EE564 First Project II: TESLA Model S Induction Motor

Table of Contents

ID

NAME : Mehmet Kaan Mutlu

STUDENT NUMBER : 2121408

E-mail : kaan.mutlu@metu.edu.tr

Specifications

In this project, design of the induction motor that is used in **Tesla Model S**. Normally it has different variations, to keep things simple; **RWD 85 Model** will be used that has the following specs:

- **Maximum Power:** 270 kW
- **Maximum Torque:** 441 Nm
- **Top Speed:** 225 km/h

Except for these given specs, these are also found from internet:

- **Number of poles:** 4
- Maximum RPM value of our motor is 21848 RPM. This value is calculated by considering Tesla Model S has 21' tires and 9.73 to 1 gear ratio.

If we assume average speed is 85 km/h. Then rated RPM value of motor will be 7960 RPM.

- **Number of phases:** 3
- **Line supply voltage:** 320 V
- **Rated Power:** 185 kW

Main Dimensions of Stator Core

Boldea's The Induction Machine Handbook is going to be used to determine parameters and dimensions of motor. In Chapter 15, it is explained that $D_{is}^2 L$ output constant concept will be used. For internal stator diameter formula below will be used:

$$D_{is}^3 = \frac{2pp_1 S_{gap}}{\pi \lambda f C_0}$$

To be able to calculate D_{is}, airgap power is needed.

At this point targeted efficiency is taken as 95 %.

Power factor is taken as 0.85

Another required parameter to be able to calculate airgap power is Ke that is defined as E1 to Vin ratio in equation 14.8.

$$K_E \approx 0.98 - 0.005 p_1$$

Now everything is ready for airgap apparent power:

$$S_{gap} = \frac{K_E P_n}{\eta_n cos\varphi}$$

Airgap power is calculated as 222.2 KVA.

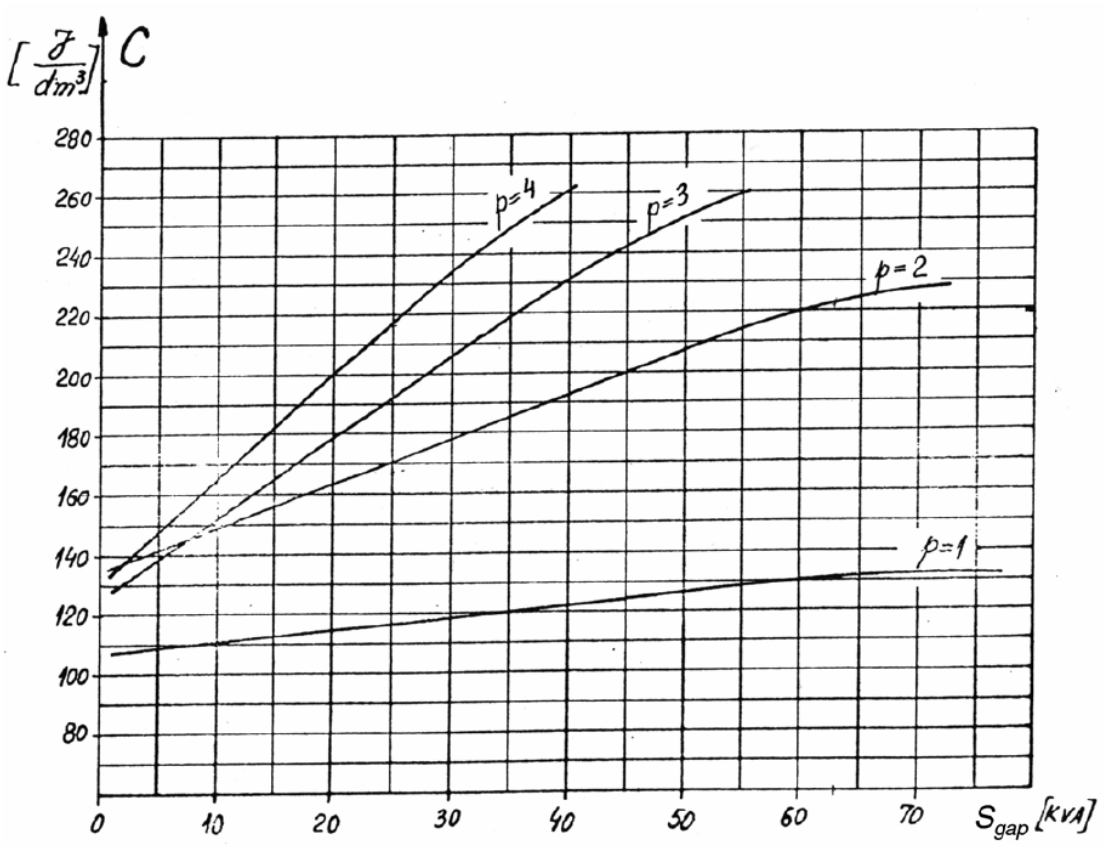
After this calculation, missing parameters are stack aspect ratio and Esson's constant Co. Stack aspect ratio is selected from table below:

Table 15.1. Stack aspect ratio λ

$2p_1$	2	4	6	8
λ	0.6 – 1.0	1.2 – 1.8	1.6 – 2.2	2 -3

It is selected as 1.5.

Esson's constant is selected using Figure 14.14.



Because our calculated airgap power is out of figure's range it isn't possible to read a certain value but for two pole-pairs after 60 kVA Esson's constant starts to saturate and for our airgap apparent power this value is taken as 240 J/dm^3.

Now we are ready to calculate internal stator diameter:

Internal diameter of stator is calculated as 18.095 cm.

For realistic dimensions it is going to be taken as 18.1 cm.

Now we can calculate stack length, deriving its formula from equation 15.2:

$$L = \frac{\lambda \pi D_{ia}}{2p}$$

Stack length L is 21.32 cm.

By using equation 14.14 it is possible to calculate the pole pitch:

$$\tau = \frac{\pi D_{ia}}{2p}$$

Pole pitch is 14.22 cm.

Next step is deciding external stator diameter. For its calculation, table below will be used.

Table 15.2. Inner/outer stator diameter ratio

$2p_1$	2	4	6	8
$\frac{D_{is}}{D_{out}}$	0.54 – 0.58	0.61 – 0.63	0.68 – 0.71	0.72 – 0.74

It gives us information about ratio of internal and external stator diameters. For 4 poles this ratio will be taken as 0.62.

```
External diameter of stator is calculated as 29.194 cm.

For realistic dimensions it is going to be taken as 29.2 cm.
```

For suitable airgap calculation book's equation of 14.38 may be used as well as the equation defined during the EE564 lecture of 6th April. Here it is important to remind that the minimum airgap is 0.2 mm.

Formula discussed in the lecture is as follows:

$$airgap = 0.18 + 0.006P^{0.4}mm$$

Book equation of 14.38 is

$$airgap = 0.1 + 0.012P^{\frac{1}{3}}mm$$

As known, too small airgap would produces large space airgap field harmonics and additional losses while a too large one would reduce the power factor and efficiency. Therefore, average of these two calculated airgap values will be used as actual airgap value.

```
Airgap is calculated as 0.8656 mm.

For being realistic it is going to be taken as 0.87 mm.
```

Published with MATLAB® R2013a