FANS AND BLOWERS

QUESTION

An induced draft industrial fan is used to draw air through a bag filter. The following information is given for this fan:

- Flow rate is 90 m^3/s at a static pressure of 80 mm water column (WC)
- 65 mm WC is the static pressure across the bag filter
- Motor power drawn is 120 kW
- Motor efficiency is 86%
- Impeller diameter is 70 mm
- RPM is 1000

The company decided to replace the bag filter with an electrostatic precipitator (ESP). After installation of the ESP:

- Static pressure across the ESP is 20 mm WC
- Flow rate increased by 20%
- The flow rate can be brought back to 90 m3/s by two options: (a) Impeller trimming and (b) Reduced pulley diameter to reduce the RPM

Calculate the following:

1. Fan static efficiency before installation of the ESP
2. The new impeller diameter if the impeller is trimmed, that would result in a reduction in fan efficiency of 5%
3. The new RPM that would result in a fan efficiency of 60%
4. Which of the two options is more energy efficient

SOLUTION

1. Calculate the fan static efficiency before installation of the ESP

Power input at fan shaft
= power drawn by motor x motor efficiency
= 120 x 0.86
= 103.2 kW

Fan static efficiency

$$= \frac{\text{Flow x Pressure developed across fan}}{\text{102 x Power required at fan shaft}}$$

$$= \frac{90 \times 80}{102 \times 103.2}$$

= 0.68 = 68 %

2. Calculate the new impeller diameter if the impeller is trimmed, that would result in a reduction in fan efficiency of 5%

New fan static efficiency = 68% - 5% = 63%

New static pressure across the fan
= total static pressure – static pressure across bag filter + static pressure across ESP
= 80 – 65 + 20
= 35 mm WC

New flow rate Q
= original flow rate x increase
= 90 m3/s x 1.2
= 108 m3/s

Static pressure at a flow rate of 90 m3/s with ESP installed (H_2)

$Q_1 / Q_2 = (H_1/H_2)^2$

Where
Q = flow rate
H = static pressure or head

$108 / 90 = (35/H_2)^2$

H_2 = 32 mm

Power required at the fan shaft

$$\text{Fan static efficiency} = \frac{\text{Flow x Pressure developed across fan}}{\text{102 x Power required at fan shaft}}$$

0.63 = (90 x 32) / (102 x power developed at fan shaft)
Power developed at fan shaft = 44.8 kW

New impeller diameter (D_2)

$(D_1 / D_2) = (kW_1 / kW_2)^{1/3}$

$D_2 = (kW_2 / kW_1)^{1/3} \times D_1$

$= 44.8 / 103.2)^{1/3} \times 70$

$= 53$ mm

3. Calculate the new RPM that would result in a fan efficiency of 60%

Power required at fan shaft

$$\text{Fan static efficiency} = \frac{\text{Flow x Pressure developed across fan}}{\text{102 x Power required at fan shaft}}$$

0.60 = 90 x 32 / 102 x Power required at fan shaft

Power required at fan shaft = (90 x 32) / (102 x 0.60) = 47 kW

New RPM (N_2)

$(N_1 / N_2) = (kW_1 / kW_2)^{1/3}$

Where

N = RPM

KW = power

$N_2 = (kW_2 / KW_1)^{1/3} \times N_1$

$= (47/ 103.2)^{1/3} \times 1000$

$= 769$ RPM

4. Determine which of the two options is more energy efficient

Power required by impeller trimming = 44.8 kW

Power required by reducing RPM = 47 kW

Therefore impeller trimming is the more energy efficient option.