2. Application 1: A 12-pole, three-phase slip-ring induction motor absorbs 250 kW from a 50 Hz supply and runs at 490 r/min. The total stator absorbs 12 kW and the efficiency is 92%.

Application 2: The speed is to be reduced to 350 r/min by adding resistances to the rotor circuit.

Determine:

the mechanical loss for application 1. (7)

The overall efficiency and the power available at the shaft for application 2 neglecting the changes in power factor and mechanical losses. (6)

The difference in torque between the two applications. (2)

[15]

2.1 Mechanical loss

Mechanical loss = mechanical power developed - rated power output

Mechanical power developed = power input to the rotor - rotor copper losses

Power input to the rotor = power input – stator losses

Rotor copper losses = slip x power input to the rotor

Rated power output = η x power input

$$Synchronous\ speed = \frac{f}{p} = \frac{50x60}{6} = 500 \quad r/\min$$

$$Slip\ at\ speed\ of\ 490\ r/\min = \frac{500-490}{500} = 0,02$$

$$Total\ power\ output = 0,92x250 = 230 \quad kW$$

$$Total\ losses = 250 - 230 = 20 \quad kW$$

$$Power\ input\ to\ the\ rotor = 250 - 12 = 238 \quad kW$$

$$Rotor\ copper\ loss = slip\,x rotor\ input = 0,02x238 = 4,76 \quad kW$$

$$Power\ output\left(including\ mechanical\ loss\right) = 238 - 4,76 = 233,24 \quad kW$$

$$Mechanical\ loss = 233,24 - 230 = 3,24 \quad kW$$

(7)

2.2 Shaft power and overall efficiency

Power available at the shaft = mechanical power developed – mechanical losses

Mechanical power developed = power input to the rotor – rotor copper losses

Rotor copper losses = slip x power input to the rotor

Efficiency = power available at shaft / power input

$$At\ 350\ r/\min\ slip = \frac{500-350}{500} = 0,3$$

$$As\ before\ power\ input\ to\ rotor = 238 \quad kW$$

$$Rotor\ copper\ loss = 0,3x238 = 71,4 \quad kW$$

$$Total\ mechanical\ power\ developed = 238 - 71,4 = 166,6 \quad kW$$

Output power = total mechanical power – mechanical losses =166,6– 3,24 = 163,36 kW

$$Overall\ efficiency = \frac{163.36}{250}x100 = 65,3\%$$

(6)

2.3 Torque = output power / rotational speed N-m [kW / rpm]

Difference in torque = T_2 / T_1 [(kW / rpm) / (kW / rpm)]

$$The\ change\ in\ torque\ between\ the\ applications = \frac{T_2}{T_1} = \frac{163.36x490}{230x350} = 0,994$$

$$The\ torque\ has\ not\ changed\ between\ applications\ 1\ and\ 2.$$

(2)
