(e) curves of input power, output power and efficiency against torque, assuming friction and iron losses are zero;

(f) the frequency and speed at which X= L is equal to the resistance R, if the phase inductance is 5 mH;

(g) what is the effect of (f) on the speed/torque curve i.e. the effect of L>0 and L>R as speed increases?

6. A brushless dc motor has 3 phases and 6 poles. The electromagnetic torque is 4 Nm with a current of 0.5 A rms. Friction and iron losses produce a constant retarding torque of 0.1 Nm. The resistance and inductance per phase are 70 and 50 mH. Assume optimum position feedback. Calculate

(a) the torque and emf constants;

(b) the emf generated for a speed of 600 rpm;

(c) the speed of the motor for a supply voltage of 200 V (ac rms per phase) with no external load;

(d) the speed, current and efficiency for an external load of 4 Nm and a supply voltage of 200 V ac rms;

(e) the supply frequency for (d), and check wL<R.

Chapter 10

BLDCM

7. A brushless dc motor has 3 phases and 4 poles. The generated emf is 220 V rms sinusoidal at 1000 rpm (open circuit voltage when tested as generator with a drive motor). Calculate

(a) the emf constant (V/Rad/s);

(b) the torque constant (Nm/A) with optimum position feedback angle;

(c) the speed/torque curve, if the resistance per phase is 4 ;

(d) the supply frequency at 1000 rpm;

(e) curves of input power, output power and efficiency against torque, assuming friction and iron losses are zero;

(f) the frequency and speed at which X= wL is equal to the resistance R, if the phase inductance is 5 mH;

(g) what is the effect of (f) on the speed/torque curve i.e. the effect of L>0 and L>R as speed increases?

Solution:

a) $E = \frac{P}{2}\lambda_m w_r$, $220 = \frac{P}{2}\lambda_m$ (2*(22/7)*1000/60)

$\frac{P}{2}\lambda_m$ = 2.1 V/Rad/Sec

b) $T_{em} = \frac{mP}{2}\lambda_m I$, $\frac{mP}{2}\lambda_m$ = 3*2.1=6.3 Nm/A

c) $w_r = \frac{V}{p\lambda_m/2} - \frac{R}{m(p\lambda_m/2)^2}T_{em}$

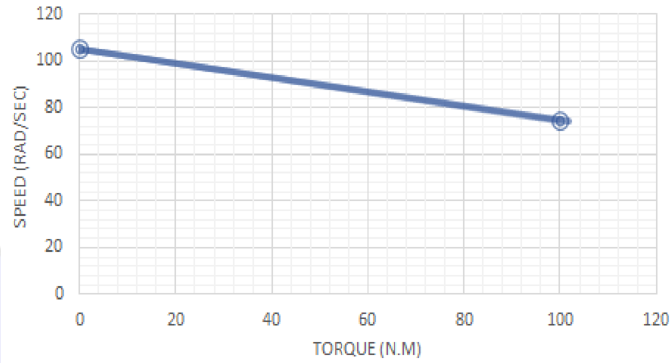
$w_r = \frac{220}{2.1} - \frac{4}{3(2.1)^2}T_{em}$,

$\boldsymbol{w_r = 104.76 - 0.302T_{em}}$

Make table between speed and torque take two values of torque

When T_{em}=0, wr=104.76 rad/sec

When T_{em}=100 , wr=74.56 rad/sec



So the curve as in Figure

d) w_r = 2w/p, w=wr*p/2=2*(22/7)*1000/60)*4/2=209.5 Hz

e) $T_{em} = \frac{P_{em}}{w_r}$, **$P_{out}$** = p_{em}=T_{em}*w_r, **=104.76 T_{em}** (1)

use T_{em}= 0, then P_{out} =0 watt, T_{em}=10, then p_{out}=1047.6 watt

$P_{in} = P_{cu} + P_{Fe} + P_{mec} + P_{out}$, $P_{in} = P_{cu} + P_{out}$

Pin = mRI^2 + T_{em}*w_r, $I = \frac{2*T_{em}}{mP\lambda_m}$ sub in P_{in}

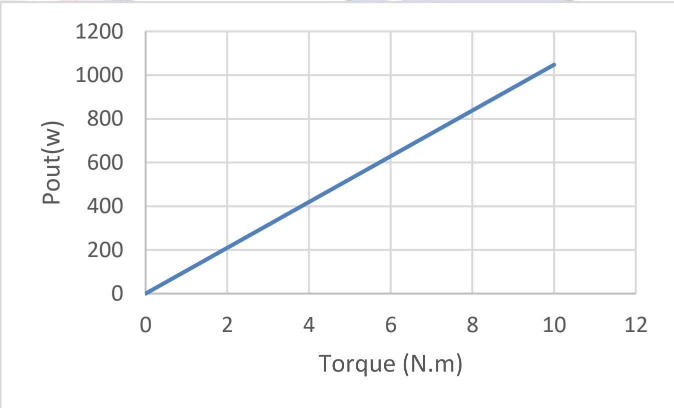
P_{in} = mR$\frac{2*T_{em}}{mP\lambda_m}^2$ + T_{em}*w_r, P_{in} = 4$\frac{T_{em}}{2.1}^2$ + T_{em}*104.76,

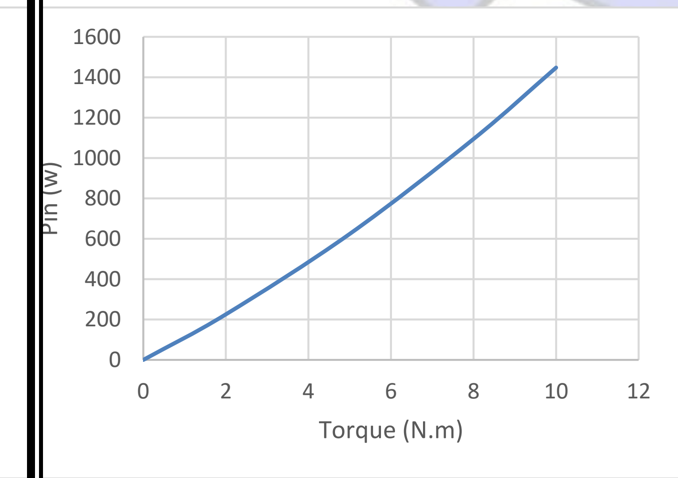
T_{em}	Pout
0	0
2	209.5
5	523.8
8	838
10	1047.6

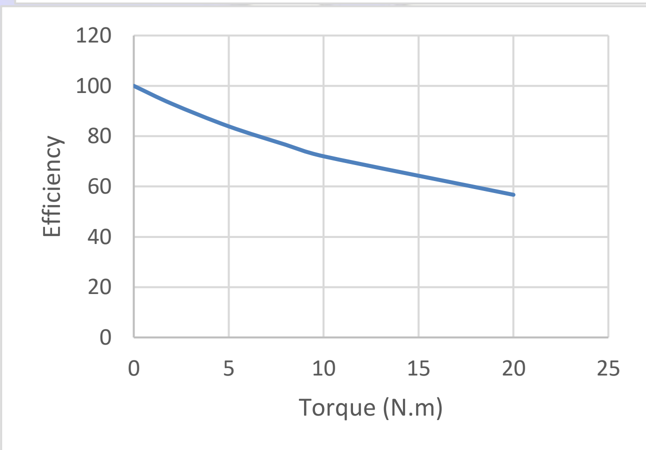
P_{in} = 0.302T_{em}^2 + 104.76 T_{em} (2)

T=0, then p_{in}=0, T=2, p_{in}=225.5

Other calculation in table







$\eta = \frac{P_{out}}{P_{in}} = \frac{\text{Tem} * \text{wr}}{0.302T_{em}^2 + 104.76\ \text{Tem}}$

$\boldsymbol{\eta} = \frac{\mathbf{104.76}}{\mathbf{4\ Tem + 104.76}}$**x100%** (3)

T=0, $\eta = 100\%$, T=2, Type equation here.

T_{em}	P_{in}
0	0
2	225.5
5	623.8
8	1094
10	1447.6

T_{em}	Effe
0	100
2	
5	98.5
8	
10	
20	
100	

f) X=wL=R, w=R/L
W=4/(0.005)=800 Hz
Wr=2w/p=2*800/4=400 rad /sec

g) $w_r = \frac{V}{p\lambda_m/_2} - \left(\frac{R}{m\left(p\lambda_m/_2\right)^2} + j\frac{wL}{m\left(p\lambda_m/_2\right)^2}\right)T_{em}$

When L increased the drop-in speed will increased at constant torque while the torque will decreased also when L increased at constant speed