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Coefficient in thermal model of 50kW synchronous machine

Druh úkolu: scientific research

Řešitelé: Ing. Roman Pechánek

Vedoucí úkolu: Doc. Ing. Bohumil Skala, Ph.D.

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Annotation

This report is focused to thermal coefficient and „Matlab - Simulink“ model of the machine, which has been calculated in report no. 22190 – 007 – 2011.

Work deals with the definition of thermal resistances and thermal capacities in thermal network model of synchronous motor. Thermal resistances are recalculate to thermal conductivity G (i) - that is implemented in Simulink model. Thermal capacities are defined at work, in Simulink model are represented by C (i).

Symbols

A_end	cooling area of stator endwinding	[m^2]
b_p	rotor teeth width	[m]
b_r	rotor slot width	[m]
b_s	stator slot width	[m]
b_t	teeth width	[m]
b_t_r	rotor teeth width	[m]
C	thermal capacitance	[J/kgK]
c_Cu	copper specific heat	[J/kgK]
c_Fe	iron specific heat	[J/kgK]
c_W	water specific heat	[J/kgK]
D_cd	cooling duct diameter	[m]
D_e_frame	external diameter of frame	[m]
D_e_r	external rotor diameter	[m]
D_e_s	outer stator diameter	[m]
d_h	equivalent endwinding diameter	[m]
D_i_r	internal rotor diameter	[m]
D_i_s	inner stator diameter	[m]
D_shaft	shaft diameter	[m]
D_vk_r	equivalent diameter of rotor cooling duct	[m]
dP_Cu_1	stator winding losses	[W]
dP_Cu_2	rotor winding losses	[W]
dP_Fe	iron losses	[W]
Fi	friction coefficient	[-]

G	thermal conductance	[W/K]
h_delta	film coefficient ambient	[W/m^{2}K]
h_end	end winding film coefficient (heat transfer)	[W/m^{2}K]
h_frame	frame hight	[m]
h_i	insulation in slot thickness	[m]
h_i_s	insulation wire thickness	[m]
h_r	rotor slot hight	[m]
h_rot	film coefficient solid part - air	[W/m^{2}K]
h_s	stator slot hight	[m]
h_shield	shield width	[m]
h_w	film coefficient iron, air - water	[W/m^{2}K]
h_y_r	rotor iron hight	[m]
h_y_s	stator iron hight	[m]
k_v	winding coefficient	[-]
L_end	length of endwinding	[m]
L_fe	lamination length	[m]
L_frame_ax	frame axial length	[m]
L_p	length of pole	[m]
L_r	length of rotor	[m]
n_cd	number of cooling ducts	[-]
Nu	Nusselt number	[-]
Q_p	number of poles	[-]
Q_r	number rotor slots	[-]
Q_s	stator slot number	[-]
Q_w	water mass flow rate	[m^3/s]

R	thermal resistivity	[K/W]
Re	Reynolds number	[-]
ro_Cu	copper density	[kg/m^3]
ro_fe	iron density	[kg/m^3]
ro_w	water density	[kg/m^3]
rpm	rotating speed	[RPM]
S_Cu	cross area of stator winding	[m^2]
S_Cu_r	cross area of rotor excitation winding	[m^2]
S_fe	middle stator iron area	[m^2]
S_shield	shield surface area	[m^2]
S_y_air	cooling surface ambient	[m^2]
S_y_amb	cooling area to ambient	[m^2]
S_y_w	cooling surface to water	[m^2]
T_amb	ambient temperature	[°C]
T_loss	temperature of input losses	[°C]
T_w	inlet water temperature	[°C]
w_k	covering water surface	[-]
Z	recalculate losses	[W]

Contents

1 Input data and parameters

1.1 Geometric dimensions

Input data in this table depends on the geometrical dimensions of the machine. It is possible to change values depending on the electromagnetic calculation. Change is possible in "INPUT_VW.m".

matlab symbols	equation symbols	name	value	
rpm	*rpm*	rotating speed	1200	[RPM]
		stator		
L_fe	L_{fe}	lamination lenght	0.4	[m]
D_e_s	D_{es}	outer diameter	0.258	[m]
D_i_s	D_{is}	inner diameter	0.175	[m]
Q_s	*Q_s*	slot number	30	
h_s	h_s	slot high	0.019688	[m]
b_s	b_s	slot width	0.01185	[m]
h_i_s	h_{is}	insulation thickness	0.00007	[m]
h_i	h_i	insulation thickness	0.0005	[m]
k_v	k_v	winding coef	0.54	[m]
b_t	b_t	teeth width	0.009	[m]
L_end	L_{end}	lenght of endwinding	0.132	[m]
		rotor		
D_e_r	D_{er}	external rotor diameter	0.1738	[m]
D_i_r	D_{ir}	internal rotor diameter	0.04	[m]
D_cd_r	D_{cdr}	quivalent diameter of rotor cooling duct	0.096	[m]
L_r	L_r	lenght of rotor	0.4	[m]
h_r	h_r	slot high	0.0305	[m]
b_r	b_r	slot width	0.00454	[m]
Q_r	Q_r	number rotor slots	40	
b_t_r	b_{tr}	rotor teeth width	0.02955	[m]
b_p	b_p	rotor pole width	0.030	[m]
Q_p	Q_p	number of poles	8	
L_p	L_p	lenght of pole	0.4	[m]
		frame		[m]
D_e_frame	D_{eframe}	external diameter of frame	0.28	[m]
h_frame	h_{frame}	frame high	0.022	[m]
L_frame_ax	$L_{frameax}$	frame lenght	0.04	[m]
D_cd	D_{cd}	cooling duct diameter	0.005	[m]

n_cd	n_{cd}	number of cooling duct	70	
w_k	w_k	covering water surface	0.5	[m]
h_shield	h_{shield}	shield high	0.01	[m]
D_shaft	D_{shaft}	shaft diameter	0.046	[m]

1.2 Material properties

Material properties correspond to the physical properties of the materials used.

matlab symbols	equation symbols	name	value	
c_Cu	c_{Cu}	copper specific heat	384	[$Jkg^{-1}K^{-1}$]
c_Fe	c_{Fe}	iron specefic heat	452	[$Jkg^{-1}K^{-1}$]
c_W	c_W	water specefic heat	4184	[$Jkg^{-1}K^{-1}$]
ro_Cu	ro_{Cu}	copper density	8960	[kg/m^3]
ro_fe	ro_{fe}	iron density	7860	[kg/m^3]
ro_w	ro_w	water density	1000	[kg/m^3]

Specific thermal conductivity of materials used in the program are entered. In the future it is possible to make the change to variable.

copper thermal conductivity = 380 [$W.m^{-1}.K^{-1}$]
iron thermal conductivity = 45 [$W.m^{-1}.K^{-1}$]
insulation thermal conductivity = 0.3 [$W.m^{-1}.K^{-1}$]

1.3 Initial conditions

Possible to change values depending type of simulation.

Q_w	Q_w	water mass flow rate	0.0006	[m^3]
T_amb	T_{amb}	ambient temperature	40	[°C]
T_w	T_w	water temperature	90	[°C]
T_loss	T_{loss}	temperature of input losees	25	[°C]

1.4 Losses and given duty cycle

Loading of the machine:

120 sec at a power of 40kW

30 sec at a power of 85kW

Simulation is made for 1 hour.

dP_Cu_1	ΔP_{Cu1}	stator winding	1208 [W]
dP_Cu_2	ΔP_{Cu2}	rotor winding	799 [W]
dP_Fe	ΔP_{Fe}	iron losses	489 [W]

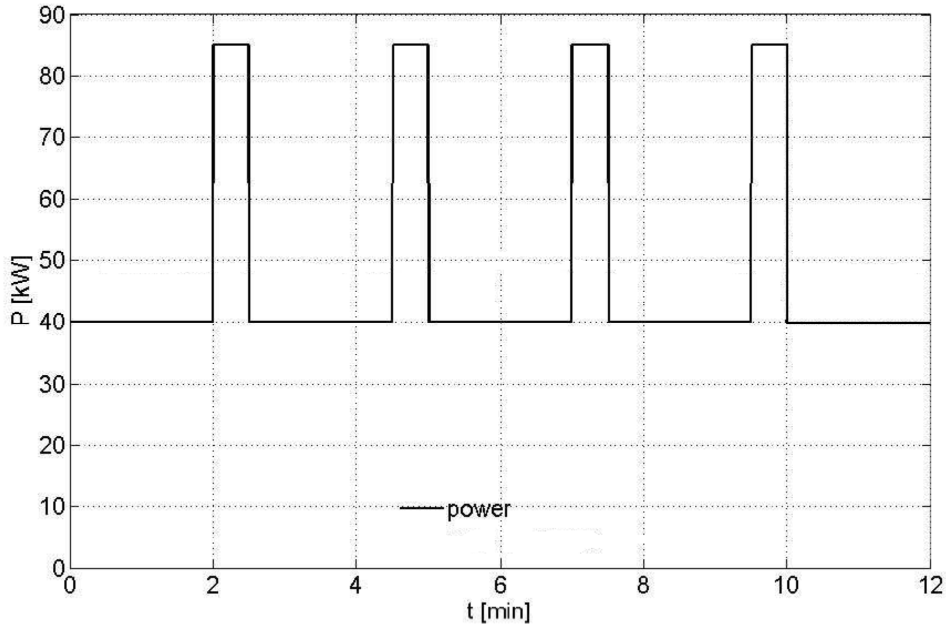

Fig. 1-1 duty cycle of working synchronous machyne

Shown is 12min. Real simulation is 1 hour

All coefficient is described and calculated in “INPUTS_VW.m”

2 Matlab – Simulink model

The thermal network model is sufficiently detailed to include all the major components and heat transfer mechanisms within the machine without being over complex. The geometry of a synchronous motor can be subdivided into the 6 components shown in Fig. 2-1, where symmetry is assumed about the shaft and a radial plane through the centre of the machine. The solid components of the stator iron (3), windings (1, 2), excitation winding (4), cooling water (5) are all modelled as a thermal network. Thermal resistances is based on a general lumped component. One further component of negligible thermal capacitance represent the air (6). The 6 components (nodes) are interconnected directly through thermal resistors R(1) – R(12). Any heat transfer due to radiation from the internal surfaces is neglected [1]. Equivalent thermal network is presented at Fig. 2-2.

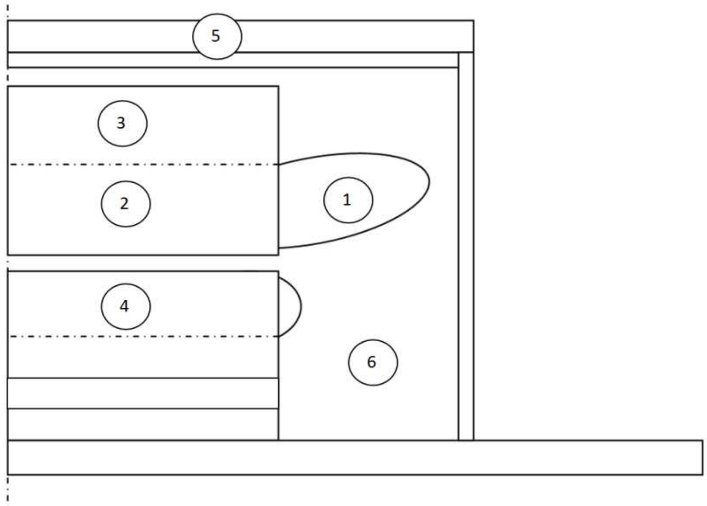

Fig. 2-1 Synchronous machine construction

1 – End winding, 2 – Slot winding, 3 – Stator iron, 4 - excitation winding, 5 – Water, 6 – Endcap air

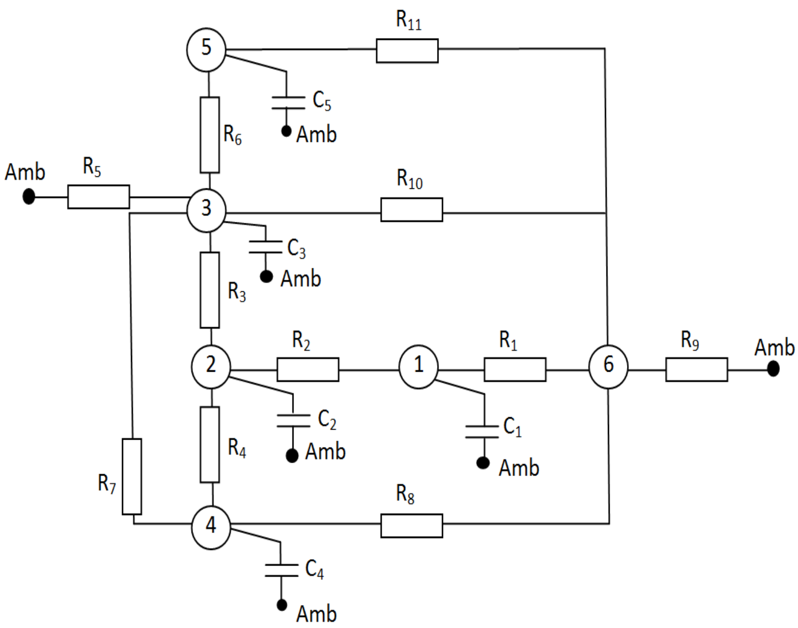

Fig. 2-2 Total synchronous machine thermal model

2.1 Parameters – auxiliary dimensions

Cooling surface area to water

```
S_y_w =pi * D_e_s * L_fe* w_k
```

Cooling surface area to ambient

```
S_y_amb = pi * D_e_frame * L_frame_ax
```

Cooling surface area of stator endwinding

```
A_end = 2*(h_s + b_s)
```

Cross surface area of stator winding

```
S_Cu = h_s*b_s*k_v
```

Stator iron hight

```
h_y_s = (D_e_s-D_i_s)/2-h_s
```

Shield surface area

```
S_shield = pi/4 * (D_e_s^2 - D_shaft^2)
```

Middle stator iron surface area

```
S_fe = pi/4 * (D_e_s^2 - D_i_s^2) - (Q_s * h_s * b_s)
```

Cross surface area of rotor excitation winding

```
S_Cu_r = b_r * h_r * k_v
```

Rotor iron hight

```
h_y_r = (D_e_r-D_cd_r)/2-h_r
```

Cooling surface area to ambient

```
S_y_air = S_y_w*(1-w_k)
```

2.2 Heat transfer coefficients

(I) h_{amb} = heat transfer between frame and external air

```
h_amb = 13
```

(II) h_{delta} = heat transfer between stator or rotor and air gap

```
h_delta = 14*sqrt((pi * D_e_r  * rpm/60) ^ 2 + 0.1*(pi *
D_e_r  * rpm/60) ^ 2)^0.65
```

(III) h_{end} = heat transfer between stator endwindings, inside side of shield and endcap air

```
d_h=2*(h_s+b_s)/pi
Re=(pi *D_e_r*rpm / 60) * d_h / (2.1 * 10 ^(-5)
Nu=0.294*Re^0.6
h_end = Nu * 0.025/d_h
```

(IV) h_{rot} = heat transfer between stator and rotor cooling holes and circulating endcap air

```
h_rot= (20*sqrt((pi *D_e_r*rpm / 60))-15)
```

(V) h_w = heat transfer coefficient between stator iron and cooling water

```
v_= Q_w / (pi/4* D_cd^2 * n_cd
Re = v_ * D_cd / (6.58 * 10 ^(-5))
fi = Re * 4.35 * D_cd / 2; Nu = 8.614 * (fi)^(1/3)
h_w = Nu * 3.628 / D_cd
```

2.3 Thermal resistance

Thermal resistance between endwinding and inside air is defined

```
R(1) =( h_i_s) / (Q_s * A_end *L_end *0.3) + 1/(Q_s *
A_end *L_end * h_end)
```

Thermal resistance between endwinding and slot winding is defined

```
R(2) = (L_end / 2 + L_fe / 4)/(3* Q_s * S_Cu * 380)
```

Thermal resistance between stator slot winding and stator iron is defined

```
R(3) = (h_s/2) / (Q_s * b_s * L_fe / 2 * 380) + (h_y_s/2)
/ (Q_s * b_s * L_fe / 2 * 45)+ (h_i + h_i_s) / (Q_s * b_s
* L_fe / 2 * 0.3)
```

Thermal resistance between stator slot winding and rotor excitation winding is defined

```
R(4) = (h_s/2) / (Q_s * b_s * L_fe / 2 * 380) + (h_i_s +
h_i) / (Q_s * b_s * L_fe / 2 * 0.3) + 1/(Q_s * b_s *L_fe/2
* h_delta)+ (h_r/2) / (Q_r * b_r * L_r / 2 * 380) + (h_i +
h_i_s) / (Q_r * b_r * L_r / 2 * 0.3) + 1/(Q_r * b_r
*L_r/2*h_delta)
```

Thermal resistance between stator iron and ambient is defined

```
R(5) = (h_y_s/2) / (pi* D_e_s * L_fe / 2* 45) +1 /
((S_y_amb / 2) * h_amb)
```

Thermal resistance between stator iron and cooling water is defined

```
R(6) = (h_y_s/2) / (pi* D_e_s * L_fe / 2 * 45)  +
1/((S_y_w / 2) * h_w)
```

Thermal resistance between stator iron and rotor excitation winding

```
R(7) = (h_y_s/2 + h_s) / (Q_s* b_t * L_fe / 2 * 45) +
1/(Q_s * (b_t * L_fe /2) * h_delta)+ 1/(Q_p * b_t_r *
L_r/2 *h_delta)
```

Thermal resistance between rotor excitation winding and inside air

```
R(8) = (h_r/2) / (Q_r * b_r * L_r / 2 * 380) + (h_y_r/2) /
(pi * 3 * D_cd_r * L_r / 2 *1.2 * h_rot)+ (h_i + h_i_s) /
(Q_r * b_r * L_r / 2 * 0.3)
```

Thermal resistance between inside air and ambient

```
R(9) = 1/(S_shield * h_end) + h_shield / (45 * S_shield)+
1/(S_shield * h_amb)
```

Thermal resistance between inside air and stator iron

```
R(10) = (h_y_s/2) / (pi* D_e_s * L_fe / 2* 45) + 1 /
((S_y_air / 2) * h_rot)
```

Thermal resistance between inside air and water

```
R(11) =  1/((S_y_air / 2) * h_w) + 1 / ((S_y_air / 2) *
h_rot)
```

Water thermal resistance

```
R(12)= 1/ (C(5))
```

Thermal conductance

```
G(i)=1/R(i)
```

2.4 Thermal capacitance

Endwindig

```
C(1)=c_Cu * ro_Cu * S_Cu * L_end * Q_s
```

Stator winding in slot

```
C(2)=c_Cu * ro_Cu * S_Cu * L_fe /2 * Q_s
```

Stator iron

```
C(3)=c_Fe * ro_fe * S_fe * L_fe / 2
```

Rotor excitation winding

```
C(4)= c_Cu * ro_Cu * S_Cu_r * (L_r /2) * Q_r
```

Water

```
C(5)=c_W * ro_w * Q_w
```

2.5 Losses

Endwinding

```
Z(1) = (dP_Cu_1 /2 * L_end / (L_fe + L_end))
```

Stator winding in slot

```
Z(2) = dP_Cu_1/2 * L_fe / (L_fe + L_end)
```

Stator iron

```
Z(3) = dP_Fe /2
```

Rotor excitation winding

```
Z(4) = dP_Cu_2/2
```

3 Complete model in simulink

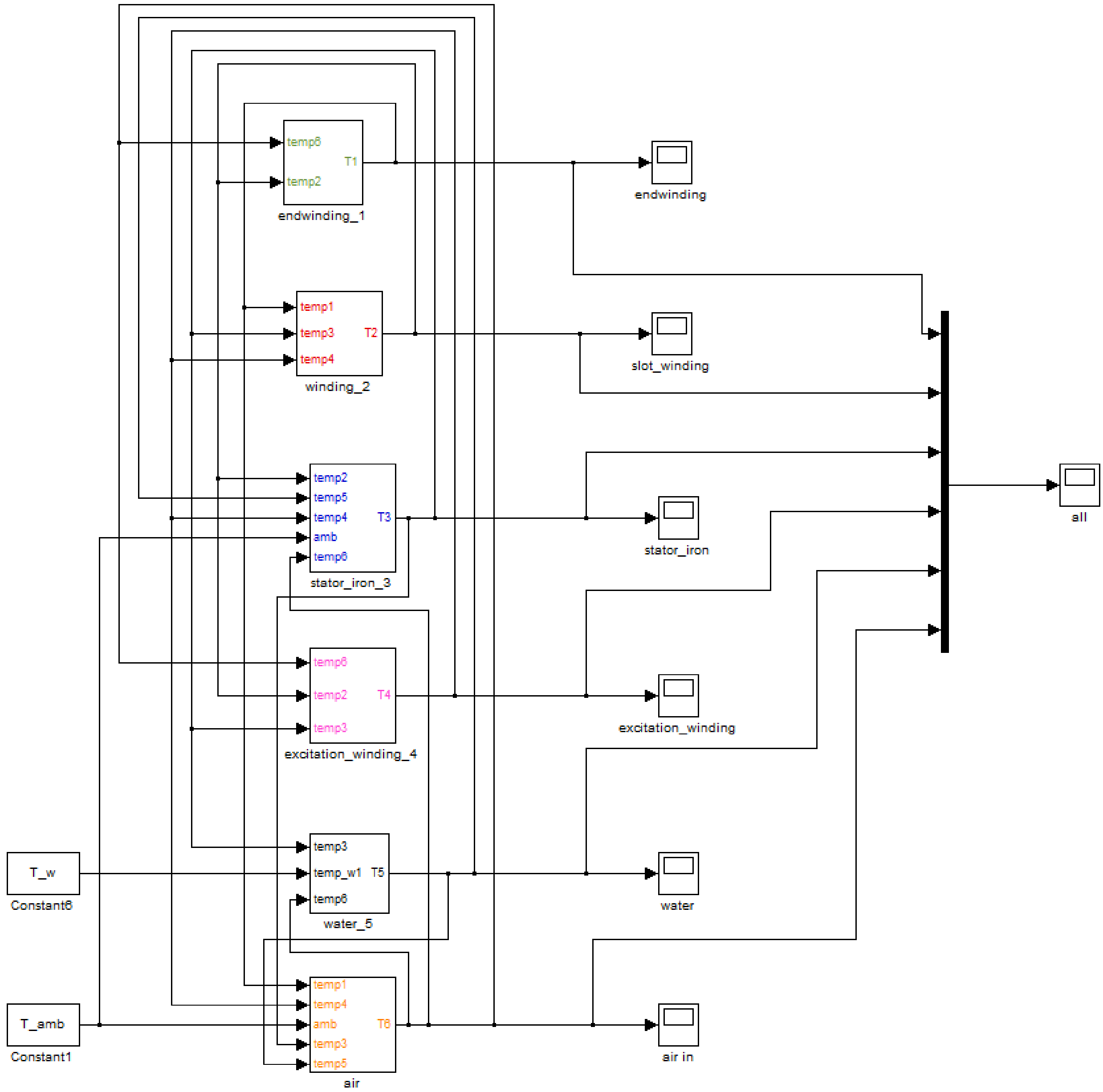

Fig. 3-1 Simulink model of synchronous machine

Where:

T_w is temperature of cooling water.

T_amb is temperature of ambient air.

3.1 Stator endwinding, endwinding_1, node 1

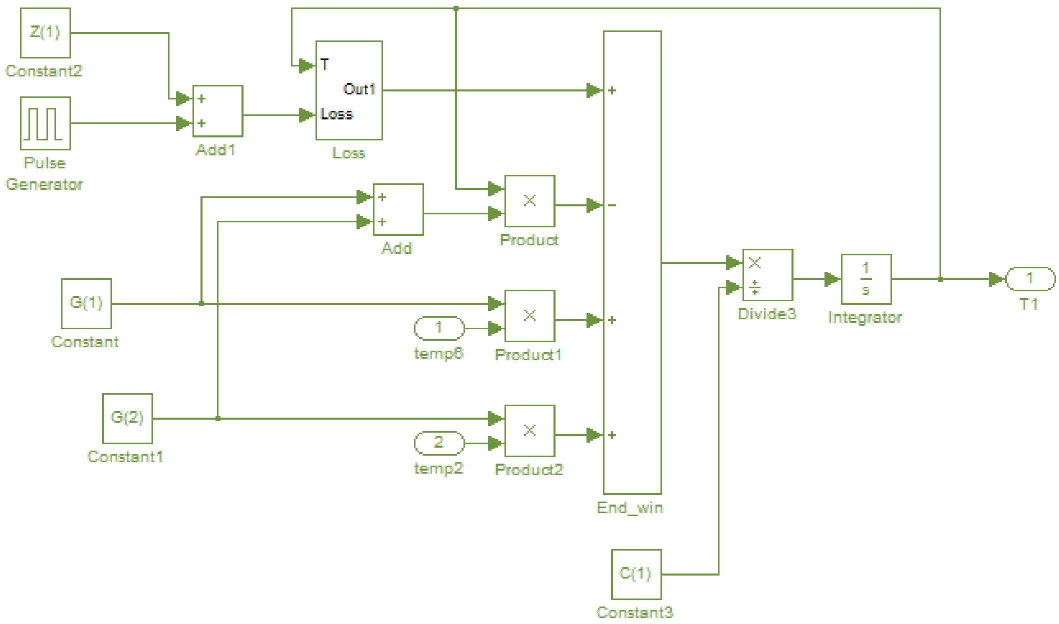

Fig. 3-1 Simulink model of stator endwinding

Stator endwinding is represented in thermal model by node (1) see Fig. 2-1, Fig. 2-2, Fig. 3-1.

For that node can be written

$$C_1\frac{dT_1}{dt}+\frac{1}{R_1}\cdot\left(T_1(t)-T_6(t)\right)+\frac{1}{R_2}\cdot\left(T_1(t)-T_2(t)\right)=Z_1(t)$$

$$\frac{dT_1}{dt}=\frac{Z_1(t)-\left(\frac{1}{R_1}+\frac{1}{R_2}\right)T_1(t)+\frac{1}{R_2}\cdot T_2(t)+\frac{1}{R_1}\cdot T_6(t)}{C_1}$$

Where:

Z(1) – Z_1 losses of stator endwinding. Z(1) is described in chapter 2.5

C(1) - C_1 thermal capacitance of stator endwinding is defined in chapter 2.4.

G(1) and G(2) are thermal conductivity. G(1) and G(2) are defined by $G(1)=\frac{1}{R(1)}$, $G(2)=\frac{1}{R(2)}$.

R(1) - R_1 and R(2) – R_2 are thermal resistivity. R(1) and R(2) are defined in chapter 2.3.

temp2 – T_2 is temperature of slot winding.

temp6 – T_6 is temperature of inside air.

3.2 Slot winding, winding_2, node 2

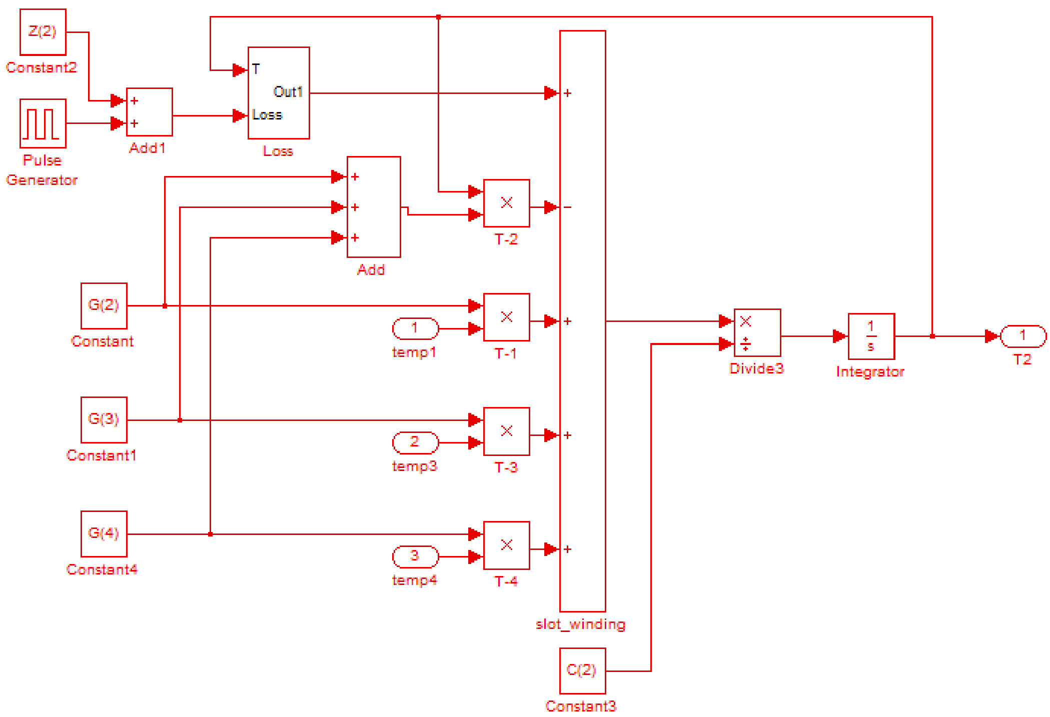

Fig. 3-2 Simulink model of stator winding in slot

Stator winding in slot is represented in thermal model by node (2) see Fig. 2-1, Fig. 2-2, Fig. 3-1, For that node can be written

$$C_2\frac{dT_2}{dt}+\frac{1}{R_2}\cdot\left(T_2(t)-T_1(t)\right)+\frac{1}{R_3}\cdot\left(T_2(t)-T_3(t)\right)+\frac{1}{R_4}\cdot\left(T_2(t)-T_4(t)\right)=Z_2(t)$$

$$\frac{dT_2}{dt}=\frac{Z_2(t)-\left(\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}\right)T_2(t)+\frac{1}{R_2}\cdot T_1(t)+\frac{1}{R_3}\cdot T_3(t)+\frac{1}{4}\cdot T_4(t)}{C_2}$$

Where:

Z(2) – Z_2 losses of slot winding. Z(2) is defined in chapter 2.5

C(2) – C_2 thermal capacitance of slot winding is defined in chapter 2.4.

G(2), G(3) and G(4) are thermal conductivity. G(2), G(3) and G(4) are defined by $G(2)=\frac{1}{R(2)}$, $G(3)=\frac{1}{R(3)}, G(4)=\frac{1}{R(4)}$.

R(2) – R_2, R(3) – R_3 and R(4) – R_4 are thermal resistivity. R(2), R(3) and R(4) are defined in chapter 2.3.

temp1 – T_1 is temperature of endwinding.

temp3 – T_3 is temperature of stator iron.

temp4 – T_4 is temperature of excitation winding.

3.3 Stator iron, stator_iron_3, node 3

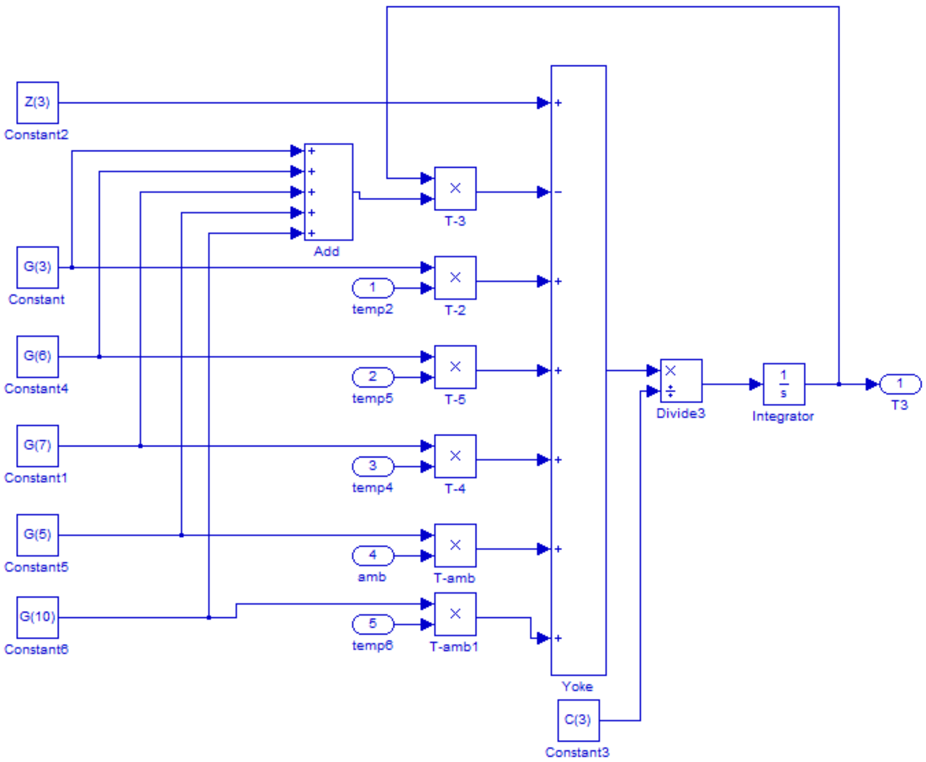

Fig. 3-3 Simulink model of stator iron

Stator iron is represented in thermal model by node (3) see Fig. 2-1, Fig. 2-2, Fig. 3-1. For that node can be written

$$C_3\frac{dT_3}{dt}+\frac{1}{R_3}\cdot\big(T_3(t)-T_2(t)\big)+\frac{1}{R_5}\cdot\big(T_3(t)-T_{amb}\big)+\frac{1}{R_6}\cdot\big(T_3(t)-T_5(t)\big)$$
$$+\frac{1}{R_7}\cdot\big(T_3(t)-T_4(t)\big)+\frac{1}{R_{10}}\cdot\big(T_3(t)-T_6(t)\big)=Z_3(t)$$

$$\frac{dT_3}{dt}=$$
$$\frac{Z_3(t)-\left(\frac{1}{R_3}+\frac{1}{R_5}+\frac{1}{R_6}+\frac{1}{R_7}+\frac{1}{R_{10}}\right)T_3(t)+\frac{1}{R_3}\cdot T_2(t)+\frac{1}{R_5}\cdot T_{amb}+\frac{1}{R_6}\cdot T_5(t)+\frac{1}{R_7}\cdot T_4(t)+\frac{1}{R_{10}}\cdot T_6(t)}{C_3}$$

Where:

Z(3) – Z_3 iron losses. Z(3) is defined in chapter 2.5

C(3) – C_3 thermal capacitance of stator yoke is defined in chapter 2.4.

G(3), G(5), G(6), G(7) and G(10) are thermal conductivity. G(i) are defined by $G(i) = \frac{1}{R(i)}$,

R(3) – $R_{3,}$ R(5) – $R_{5,}$ R(6) – $R_{6,}$ R(7) – R_7 and R(10) – R_{10} are thermal resistivity. R(3), R(5), R(6), R(7) and R(10) are defined in chapter 2.3.

temp2 – T_2 is temperature of slot winding.

temp4 – T_4 is temperature of excitation winding.

temp5 – T_5 is temperature of water cooling.

temp6 – T_6 is temperature of inside air.

amb – T_{amb} is ambient temperature.

3.4 Excitation winding, excitation_winding_4, node 4

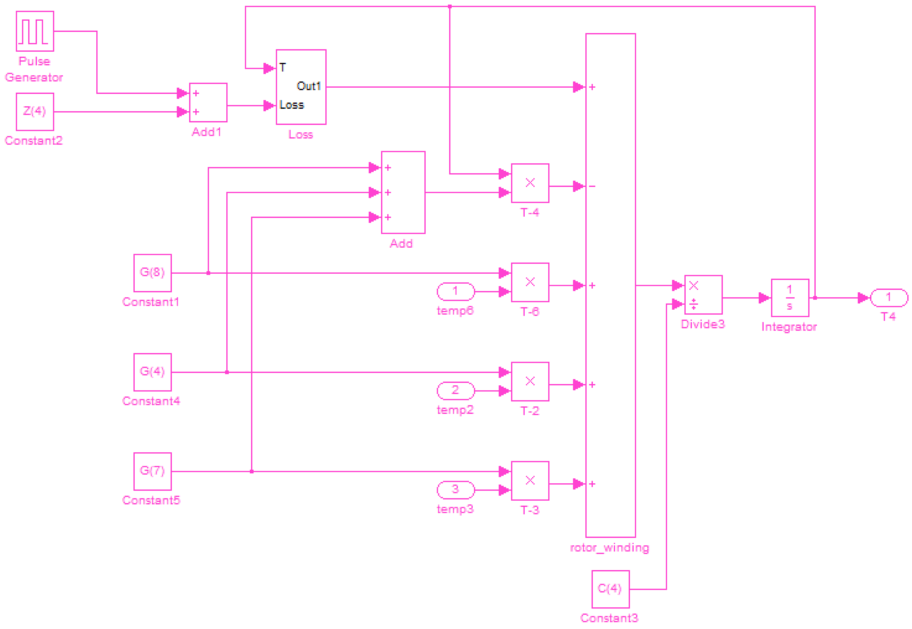

Fig. 3-4 Simulink model of rotor excitation winding

Excitation winding is represented in thermal model by node (4) see Fig. 2-1, Fig. 2-2, Fig. 3-1.

For that node can be written

$$C_4 \frac{dT_4}{dt} + \frac{1}{R_4} \cdot \left(T_4(t) - T_2(t)\right) + \frac{1}{R_7} \cdot \left(T_4(t) - T_3(t)\right) + \frac{1}{R_8} \cdot \left(T_4(t) - T_6(t)\right) = Z_4(t)$$

$$\frac{dT_4}{dt} = \frac{Z_4(t) - \left(\frac{1}{R_4} + \frac{1}{R_7} + \frac{1}{R_8}\right) T_4(t) + \frac{1}{R_4} \cdot T_2(t) + \frac{1}{R_7} \cdot T_3(t) + \frac{1}{R_8} \cdot T_6(t)}{C_4}$$

Where:

Z(4) – Z_4 losses of excitation winding. Z(4) is defined in chapter 2.5

C(4) – C_4 thermal capacitance of excitation winding is defined in chapter 2.4.

G(4), G(7), and G(8) are thermal conductivity. G(i) are defined by $G(i) = \frac{1}{R(i)}$,

R(4) – R_4, R(7) – R_7, and R(8) – R_8 are thermal resistivity. R(4), R(7), and R(8) are defined in chapter 2.3.

temp2 – T_2 is temperature of slot winding.

temp3 – T_3 is temperature of stator iron.

temp6 – T_6 is temperature of inside air.

3.5 Water, water_5, node 5

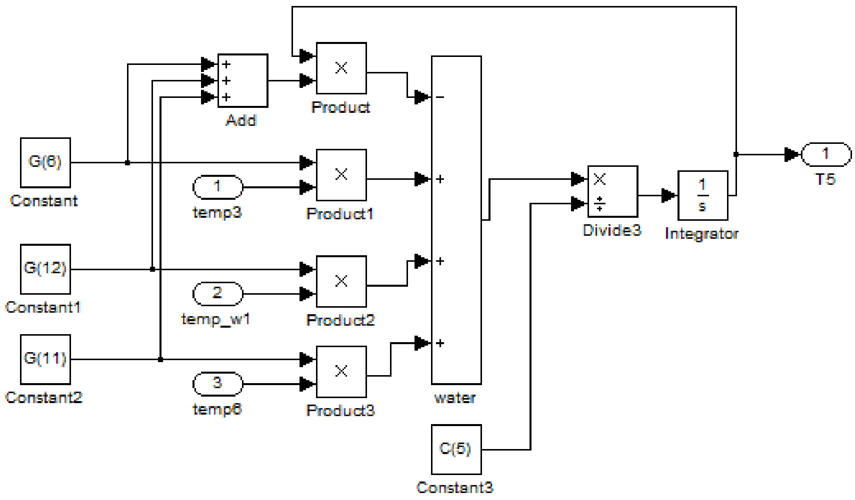

Fig. 3-5 Simulink model of cooling water

Cooling water is represented in thermal model by node (5) see Fig. 2-1, Fig. 2-2, Fig. 3-1. For that node can be written

$$C_5\frac{dT_5}{dt}+\frac{1}{R_6}\cdot\left(T_5(t)-T_3(t)\right)+\frac{1}{R_{11}}\cdot\left(T_5(t)-T_6(t)\right)+\frac{1}{R_{12}}\cdot\left(T_5(t)-T_{water}\right)=0$$

$$\frac{dT_5}{dt}=\frac{-\left(\frac{1}{R_6}+\frac{1}{R_{11}}+\frac{1}{R_{12}}\right)T_5(t)+\frac{1}{R_6}\cdot T_3(t)+\frac{1}{R_{11}}\cdot T_6(t)+\frac{1}{R_{12}}\cdot T_{water}}{C_1}$$

Where:

C(5) – C_5 thermal capacitance of cooling water is defined in chapter 2.4.

G(6), G(11), and G(12) are thermal conductivity. G(i) are defined by $G(i)=\frac{1}{R(i)}$,

R(6) – R_6, R(11) – R_{11}, and R(12) – R_{12} are thermal resistivity. R(6), R(11), and R(12) are defined in chapter 2.3.

temp3 – T_3 is temperature of stator iron.

temp6 – T_6 is temperature of inside air.

temp_w1 – T_{water} is temperature of cooling water.

3.6 Inside air, air, node 6

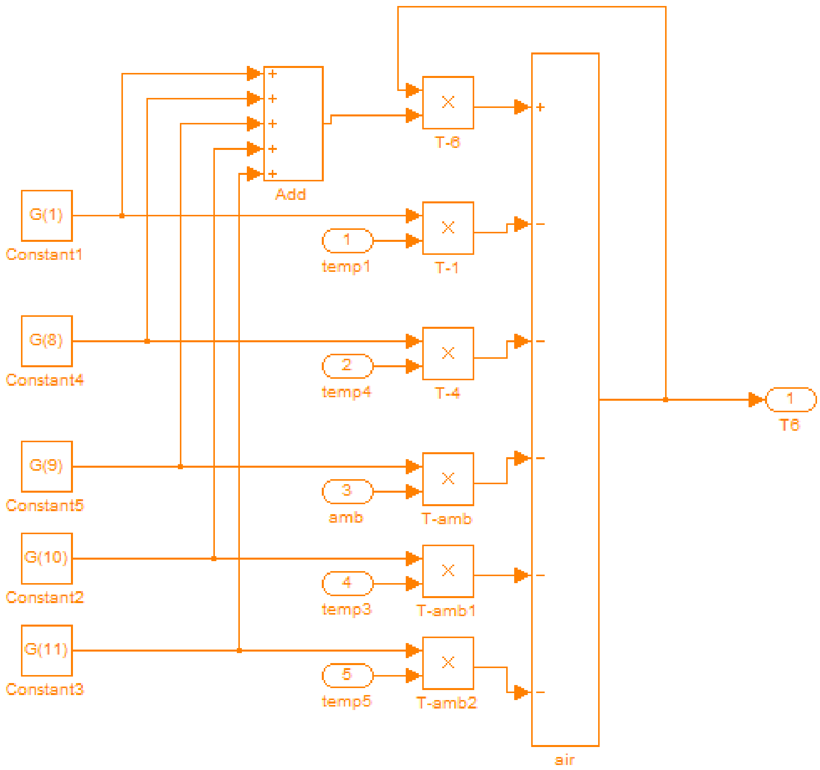

Fig. 3-6 Simulink model of inside air

Inside air is represented in thermal model by node (6) see Fig. 2-1, Fig. 2-2, Fig. 3-1. For that node can be written

$$\frac{1}{R_1}\cdot\big(T_6(t)-T_1(t)\big)+\frac{1}{R_8}\cdot\big(T_6(t)-T_4(t)\big)+\frac{1}{R_9}\cdot\big(T_6(t)-T_{amb}\big)+\frac{1}{R_{10}}\cdot\big(T_6(t)-T_3(t)\big)$$
$$+\frac{1}{R_{11}}\cdot\big(T_6(t)-T_5(t)\big)=0$$

$$T_6(t) = \left(\frac{1}{R_1} + \frac{1}{R_8} + \frac{1}{R_9} + \frac{1}{R_{10}} + \frac{1}{R_{11}}\right) \cdot T_6(t) - \frac{1}{R_1} \cdot T_1(t) - \frac{1}{R_8} \cdot T_4(t) - \frac{1}{R_9} \cdot T_{amb}$$
$$- \frac{1}{R_{10}} \cdot T_3(t) - \frac{1}{R_{11}} \cdot T_5(t)$$

Where:

G(1), G(8), G(9), G(10) and G(11) are thermal conductivity. G(i) are defined by $G(i) = \frac{1}{R(i)}$,

R(1) – R_1, R(8) – R_8, R(9) – R_9, R(10) – R_{10}, and R(11) – R_{11} are thermal resistivity. R(1), R(8), R(9), R(10), and R(11) are defined in chapter 2.3.

temp1 – T_1 is temperature of endwinding.

temp3 – T_3 is temperature of stator iron.

temp4 – T_4 is temperature of excitation winding.

temp5 – T_5 is temperature of water cooling.

amb – T_{amb} is ambient temperature.

4 Conclusion

A coefficient of the thermal model of a 50 kW synchronous machine has been presented. Thermal resist and thermal capacitance is defined.

We need to know your decision about thermal model of e-motor for our future work.

A) Continue in this "simulink" model of e-motor (old one - classic synchronous machine with brush excitation).

- Unfortunately, thermal conductivity of materials are defined as values now.
- Thermal conductivity of materials cannot be changed in specification.
- Teeth are not considered in the model.
- We need 3 weeks to adding teeth to the thermal model as a new node of thermal network.
- Time consuming to work on two different model.

  Old one (classic synchronous machine with brush excitation)

  New designed e-motor (excitation through electromagnetic induction, power electronic and brush less).

B) Complete new model for currently designed e-motor (excitation through electromagnetic induction, power electronic and brush less).

- Build a complete new model, according to your current requirements.
- Teeth will be added to the model.
- Material properties will be set up as inputs data.
- More easier and comfortable for us.

We prefer option B).

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Figures

Revision History

Rev.	Chapter	Description of changes	Date Name/ Dept.