Chapter 4.6: Fans and Blowers

Short type questions

1.	Mention the basic parameters that have to be measured during performance testing of a Fan. **Ans.** a. Static pressure b. Dynamic pressure c. Power input to the motor d. Cross sectional area of the duct. e. Temperature f. RPM of Fan
2.	Define dynamic Pressure? **Ans:** Dynamic Pressure is the rise in static pressure which occurs when air moving with specified velocity at a point is bought to rest without loss of mechanical energy. It is also known as velocity pressure
3.	Give the formulae to calculate volumetric flow by using Dynamic pressure and area. **Ans.** **Volume Metric flow (NM^3/sec)** = $\frac{A \times Cp \times \sqrt{2 \times 9.81 \times \Delta P \times \gamma}}{\gamma}$ Where, A= Area of cross section of duct, m^2 Cp= The picot tube coefficient (Take manufacturer's value or assume 0.85) P = The average velocity pressure measured using picot tube and inclined manometer by taking number of points over the entire cross-section of the duct, mm Water Column γ = Gas density, kg/m^3 corrected to normal temperature
4.	Give the equation to calculate static efficiency of fan? **Ans.** Static Fan Efficiency = $\frac{\text{Volume in } m^3/\text{sec x total static pressure in mm WC}}{\text{102 x Power input to the shaft in kW}}$
5.	What is the relationship between static pressure, dynamic pressure and total pressure? Total pressure = Static pressure + Dynamic pressure
6.	List at least three different flow control methods adopted in a fan system? **Ans.** The three important flow control methods are: ➢ Variable speed drives ➢ Change in Pulley size ➢ Inlet guide vane control
7.	Give the formula to evaluate the velocity by using dynamic pressure for air system? **Ans.** Velocity (m/s) = $\frac{Cp \times \sqrt{2 \times g \times \Delta P \times \gamma}}{\gamma}$ Where, Cp : Pitot tube coefficient (take manufacturers value or assume 0.85)

	♠ P: the average velocity pressure measured using Pitot tube and inclined manometer by taking number of points over the entire cross-section of the duct, mmWC γ : Gas density, kg/m³ corrected to normal temperature
8.	What are the various instruments used for evaluation of air flow in fans? Pitot tube, anemometer
9.	What are the factors affecting fan performance? (name at least three of them) The factors affecting fan performance are ➢ Type of fan used for a particular application ➢ Blade characteristics ➢ Air flow delivered by fan ➢ System pressure ➢ Ducting dimensions ➢ Pressure drop
10.	Calculate the density of air at the measurement temperature of 32°C **Ans.** Density at measurement point = $\frac{273 \times 1.293}{273 + 32} = 1.15 \text{ kg / m}^3$

Long type questions

1.	What are the factors that could affect the performance testing of fans? **Ans.** • Leakage, re-circulation or other defects in the system; • Inaccurate estimation of flow resistance; • Erroneous application of the standardized test data; • Excessive loss in a system component located too close to the fan outlet; • Disturbance of the fan performance due to a bend or other system component located too close to the fan inlet; • Error in site measurement
2.	Write brief notes on: a. Static pressure, b. Dynamic Pressure c. Total pressure d. Static fan efficiency **Ans.** **Static Pressure:** The absolute pressure at a point minus the reference atmospheric pressure. **Dynamic Pressure:** The rise in static pressure which occurs when air moving with specified velocity at a point is bought to rest without loss of mechanical energy. It is also known as velocity pressure. **Total Pressure**: The sum of static pressures and dynamic pressures at a point. **Fan Shaft Power:** The mechanical power supplied to the fan shaft **Motor Input Power:** The electrical power supplied to the terminals of an electric motor drive. **Fan Efficiency:** The air power static divided by impeller power

	Static Fan Efficiency% = $\frac{\text{Volume in } m^3/\text{Sec x Total Static Pressures, mmWC}}{102 \text{ x Power input to the shaft in (kW)}}$

Numerical type questions

1.	For a coal fired boiler an ID fan is used for controlling the draft. During the performance analysis of ID fan the following parameters are measured for analyses. Coal flow to the boiler = 15 tph ID fan – IGV% opening = 65% ID fan motor input power = 85 kW ID fan suction static pressure = -120 mmWC ID fan discharge static pressure = 15 mmWC Total flue gas quantity at APH inlet = 94 tph Flue gas temperature at ID fan inlet = 120°C O_2% before APH = 4.0% O_2% before ID fan = 8.0% Calculate (a) Infiltration air quantity (b) Fan static efficiency (consider motor efficiency as 90%) (c) Expected annual energy saving after arresting the infiltration for the following change in parameters. O_2 before ID Fan = 5% Δp across fan = 138 mmWC Improvement in fan efficiency = 5% Flue gas temperature, before ID Fan = 125°C Take unit prices as Rs. 3.8 per unit, 8200 hrs of operation/year **Ans.** Excess air factor before APH = $1 + \frac{O_2}{21 - O_2}$ = $1 + \frac{4}{21 - 4}$ = 1.235 Excess air factor before ID fan = $1 + \frac{8}{21 - 8}$ = 1.615 Flue gas quantity at ID fan inlet = Flue gas qty. at APH inlet x $\frac{\text{Excess air factor at ID fan inlet}}{\text{Excess air factor at ID fan outlet}}$ = $94 \text{ x } \frac{1.615}{1.235}$ = 123 tph Δp across the fan = 15 – (-120) = 135 mmWC

	Fan air kW	=	$\dfrac{\left(\dfrac{123 \text{ x } 1000}{3600 \text{ x } \rho}\right) \text{x } 135}{102}$
	Density of Air at ID inlet	=	$\dfrac{273}{273 + 120}$ x 1.293
		=	0.898 kg/m³
	Fan air kW	=	$\dfrac{\left(\dfrac{123 \text{ x } 1000}{3600 \text{ x } 0.898}\right) \text{x } 135}{102}$ = 50.36 kW
	Infiltration air quantity	=	123 – 94 = 29 tph
	η fan	=	$\dfrac{50.36}{85 \text{ x } 0.9}$ = 65.8%
	Excess air factor before ID after arresting		
	Air infiltration	=	$1 + \dfrac{5}{21 - 5}$ = 1.3125
	Flue gas quantity	=	94 x $\dfrac{1.3125}{1.235}$ = 99.9 tph
	Power consumption after infiltration air arrest	=	$\dfrac{\left(\dfrac{99.9 \text{ x } 1000}{3600 \text{ x } 0.887}\right) \text{x } 138}{102 \text{ x } 0.708 \text{ x } 0.9}$ = 66.43 kW
	Power savings after arresting air infiltration	=	85 – 66.43 = 18.6 kW
	Annual energy savings	=	18.6 x 8200 = 1,52,520 kWh
	Annual cost savings	=	152520 x 3.8 = 5.80 lakh
2.	The audit report of a coal mill fan is given below: Data Temperature of gas : 52 °C Fan efficiency : 65% Motor efficiency : 90% Static pressure before damper : -822 mmWC Static pressure after damper : -1342 mmWC ***Estimate the power loss across damper*** Static pressure before damper : -822 mmWC Static pressure after damper : -1342 mmWC Pressure loss across damper : abs (-1342 – (-822)) : 520 mmWC Measured flow : 108632 m³/h		

	Power loss	:	$\frac{\text{Volume in } m^3/\text{Sec x total pressure in mmWC}}{102}$
		:	$\frac{108632 \text{ x } 520}{102 \text{ x } 3600}$ = 153.8 kW

3.	In a soda ash manufacturing plant following measurements were carried out for a fan. Calculate the fan operating efficiency? Give one suggestion to improve the efficiency in case the calculated efficiency is low? Measured total pressure =536 mm WC Air temp = 41°C Density of air = 1.12 kg/cm^2 Velocity = 9.7 m/s Cross sec area of duct = 0.301 m^2 Actual power drawn by the fan motor = 43.57 kW Fan motor efficiency = 90% Damper position = 70% closed Air flow rate = 0.301x 9.7=2.92 m^3/sec Power input to shaft = 0.9x 43.57=39.2 kW **Fan Efficiency %** = $\frac{\text{Volume in } m^3/\text{Sec x total pressure in mmWC}}{102 \text{ x Power input to the shaft in (kW)}}$ = $\frac{2.92 \text{ x } 536}{102 \text{ x } 39.2}$ = 39.1% **Suggestion: Provide inlet guide vane**

4	A fan-duct system is designed so that when the air temperature is 20°C, the mass flow rate is 25,000 kg/hr when the fan speed is 800 rpm and the fan motor requires 8 kW. A new set of requirement is imposed on the system: the operating air temperature is changed to 50°C, and the fan speed is increased so that the same mass flow of air prevails. What are the revised fan speed and power requirements? **Ans.** $\rho 1 = \frac{273}{273+20} \text{ x } 1.293 = 1.2047 kg/m^3$ $\rho 2 = \frac{273}{273+50} \text{ x } 1.293 = 1.0928\ kg/m^3$ m1 = m2 = 25,000 kg/h a) To find the required change in speed $N \propto Q \quad \frac{N1}{N2} = \frac{Q1}{Q2} = \frac{\rho 2}{\rho 1}$

	$N2 = N1 \times \frac{\rho 1}{\rho 2} = 800 \times \frac{1.2047}{1.0928} = 882\ rpm$ b) To find the required change in power $\frac{P2}{P1} = \left(\frac{\rho 1}{\rho 2}\right)^3$ $P2 = P1 \times \left(\frac{\rho 1}{\rho 2}\right)^3 = 8 \times \left(\frac{1.2047}{1.0928}\right)^3 = 10.72\ kW$
5	A fan is delivering 5400 Nm^3/h of air at static pressure rise of 60 mmWC. If the static efficiency is 70%, find out the shaft power drawn. **Ans.** Q = 5400 Nm^3/h Sp = 60 mmWC $\eta_{static\ efficiency}$ = 70%, P = ? Fan static Efficiency % $= \frac{\text{Volume in } m^3/\text{Sec x total static pressure in mmWC}}{102 \text{ x Power input to the shaft in (kW)}}$ $0.7 = \frac{\left(\frac{5400 \times 60}{3600}\right)}{102 \times P}$ Shaft power drawn (P) $= \frac{1.5 \times 60}{102 \times 0.7} = 1.26kW$