Indian Institute of Technology Bombay

EE 114 Power Engineering 1 (S2)
2021-2022, Semester 2
Assignment 6

1. A 230 V DC shunt machine has an armature resistance of 0.5 Ω and field resistance of 115 Ω. When the machine is connected to 230 V supply it operates as a motor. When operated as a generator the machine supplies a terminal voltage of 230 V. If the line current in each case is 40 A, find the ratio of the generator speed to the motor speed.

   [Ans: 1.1895]

2. A 100 hp, 250 V shunt motor takes 10 A when running on no load. The resistance of the armature and the field are 0.5 Ω and 100 Ω, respectively. Assume mechanical losses to be constant.

   (a) Calculate the motor efficiency when the motor is loaded to draw 150 A from the source.

   (b) Calculate the maximum efficiency of the motor.

   (c) Calculate the maximum efficiency when it operates as a generator.

   [Ans: (a) η = 64.4 %, (b) η_{max} = 72.84 %, (c) η_{max} = 77.42 %]

3. A 230 V, 250 RPM, 100 A separately excited DC motor has an armature resistance of 0.5 Ω. The motor is now connected to a 230 V DC supply and the rated DC voltage is applied to the field winding. It is driving a load whose torque speed characteristic is given by $T_L = 500 - 10\omega$, where ω is the rotational speed in rad/sec and T_L is in Nm. Find the steady state speed at which the motor will drive the load and the armature current drawn from the source. Neglect rotational losses.

   [Ans: ω = 31.51 rad/sec, I_a = 27.08 A]

4. A 240 V, 2 hp, 1200 RPM DC shunt motor drives a load whose load torque varies directly with speed. The armature resistance of the motor is 0.75 Ω. The motor draws a line current of 7 A, where the field current I_f = 1 A and rotates at 1200 RPM. Neglect the armature reaction and magnetic saturation.

   (a) While maintaining the rated voltage, if the field current is reduced to 0.7 A by increasing the field resistance, what will be the operating speed of the motor?

   (b) For the operating condition in (a) determine the efficiency, neglecting the rotational losses.

   [Ans: Speed = 1683.5 RPM, η = 90.9 %]

5. A DC series motor runs at 1500 RPM, drawing a current of 25 A from a 220 V supply, with its field halves connected in parallel. The voltage drop across the armature and field resistances can be neglected. Assuming the load torque to be proportional to the speed, if the field halves are reconnected in series, at what speed would the motor run? Also calculate the armature current.

   [Ans: Speed = 1196 RPM, Current = 15.76 A]

Changing the field current will change the flux associated with the circuit.

6. A DC series motor has an armature resistance of 0.5 Ω and field resistance of 0.3 Ω. On a certain load, the motor draws 25 A from a 250 V DC supply. Find the value of series resistance to be inserted to reduce the speed by 20 %. The load torque is proportional to ω^3. Assume linear magnetization characteristic.

[Ans: 5.82 Ω]

7. The combined armature and field resistance of a DC series motor is 0.3 Ω. When tested at standstill, 25 A of motor current produces a shaft torque of 10 Nm. The motor is now connected to a 200 V DC source and is driving a constant load torque of 30 Nm. Calculate the speed at which the load is driven.

[Ans: Speed = 2577.67 RPM]

8. An automatic starter circuit is to be designed for a DC shunt motor rated at 20 hp, 240 V and 75 A. The armature resistance of the motor is 0.12 Ω and shunt field resistance is 40 Ω. At starting the motor armature current must not exceed 250 % of its rated value. Whenever the armature current falls to the rated value one of the starting resistances can be cut off. Find out the required number of stages of the starting resistances and the calculate the values of each resistor.

[Ans: 3 stages, 0.833 Ω, 0.335 Ω, 0.102 Ω]

9. A 6 pole 230 V DC series motor has a flux per pole per ampere of 4 mWb/A. The load torque is proportional to the square of the speed and its value at 800 RPM is 20 Nm. There are 432 wave connected conductors and the total resistance of the motor is 1 Ω. Determine the motor speed and current when it is connected to the rated supply voltage.

[Ans: Speed = 652.36 RPM, I_a = 4.0 A]

10. A separately excited DC motor takes 50 A on some load from 250 V mains. Its speed is to be raised by 40 % by weakening the field flux. If the torque at the increased speed is 20 % more than that at the initial speed, find the percentage change in field flux. The armature resistance including brush resistance is 0.5 Ω. In-case of more than one solution, suggest the more practical one and justify your answer.

[Ans: 35.1 %]