Example 6-5

Fig. E6-5 shows a *50-hp*, *120-V*, *1800-rpm* shunt DC motor. The armature resistance is *0.1 Ω* and the field resistance is *50 Ω*. Assume compensating windings have completely taken care of the armature reaction. Also, ignore mechanical, core and miscellaneous losses. Initially, the motor is running a constant-torque load and draws *12 kW* from the source at *1,500 rpm*. Assume ϕ-I_f relation is linear. If the field resistance is increased to *60 Ω* using an adjustable resistance in series with the field winding, find the new steady-state armature current and speed, as well as the power loss in the adjustable resistance.

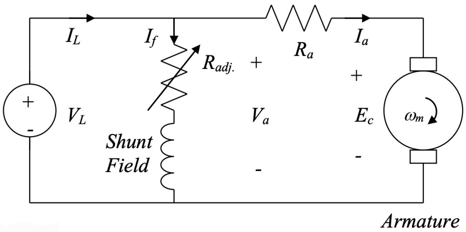

Fig. E6-5

Armature current before increasing resistance :

$$I_{a1} = I_{L1} - I_{f1}$$

$$P_{in} = 12000 \text{ W} = V_L I_{L1}$$

$$I_{L1} = \frac{12000}{120} = 100 \text{ A}$$

$$I_{f1} = \frac{V_L}{R_{f1}} = \frac{120}{50} = 2.4 \text{ A}$$

$$\therefore I_{a1} = I_{L1} - I_{f1} = 100 - 2.4 = 97.6 \text{ A}$$

Load torque is constant → Developed torque in situation 2 = Developed torque in situation 1

$$\tau_{d1} = \tau_{d2}$$

$$K\phi_1 I_{a1} = K\phi_2 I_{a2}$$

$$I_{a2} = \frac{\phi_1}{\phi_2} I_{a1}$$

$\phi - I_f$ relation is linear :

$$\frac{\phi_1}{\phi_2} = \frac{I_{f1}}{I_{f2}} = \frac{V_L / R_{f1}}{V_L / R_{f2}} = \frac{R_{f2}}{R_{f1}} = \frac{60}{50} = 1.2$$

$$I_{a2} = \frac{\phi_1}{\phi_2} I_{a1} = 1.2 \times 97.6 = 117.12 \text{ A}$$