Example 1

A separately excited dc machine is operated at a constant speed of 3000r/min with a constant field current such that the emf E_a is 125V. The armature resistance R_a is 0.02Ω. Compute the armature current, terminal power and electromagnetic power and torque when the terminal voltage U is 128V.

Solution

In this case U is larger than E_a, and thus the machine is operating as a motor. Hence

$$I_a=(U-E_a)/R_a=(128-125)/0.02= 150 \text{ A}$$

and the power input at motor terminal is

$$P_1=UI_a=128*150 = 19.2 \text{ kW}$$

The electromagnetic power is given by

$$P_e = E_aI_a=125*150=18.75 \text{ kW}$$

Finally, the electromagnetic torque is

$$T_e= P_e /\Omega,\ \Omega=2\pi n/60=2\pi*3000/60=100\pi,\ T_e= 18.75*10^3/(100\pi)=59.7 \text{ N·m.}$$

Example 2

A separately excited dc machine is operated at a constant speed of 3000r/min with a constant field current such that the emf E_a is 125V. The armature resistance R_a is 0.02Ω. Compute the armature current, terminal power and electromagnetic power and torque when the terminal voltage U is 124V.

Solution

In this case, E_a is larger than U and hence armature current will flow out of the machine, and thus the machine is operating as a generator. Hence

$$I_a=(E_a -U)/R_a=(125-124)/0.02= 50 \text{ A}$$

and the power out at generator terminal is

$$P_2=UI_a=124*50 = 6.20 \text{ kW}$$

The electromagnetic power is given by

$$P_e = E_aI_a=125*50=6.25 \text{ kW}$$

Finally, the electromagnetic torque is

$$T_e= P_e /\Omega,\ \Omega=2\pi n/60=2\pi*3000/60=100\pi,\ T_e= 6.25*10^3/(100\pi)=19.9 \text{ N·m.}$$

Example 3

A separately excited dc machine is operated at a constant speed of 3000r/min with a constant field current such that the emf E_a is 125V. The armature resistance R_a is 0.02Ω. The machine is observed to be operating as a motor with a terminal voltage U of 123 V and with an input terminal power of 21.9 kW. Calculate the speed of the motor.

Solution

The armature current can be found from the terminal voltage U and power as

$$I_a=P_1/U = 21900/123= 178 \text{ A}$$

Thus the emf E_a is

$$E_a=U-I_aR_a=119.4\text{V}$$

Because $E_a=C_e\Phi n$, then the rotational speed can be found as

$$n=n_0*E_a/E_{a0} = 3000*119.4/125=2866 \text{ r/min}$$

Example 4

A permanent-magnet dc motor without field winding is known to have an armature resistance of 1.03 Ω. When operated at no load from a dc source 50V, it is observed to rotate at a speed of 2100 r/min and to draw a current of 1.25A. Find (a) The $C_e\Phi$ (b) the no-load rotational losses of the motor, and (c) the power output of the motor when it is operating at 1700 r/min from a 48V source.

Solution

a. The emf Ea can be found as

$$E_a=U-I_aR_a=50-1.25*1.03=48.7\text{V}$$

At a speed of 2100 r/min

$$E_a= C_e\Phi n \qquad C_e\Phi = E_a/ n =48.7 /2100=0.0232 \text{ V}\cdot(\text{min/r})$$

b. At no load, all the electromagnetic power P_e is used to supply rotational losses. Therefore

$$P_0=P_e-P_2=P_e= E_aI_a=48.7*1.25=60.87 \text{ W}$$

$$T_0=P_0/\Omega=60.87/(6.28*2100/60)=0.277 \text{ N}\cdot\text{m}$$

c. At 1700r/min

$$E_a= C_e\Phi n= 0.0232 *1700=39.44 \text{ V}$$

The armature current can be found as

$$I_a=(U-E_a)/R_a=(48-39.44)/1.03= 8.31 \text{ A}$$

The electromagnetic power P_e can be calculated as

$$P_e= E_aI_a=39.44*8.31=327.74 \text{ W}$$

Assuming the no-load Torque T_0 to be constant at their no-load value (certainly an approximation), the output shaft power P_2 can be calculated:

$$P_0= T_0*\Omega=0.277*6.28*1700/60=49.29 \text{ W}$$

$$P_2=P_e-P_0=327.74- 49.29=278.45 \text{ W}$$