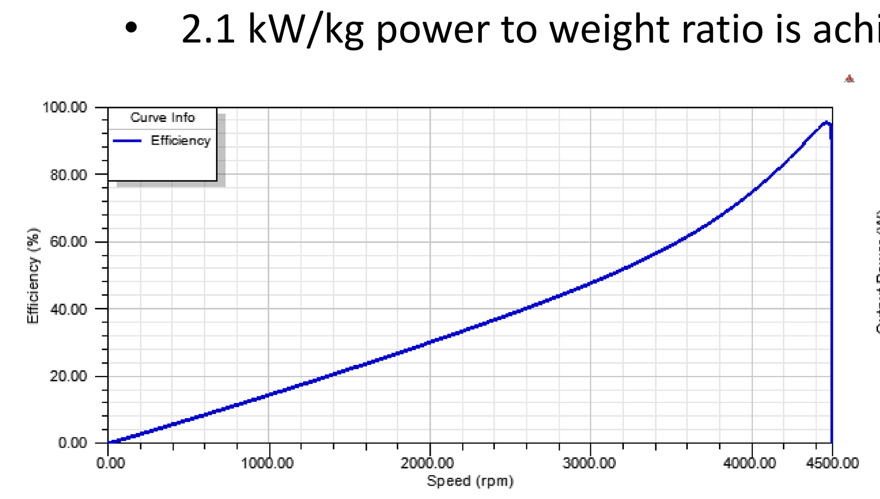

Figure 6. Efficiency vs. Speed

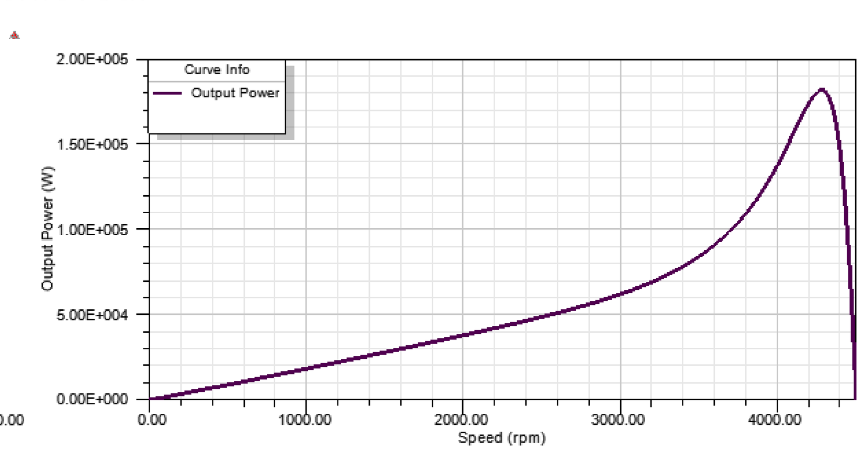

Figure 7. Output Power vs Speed

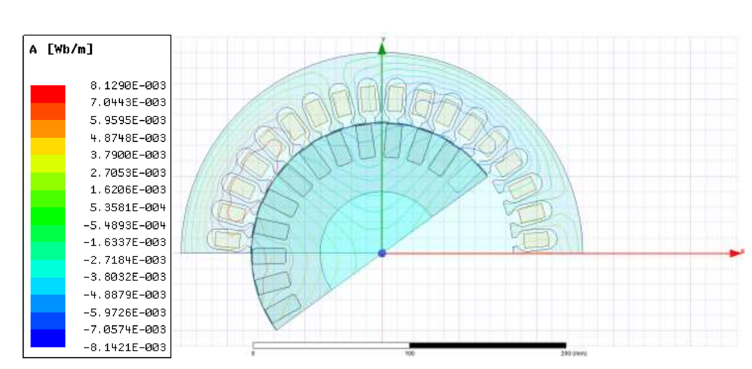

Figure 8. Flux Lines

DISCUSSION

- Targeted values for efficiency, output power, torque and power to weight ratio are achieved.
- Since the motor weight is heavier than the targeted value, we are working on reducing the weight.
- As a future work, efficiency map of the motor will be generated.

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