

Tesla Model S Induction Motor

RWD 85 Model

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Chapter 1. Introduction

The specs of the induction motor are as follows:

```
% Input Parameters of the
% Tesla Model S Induction Motor
power_max = 270;           % [kW] from project2
torque_max = 440;          % [Nm] from project2
speed_max = 225;           % [km/sa] from project2
m = 3;                    % [-] three phases
p1 = 2;                   % [-] pole pair from Hendershot-FIU-Lecture
power_rated = 288 * 0.746 ; % [kW] from Hendershot-FIU-Lecture
tire_diameter = 27.7 * 25.4; % [mm] from
                             % https://tiresize.com/tires/Tesla/Model-S/
                             % https://tiresize.com/tiresizes/245-45R19.htm
gear = 9.73;              % [-] 9.73:1 (transmission) from
                             % https://en.wikipedia.org/wiki/Tesla_Model_S
speed_rpm_max = (speed_max*10^3/3600)/(tire_diameter*10^-3/2)*(60/2*pi())*gear; %
speed_rpm_rated = 6000;   % [rpm] from Hendershot-FIU-Lecture
                             % approx. knee of the torque-speed curve
f1 = speed_rpm_rated*2*p1/120; % [Hz] frequency of the driver unit
```

Chapter 2. Main Dimensions of Stator Core

$Dis^2 * L$ output constant concept is used to determine parameters.

```
% Based on the The Induction Machine Handbook Chpater 14 & 15
neff = 0.96; % [-] targetted efficiency (IE3)
pwr_factor = 0.88; % [-] typ. power factor for induction motors
% at full load varies between 0.85-0.90
Ke = 0.98 - 0.005*p1; % [-] Ke defined as  $E_1 / V_{ln}$  (eq. 14.8)
% and approx. given as eq. 14.10
Sgap = Ke * powerRated * 10^3 / (neff * pwr_factor); % [VA] (eq. 15.2)
stack_aspect = 1.5; % [-] stack aspect ratio define as
% stack length to pole pitch ratio (eq. 14.19)
% (table 15.1)
Co = 240*10^3; % [J/m^3] extracted from figure 14.14
Dis = ((2*p1*p1*Sgap)/(pi()*stack_aspect*f1*Co))^(1/3); % [m] (eq. 15.1)
pole_pitch = pi()*Dis/(2*p1); % [m] pole pitch (eq. 15.2)
L = stack_aspect * pole_pitch; % [m] stack length (eq. 15.2)
Ftan_max = torque_max / (Dis/2); % [N] tangential force
Sr = pi()*Dis*L; % [m^2] surface area
shear_stress_max = Ftan_max / Sr; % [N/m^2], [Pascal] tangential shear stress
Cmech = power_max / (Dis^2*L*f1/p1); % [kWs/m^3] specific machine constant
max_stator_num = round(pi()*Dis/0.007); % [-] max. stator number from
% ee564_basic_machine_design2, 8/23
min_stator_num = ceil(pi()*Dis/0.045); % [-] min. stator number
Kd = 0.62; % [-] for 2p1 pole number (Table 15.2)
Dout = Dis / Kd; % [m] outer diameter of the stator (eq. 15.4)
g1 = 0.1+0.012*(powerRated*10^3)^(1/3); % [mm] airgap (eq. 15.5)
g2 = 0.18+0.006*(powerRated*10^3)^(0.4); % [mm] airgap from
% ee564_basic_machine_design 16/18

if (g1 > g2)
    g = g1;
else
    g = g2;
end;
g = g * 1.6; % [mm] to add safety factor
```

Chapter 3. The Stator Winding

```
% Based on the The Induction Machine Handbook Chpater 14 & 15
Ns = 2*p1*m*4;           % [-] number of stator slots
q = Ns/(2*p1*m);         % [-] slots per pole per phase
pitch_factor = 5/6;      % [-] to minimize 5th and 7th harmonics
pitch_angle = 5/6*180;   % [°] pitch angle
slot_angle_alpha = 180/(Ns/(2*p1)); % [°] slot angle (eq. 15.7)
Kp1 = sind(pitch_angle/2); % [-] fundamental pitch factor (eq. 15.9)
Kd1 = sind(q*slot_angle_alpha/2)/(q*sind(slot_angle_alpha/2));
                        % [-] fundamental distribution factor (eq. 15.8)
Kw1 = Kp1*Kd1;           % [-] fundamental winding factor
```

The number of stator slots (N_s) should be multiple of 12.

By referring the suggested stator slot pitch for induction machines (7-45mm), N_s should be between 15-92.

Let's choose N_s as 48.

To reduce harmonic frequency components let's use fractional pitch. 5/6 fraction is used to reduce 5th and 7th harmonics.

Note that

5/6 pitch will

minimize the 5th harmonic but not eliminate it as will 4/5 pitch

minimize the 7th harmonic but not eliminate it as will 6/7 pitch