Chapter 3.5: Fans and Blowers

Part – I: Objective type questions and answers

1.	The parameter used by ASME to define fans, blowers and compressors is____ a) Fan ration b) Specific ratio c) Blade ratio d) Twist factor
2.	Which of the following axial fan types is most efficient? a) Propeller b) Tube axial c) Vane axial d) Radial
3.	Which of the following is not a centrifugal fan type? a) Vane axial b) Radial c) Airfoil, backward d) Forward curved
4.	Match the following for centrifugal fan types. Type / Suitable for a) Backward curved / i) High pressure, medium flow b) Forward curved / ii) Medium pressure, high flow c) Radial / iii) High pressure, high flow (a)-iii); (b)-ii); (c)-i)
5.	For fans, the relation between discharge and speed is indicated by____ a) $\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$ b) $\frac{Q_1}{Q_2} = \frac{N_1^2}{N_2^2}$ c) $\frac{Q_1}{Q_2} = \frac{N_1^3}{N_2^3}$ d) None
6.	The choice of fan type for a given application depends on _______ a) Flow b) Static Pressure c) Both a & b d) neither (a) nor (b)
7.	The efficiency of backward curved fans compared to forward curved fans is__ a) Higher b) Lower c) Same d) None
8.	Name the fan which is more suitable for high pressure application? a) Propeller type fans b) Tube-axial fans c) Backward curved centrifugal fan d) None of the above
9.	Axial fans are best suitable for____ application. a) Large flow, low head b) Low flow, high head c) High head, large flow d) Low flow, low head
10.	The efficiency of forward curved fans compared to backward curved fans is ____

	a) Lower b) higher c) Same d) none
11.	The efficiency values of Vane axial fans are in the order of: a) 78 – 85% b) 60 – 70% c) 90 – 95% d) 50 – 60%
12.	Backward curved fans have efficiency in the range of: a) 65 – 70% b) 75– 85% c) 90 – 95% d) 50 – 60%
13.	The pressure to be considered for calculating the power required for centrifugal fans is: a) Discharge static pressure b) Static + dynamic pressure c) Total static pressure d) Static + ambient air pressure
14.	Typical design efficiency of aerofoil fan handling clean air is: a) 40 to 50% b) 80 to 90% c) 60 to 70% d) 70 to 80%
15.	The clearance required for efficient operation of impeller of 1 meter plus diameter in Radial type fans is ____ a) 5 to 10 mm b) 1 to 2 mm c) 20 to 30 mm d) 0.5 to 1.5 mm
16.	Which type of control gives maximum benefits for fan application from energy saving point of view? a) Discharge damper control b) Inlet guide vane control c) Variable pitch control d) Speed control
17.	The pressure along the line of the flow that results from the air flowing through the duct is _____ a) Static pressure b) velocity pressure c) Total pressure d) Dynamic pressure
18.	The outer tube of the pitot tube is used to measure _____ a) Static pressure b) velocity pressure c) Total pressure d) Dynamic pressure
19.	Axial-flow fans are equipped with ______ a) fixed blades b) Curved blades c) Flat blades d) variable pitch blades
20.	The ratio of maximum to minimum flow rate is called ________- a) turn – up ratio b) turn-down ratio c) up-down ratio d) None
21.	The density of a gas at a temperature of 50 deg. C at site condition is __ a) 0.94 kg/m^3 b) 1.2 kg/m^3 c) 1.5 kg/m^3 d) 1.4 kg/m^3

Part – II: Short type Questions and Answers

1.	Differentiate between 'centrifugal' and 'axial flow' fans? In centrifugal fans, pressure is developed due to the centrifugal force imparted to air, unlike axial flow fans where velocity energy is imparted to air, which in turn is converted to pressure energy at the fan outlet.
2.	Which type of fan is suitable for higher pressure application? Centrifugal fans are suitable for high pressure applications as compared to axial flow fans.
3.	Under which conditions of pressure ratios and volumes, low speed fans are preferred? Low speed fans are preferred for low pressure ratios and large volumes.
4.	Why generally fans operate at very poor efficiency? A very conservative approach is adopted allocating large safety margins, resulting in oversized fans, which operate at flow rates much below their design values and consequently which leads to operate at very poor efficiency.
5.	What are the types of centrifugal fans available? Radial, forward curved and backward inclined fans
6.	Write the advantages of forward curved fans? Forward curved fans have the advantage of lower shut off power, which is desirable for low flow rate operation.
7.	Which type of housing is more efficient for better fan performance? Performance of fans also depends on the fan enclosure and duct design. 'Spiral housing' designs with inducers, diffusers are more efficient as compared to 'square housings'.
8.	Name different options available to control the speed of a fan? a) changing pulley ratio for drive and driven equipments. b) variable frequency drive c) variable speed fluid coupling
9.	How do you calculate the velocity of air in the duct using the average differential pressure and density of the air/gas? Velocity v, m/s = $\frac{C_p \text{ x } \sqrt{2 \times 9.81 \times \Delta p \times \gamma}}{\gamma}$ C_p = Pitot tube constant, 0.85 (or) as given by the manufacturer $\triangle$ p = Average differential pressure measured by Pitot tube by taking

	measurement at number of points over the entire cross section of the duct. γ = Density at air/gas at test condition
10.	List at least five energy saving opportunities for a fan application. 1. Change of impeller by a high efficiency impeller along with cone. 2. Change of fan assembly as a whole, by a high efficiency fan 3. Impeller derating (by a smaller dia impeller) 4. Fan speed reduction by pulley dia modifications for derating 5. Option of two speed motors or variable speed drives for variable duty conditions 6. Option of energy efficient flat belts, or, cogged raw edged V belts, in place of conventional V belt systems, for reducing transmission losses. 7. Adopting inlet guide vanes in place of discharge damper control 8. Minimizing system resistance and pressure drops by improvements in duct system
11.	What are affinity laws governing fan performance in terms of speed, power and pressure? The affinity laws governing fan performance is given below: Flow x speed Pressure x (speed)^2 Power x (speed)^3
12.	Distinguish “speed control” vs “guide vane control”? **Speed control**: The flow is varied in accordance with the process requirement by changing the speed of the fan. **Guide vane control**: The flow is varied by guiding the inlet air into the fan in the direction of impeller rotation in accordance with the process requirement.
13.	List out main factors to be considered for proper sizing of fans The following are the factors considered for fan sizing: a) Flow requirement in m^3/hr b) Pressure drop c) Power requirement d) Density of flowing gas at the site condition

14.	What are the factors that affect the fan performance? The main factors affecting the performance of fans are flow, pressure, temperature, speed and damper positions on the fan side and the power input in KW on the motor side.
15.	What are axial fans? Give some examples for its application? When the flow of air (or) fluid is parallel to the axis of the fan it is called an axial fan. Application areas of axial fans are: HVAC, drying ovens, exhaust system
16.	What conditions suit for the application of radial type of centrifugal fans? Radial type of centrifugal fans is used at high pressure, medium flow conditions. E.g. Dust laden, moist air/gas in textile industry.
17.	What are the merits of ‘backward curved blade centrifugal fans’? The merits of backward curved blade centrifugal fans are: a) High pressure generation b) High efficiency c) Power reduction with increased flow
18.	Describe ‘inlet guide vane control’ for fan? Inlet guide vane control is one type of capacity control of fans. The inlet guide vanes are designed to guide the inlet air into the fan in the direction of impeller rotation and, therefore, improve performance, resulting in somewhat better energy efficiency than damper controlled operation.
19.	Explain how the variations in flue gas temperature will change the operating efficiency of the fan Variation in flue gas temperature will change the density of the gas given by a formula, Gas density = (273 x 1.29) / (273 + t°C). Density of gas is important consideration, since it affects both volume flow-rate and capacity of the fan to develop pressure.
20.	Specify the importance of temperature during the fan selection? 1. Ambient temperatures, both the minimum and maximum are to be specified to the supplier. This affects the choice of the material of construction of the impeller. 2. Density of gas at different temperatures at fan outlet has to be considered while designing the fan. The volume of the gas to be handled by the fan depends on temperature.

Part-III: Long type questions and answers

1. Highlight the specific differences between fan, blower and air compressors?

Fans, blowers and compressors are differentiated by the method used to move the air, and by the system pressure they must operate against. As per ASME, the specific pressure, i.e. the ratio of the discharge pressure over the suction pressure is used for defining the fans, blowers and compressors.

The details of pressure ratios are given below.

	Fan	Blower	Compressor
Specific ratio	up to 1.11	1.11 ~1.20	>1.20
Pressure rise (mm Wg)	1136	1136~2066	-

2. List out different capacity control methods for the fans?

Basic capacity (volume) control methods adopted in fans and blowers are as follows:

1. Changing the rotational speed is the most efficient. If the volume requirement is constant, it can be achieved by selecting appropriate pulley sizes. If the volume varies with the process, adjustable-speed drives can be used.

2. Changing the blade angle is a method used with some vane-axial fans.

3. Restricting the air flow is accomplished with dampers or valves which close off the air flow at the inlet or outlet. Inlet vanes, which swirl the air entering the centrifugal fan or blower, are more efficient than dampers or butterfly valves.

4. Venting the high-pressure air, or recirculating it to the inlet, is often used with positive-displacement blowers. It is sometimes used with fan systems, but is the least efficient method as there is no reduction in the air being moved.

3. List the types of fans, their characteristics and typical applications?

Axial-flow Fans			**Centrifugal Fans**		
Type	**Characteristics**	**Typical Applications**	**Type**	**Characteristics**	**Typical Applications**
Propeller	Low pressure, high flow, low efficiency, peak efficiency close to point of free air delivery (zero static pressure)	Air-circulation, ventilation, exhaust	Radial	High pressure, medium flow, efficiency close to tube-axial fans, power increases continuously	Various industrial applications, suitable for dust laden, moist air/gases
Tube-axial	Medium pressure, high flow, higher efficiency than propeller type, dip in pressure-flow curve before peak pressure point.	HVAC, drying ovens, exhaust systems	Forward-curved blades	Medium pressure, high flow, dip in pressure curve, efficiency higher than radial fans, power rises continuously	Low pressure HVAC, packaged units, suitable for clean and dust laden air / gases
Vane-axial	High pressure, medium flow, dip in pressure-flow curve, use of guide vanes improves efficiency	High pressure applications including HVAC	Backward curved blades	High pressure, high flow, high efficiency, power reduces as flow increases beyond point of highest efficiency	HVAC, various industrial applications, forced draft fans, etc.

		systems, exhausts			
			Air foil type	Same as backward curved type, highest efficiency	Same as backward curved, but for clean air applications

4. List the parameters to be considered for efficient operation of fan?

The parameters to be considered while fan selection are:

1. Design operating point of fan – volume and pressure
2. Normal operating point – volume and pressure
3. Maximum continuous rating
4. Low load operation
5. Ambient temperature
6. Density of gas at different temperatures
7. Composition of the gas
8. Dust concentration and nature of dust
9. Maximum temperature of the gas
10. Control mechanisms (proposed)
11. Altitude of the plant

5. How do you assess the performance of fans? Explain.

The fans are tested for field performance by measurement of flow, head, temperature and damper position on the fan side and electrical motor kW input on the motor side.

The fan flow is measured using Pitot tube manometer combination or a flow sensor (differential pressure instrument) or an accurate anemometer. Care needs to be taken regarding number of traverse points, straight length section (to avoid turbulent flow regimes of measurement) up stream and downstream of measurement location. The measurements can be on the suction or discharge side of the fan and preferably both where feasible.

Pressure (draft) developed by the fan can be measured by Pitot tube manometer combination, or an accurate digital draft gauge. The temperatures of the gases / fluids are measurable by a digital temperature indicator and the damper position documented as percentage opening or notch position. In case of fluid couplings, the % scoop position can be the reference. Pulley diameter and fan rpm measurements help in assessing scope for derating. Fan design performance curves are needed to compare the actual efficiency with respect to design values.

Drive motor input volts, amps, pf frequency and kW can be measured by a load analyzer, to assess input kW, pf, motor loading voltage imbalance if any.

The fan air kW is assessed as:

	$$\text{Air kW} = \frac{\text{Flow in kgs/ sec} \times \text{Total Head developed in meters of air column} \times 9.81}{1000}$$ Where head developed in meters of air column $$= \frac{\text{Head developed meters water column} \times \text{Density of water in kg/m}^3}{\text{Density of air in kg/m}^3}$$ Once the air kW and motor input motor kW are measured, motor, fan, damper combined efficiency is given by the relation, combined efficiency in percent $$= \frac{\text{Air kW}}{\text{In put kW}} \times 100$$ By an estimate of motor efficiency, (where the band of variation is nominal), the fan, damper efficiency is arrived at; It is also a good practice, to report percentage loading on capacity, i.e., flow, head and motor load, with respect to the rated values, while mentioning fan efficiency.