46.64 A centrifugal pump consumes $200hp$ when operating at $1800rpm$. What is the electrical power demand when the pump speed is reduced to $1200rpm$? Assume 100% motor efficiency.

A. $44KW$

B. $59KW$

C. $66KW$

D. $89KW$

The motor output, typically expressed in bhp, is the input to the pump. Therefore, if the pump initially *consumes* $200hp$, this represents the motor output. Since the motor efficiency is assumed to be 100%, the motor's electrical power demand (input) is equal in magnitude to its bhp (output) and differs only in its units. Electrical power input is typically expressed in KW.

To account for the reduction in speed, the Pump Affinity Laws can be used to find the new power. Select the equation under the column "Speed Change" on the row "Horsepower." Let the subscript '1' denote the original operating conditions and '2' denote the new conditions. Substitute and solve for the new bhp.

$$bhp_2 = bhp_1 \left(\frac{N_2}{N_1}\right)^3 = (200hp)\left(\frac{1200rpm}{1800rpm}\right)^3 = 59.26hp$$

Since there are assumed to be no motor losses, simply convert the units of the output power from hp to KW to determine the electrical input power.

$$\dot{W} = 59.26hp\left(\frac{745.7W}{hp}\right)\left(\frac{1KW}{1000W}\right) = 44.2KW$$

Answer A

46.65 During initial operating conditions, the cooling coil in a computer room air conditioning unit cools $90°F$ entering air to $65°F$. The unit uses $56°F$ supply chilled water to drive the coil temperature to an apparatus dew point of $60°F$. The coil is designed for a maximum air side delta T of $25°F$. After an increase in heat load, the same unit is met with $95°F$ return air. In order to stay safely within the coil's temperature limits, operators raise the chilled water supply temperature to $63°F$ such that the apparatus dew point becomes $67°F$. What is the expected discharge air temperature based on the new operating conditions?

A. $68.3°F$

B. $70.0°F$

C. $71.7°F$

D. $72.5°F$

Consider the original operating conditions as Case A and the final operating conditions as Case B. Calculate the coil efficiency for Case A. Coil efficiency is the ratio of the actual ΔTaccross the coil as compared to the maximum possible ΔT which occurs when the discharge air has been cooled to the apparatus dew point (ADP).

$$\eta_A = \frac{T_{return,A} - T_{discharge,A}}{T_{return,A} - ADP_A} = \frac{90°F - 65°F}{90°F - 60°F} = 0.833$$

Assume the coil efficiency remains constant for the new set of operating conditions.

$$\eta_B = \eta_A = 0.833$$

Use the new return temperature and new ADP for Case B to determine the new discharge temperature, $T_{discharge,B}$, after the change.

$$\eta_B = \frac{T_{return,B} - T_{discharge,B}}{T_{return,B} - ADP_B} = \frac{95°F - T_{discharge,B}}{95°F - 67°F} = 0.833$$

$$T_{discharge,B} = 71.7°F$$

While it is not required for the solution, it is noteworthy that the reduction in ΔT on the air side will require an increase in cfm to satisfy the same cooling demand, and since the problem states that the heat load has been *increased*, this compounds the need for additional airflow!

Answer C