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Homework 9: due 3/25/2020

1. What is the difference between a drip-proof motor and an explosion-proof motor?
   Drip-proof motors are protected from dripping liquids up to 15 degrees from the vertical. An explosion-proof motor, by contrast, are fully sealed, and the frames are designed to withstand the enormous pressure.
2. What is the approximate life expectancy for a motor?
   It depends on the size, speed, horsepower, what voltage and current its run at, and how long it is run at one time.
3. Explain what a NEMA Design D motor is unsatisfactory for driving a pump.
   A pump should be a consistent speed, and shouldn't take long to get to full speed. A NEMA Design D motor achieves neither of these.
4. Identify the motor components shown in Fig. 3

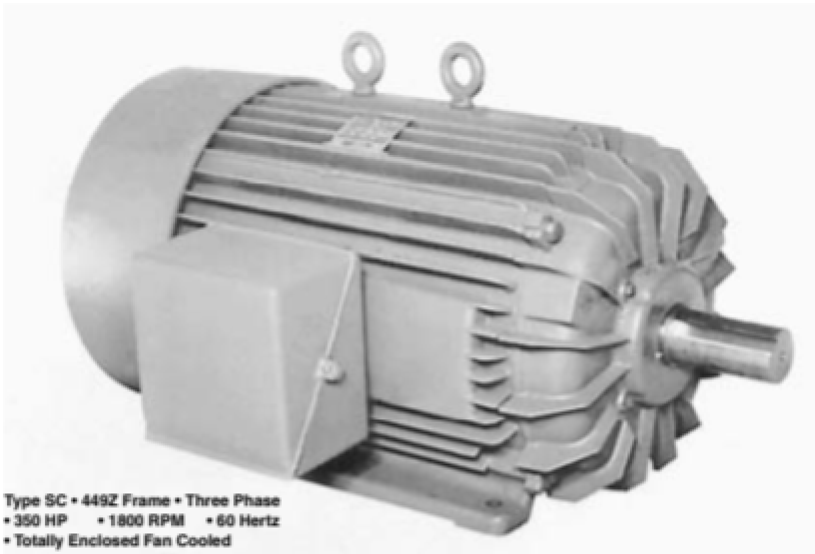
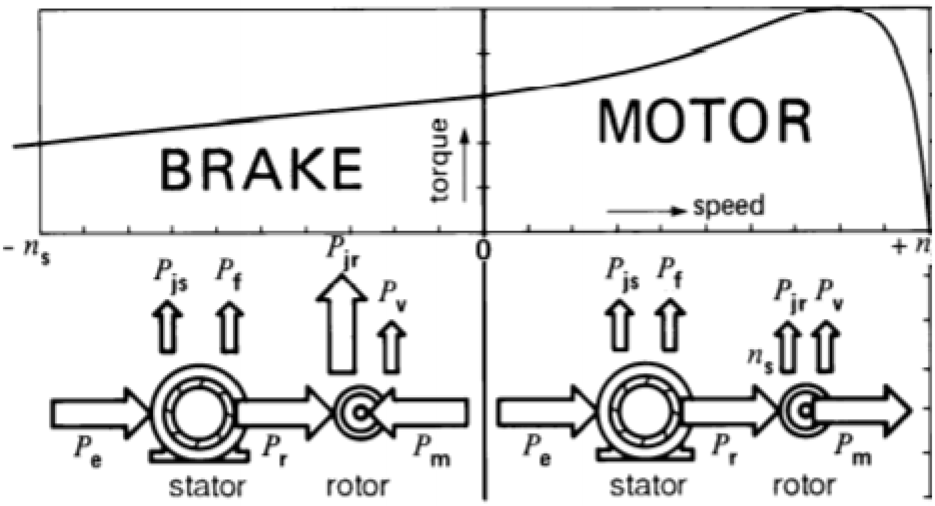


Figure 3
Totally enclosed fan-cooled induction motor rated 350 hp, 1760 r/min, 440 V, 3-phase, 60 Hz.
(Courtesy of Gould)

5. Show the flow of active power in a 3-phase induction motor when it operates
   1. As a motor.
      Power is being put into the system in the same direction as rotation.
   2. As a brake.
      Power is being put in in the opposite direction of rotation. As such, a lot of power is lost as heat.



T = torque developed by the machine

n = speed of rotation

6. Will a 3–phase motor continue to rotate if one of the lines becomes open? Will the motor be able to start on such a line?
   The motor needs all 3 phases to start. It will be able to run with only two phases, but there will be a lot of excess heat, and the motor will wear out faster.

14. A 300hp, 2.3kV, 3-phase, 60Hz, squirrel-cage induction motor turns at a full-load speed of 590r/min. Calculate the approximate value of rotor I^2R losses.

$$\begin{aligned} P_{jr} &= (\frac{120\frac{f}{p} - n}{120\frac{f}{p}}) * (3P) \qquad (1) \\ P_{jr} &= (\frac{120\frac{60Hz}{6\ poles} - 590rpm}{120\frac{60Hz}{6\ poles}}) * (3(300hp * 746W/hp)) \\ P_{jr} &= (\frac{1200rpm - 590rpm}{1200rpm}) * (3(223.8kW)) \\ P_{jr} &= (0.508\overline{3}) * (3(223.8kW)) \\ &\boxed{P_{jr} = 341.295kW} \end{aligned}$$

If the line voltage then drops to 1944V, calculate the following:

1. The new speed, knowing that the load torque remains the same.

$$
n = 1200(1 - s(\frac{V_1}{V_2})^2) = 1200(1 - 0.508\overline{3}(\frac{2300V}{1944V})^2) \tag{2}
$$
$$
n = 346rpm
$$

2. The new power output.

$$
P' = P * \frac{n'}{n} = 300hp * \frac{346rpm}{590rpm} \tag{3}
$$
$$
P' = 176.34hp \approx 131.6kW
$$

3. The new I^2R losses in the rotor.

$$
P_{jr} = (\frac{120\frac{f}{p} - n}{120\frac{f}{p}}) * (3P) \tag{4}
$$
$$
P_{jr} = (\frac{120\frac{60Hz}{6\ poles} - 346rpm}{120\frac{60Hz}{6\ poles}}) * (3(131.6kW))
$$
$$
P_{jr} = 0.711\overline{6} * 3(131.6kW)
$$
$$
P_{jr} = 280.6kW
$$

27. The bearings in a motor have to be greased regularly, but not too often. The following schedule applies to two motors:
    Motor A: 75hp, 3550r/min; lubricate every 2200 hours of running time.
    Motor B: 75hp, 900r/min; lubricate every 10000 hours of running time.
    Motor A runs continually, 24 hours per day. Motor B drives a compressor and operates about 6 hours per day. How often should the bearings of each motor be greased per year?
    Motor A should be greased about once every quarter, or 4 times in a year.
    Motor B should be greased about once every 5 years.
28. A 40hp 1780r/min, 460V, 3-phase, 60Hz, drip proof Baldor Super E premium energy induction motor has a power factor of 86% and an efficiency of 93.6%. The motor, priced at $2243, runs at full-load 12 hours a day, 5 days a week. Calculate the driving cost of the motor during a 3-year period, knowing that the cost of energy is $0.06/kWh.

    $$

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12\ hours*5\ days/week\ *52\ weeks/year*3\ years=9360\ hours\\
P_{in}={P_{out}\over eff}={40hp*746W/hp\over0.936}=31.9kW\\
Cost=price/kWh*kW*h=\$0.06*9360\ hours*31.9kW\\
Running\ cost=\$17,904.00\\
Cost\ w/\ motor=\$20,147.00
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$$

$$
\begin{aligned}
12\ hours*5\ days/week\ *52\ weeks/year*3\ years=9360\ hours \quad (5)\\
P_{in}={P_{out}\over eff}={40hp*746W/hp\over0.936}=31.9kW\\
Cost=price/kWh*kW*h=\$0.06*9360\ hours*31.9kW\\
Running\ cost=\$17904.00\\
Cost\ w/\ motor=\$20,147.00
\end{aligned}
$$

$$
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$$