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 E1 / V1n (eq. 14.8)
                            % and approx. given as eq. 14.10
Sgap = Ke * power_rated * 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*(power_rated*10^3)^(1/3); %[mm] airgap (eq. 15.5)
g2 = 0.18+0.006*(power_rated*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 (Ns) should be multiple of 12.
By referring the suggested stator slot pitch for induction machines
(7-45mm), Ns should be between 15-92.
Let's choose Ns 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
```