DC Series Motor Problem Solution

Given:

- Rated voltage, $V_1 = 230$ V
- Rated speed, $N_1 = 750$ rpm
- Rated current, $I_1 = 25$ A
- Combined resistance, $R = 1\ \Omega$
- New speed, $N_2 = 400$ rpm
- Torque is proportional to speed squared, $T \propto N^2$

Step 1: Determine the relationship between current and speed

$$T \propto N^2 \quad \text{and} \quad T \propto I^2$$
$$\therefore N \propto I$$

Step 2: Calculate the new current, I_2, at 400 rpm

$$\frac{N_1}{I_1} = \frac{N_2}{I_2}$$
$$\frac{750}{25} = \frac{400}{I_2}$$
$$I_2 = \frac{400 \times 25}{750} = 13.33 \text{ A}$$

Step 3: Calculate the back EMF, E_{b1}, at rated conditions

$$E_{b1} = V_1 - I_1 R = 230 - (25 \times 1) = 205 \text{ V}$$

Step 4: Calculate the new back EMF, E_{b2}, at 400 rpm

$$\frac{E_{b1}}{N_1} = \frac{E_{b2}}{N_2}$$
$$\frac{205}{750} = \frac{E_{b2}}{400}$$
$$E_{b2} = \frac{205 \times 400}{750} = 109.33 \text{ V}$$

Step 5: Calculate the new terminal voltage, V_2, at 400 rpm

$$V_2 = I_2 R + E_{b2}$$
$$V_2 = (13.33 \times 1) + 109.33 = 122.66 \text{ V}$$

Therefore, at 400 rpm:

- The motor current is 13.33 A
- The terminal voltage is 122.66 V