GAS DYNAMICS AND JET PROPULSION

1. What is the basic difference between compressible and incompressible fluid flow?

Compressible	Incompressible
1. Fluid velocities are appreciable compared with the velocity of sound 2. Density is not constant 3. Compressibility factor is greater than one.	1. Fluid velocities are small compared with the velocity of sound 2. Density is constant 3. Compressibility factor is one.

2. Write the steady flow energy equation for an adiabatic flow of air.

In an adiabatic flow q = 0. Therefore energy equation becomes.

$$h1 + \frac{c_1^2}{2} + gZ_1 = h_2 + \frac{c_2^2}{2} + gZ_2 + W_s$$

Adiabatic energy equation is $h_0 = h + ½ c^2$

3. Define the mach number in terms of bulk modulus of elasticity.

Mach number is a non-dimensional number and is used for the analysis of compressible fluid flows.

$$M = \sqrt{\frac{\text{int}\, ertiaforce}{elasticforce}}$$

$$= \sqrt{\frac{\rho A c^2}{KA}}$$

where K = Bulk modulus of elasticity $K = \rho\, a^2$

$$\therefore M = \sqrt{\frac{\rho A c^2}{\rho A a^2}} = \frac{c}{a}$$

4. Explain the meaning of stagnation state with example.

The state of a fluid attained by isentropically decelerating it to zero velocity at zero elevation is referred as stagnation state.

(e.g.) Fluid in a reservoir (or) in a settling chamber.

5. Distinguish between static and stagnation pressures.

In stagnation pressure state, the velocity of the flowing fluid is zero whereas in the static pressure state, the fluid velocity is not equal to zero.

6. Differentiate between the static and stagnation temperatures.

The actual temperature of the fluid in a particular state is known as **"static temperature"** whereas the temperature of the fluid when the fluid velocity is zero at zero elevation is known as **"stagnation temperature"**.

$T_0 = T + \frac{c^2}{2C_p}$ where

T = static temperature

T_0 = stagnation temperature

$\frac{c^2}{2C_p}$ = velocity temperature

7. What is the use of mach number?

Mach number is defined as the ratio between the local fluid velocity to the velocity of sound.

i.e. Mach number $M = \frac{Localfluidvelocity}{Velocityofsound} = \frac{c}{a}$

It is used for the analysis of compressible fluid flow problems. Critical mach number is a dimensionless number at which the fluid velocity is equal to its sound velocity. Therefore,

$M_{critical} = \frac{c*}{a*} = 1$ [$\therefore$ c* = a*]

Crocco number is a non – dimensional fluid velocity which is defined as the ratio of fluid velocity to its maximum fluid velocity.

i.e. $C_r = \frac{c}{c_{\max}} = \frac{Fluidvelocity}{Maximumfluidvelocity}$

8. Write down the relationship between stagnation and static temperature interms of the flow, mach number for the case of isentropic flow.

$\frac{T_0}{T} = 1 + \frac{\gamma - 1}{2} M^2$ where,

T_0 = stagnation temperature

T = Static temperature

M = Mach number.

9. Give the expression of $\frac{P}{P_0}$ for an isentropic flow through a duct.

The expression of

$$\frac{T_0}{T} = 1 + \frac{\gamma - 1}{2} M^2 \text{, but we know that,}$$

$$\frac{T_0}{T} = \left(\frac{P_0}{P}\right)^{\frac{\gamma-1}{\gamma}} \ (or) \ \frac{P_0}{P} = \left(\frac{T_0}{T}\right)^{\frac{\gamma}{\gamma-1}}$$

Therefore $\frac{P_0}{P} = \left[1 + \frac{(\gamma - 1)}{2} M^2\right]^{\frac{\gamma}{\gamma-1}} (or)$

$$\frac{P_0}{P} = \frac{1}{\left[1 + \frac{(\gamma - 1)}{2} M^2\right]} \frac{\gamma}{\gamma - 1}$$

10. Name the four reference velocities that are used in expressing the fluid velocities in non-dimensional form?

i. Local velocity of sound a = $\sqrt{\gamma RT}$

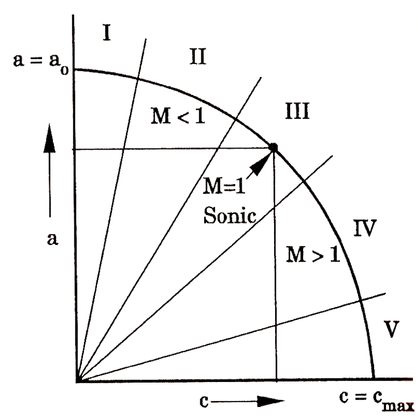
ii. Stagnation velocity of sound $a_0 = \sqrt{\gamma RT_0}$

iii. Maximum velocity of sound $C_{\max} = a_0 \sqrt{\frac{2}{\gamma - 1}}$

iv. Critical velocity of sound / fluid a* = c* = $\sqrt{\gamma RT^*}$

11. What are the different regions of compressible flow.

The adiabatic energy equation for a perfect gas is derived in terms of fluid velocity © and sound velocity (a). This is then plotted graphically on the c- a co-ordinates, a steady flow ellipse is obtained.



The various regions of flow are:

(i) Incompressible region (M ≈ 0)

(ii) Subsonic region (M < 1)

(iii) Transonic region (0.8 – 1.2)

(iv) Supersonic region (M > 1 and M < 5)

(v) Hypersonic region (M ≥ 5)

12. Define M* and give the relation between M and M*.

It is a non-dimensional mach number and is defined by the ratio between the local fluid velocity to its critical velocity of sound / fluid.

M* = $\frac{c}{c^*} = \frac{c}{a^*}$

It is also called a characteristic Mach number.

$$M^* = \sqrt{\frac{M^2(\gamma-1)}{2+M^2(\gamma-1)}}$$

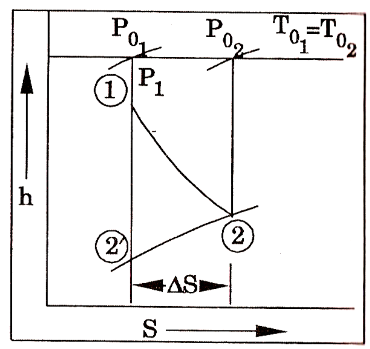
13. If an aeroplane goes to higher altitudes maintaining the same speed, the Mach number will remain constant. Say true or false.

False.

W.K.T. $M = \frac{c}{a}$

At higher altitude, the sound velocity 'a' will decrease and hence M will increase. Therefore, M is not constant.

14. Show h – S diagram for the flow through a nozzle. Show how the stagnation properties get affected.



1 – 2' = Isentropic expansion

1 – 2 = Adiabatic expansion

It is assumed that, the exit pressure is same for both cases. But stagnation pressure at the exit of the adiabatic process (P_{0_2}) will be less than isentropic pressure (P_{0_2}'). This is due to friction and irresversibilities. But stagnation temperature remains constant.

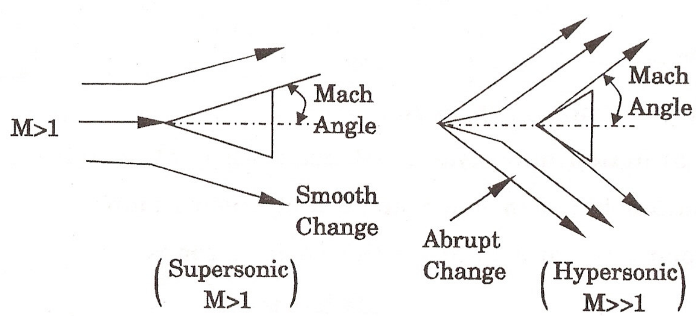
15. A plane travels at a speed of 2400 KM/h in an atmosphere of 5°C, find the mach angle.

$$c = \frac{2400}{3.6} = 666.66667; T = 278K$$

$$M = \frac{c}{\gamma RT} = \frac{666.6667}{\sqrt{1.4x287x278}} = 1.9947$$

$$\alpha = \sin^{-1}\left(\frac{1}{M}\right) = 30.0876°$$

16. Define mach angle and mach wedge.



Mach angle is formed, when an object is moving with supersonic speed. The wave propagation and changes are smooth. When an object is moving with hypersonic speed the changes are abrupt is shown in Fig. Hence for a supersonic flow over two – dimensional object **"mach wedge"** is used instead of **"mach cone"**.

17. How will you illustrate the role of mach number as a measure of compressibility?

If the flow is assumed to be incompressible, the value of pressure co-efficient (or) compressibility factor obtained by Bernoulli equation is unity.

i.e., $$\frac{P_0 - P}{\frac{\rho C^2}{2}} = 1 + \frac{M^2}{4} + \frac{M^4}{40} + ... \quad [\text{for} \quad \gamma = 1.4]$$

By substituting different values of M, we can get different values of compressibility factor and is given in the table.

M	Compressibility factor (%)	M	Compressibility factor(%)	M	Compressibility factor(%)
0.1	0.3	0.5	6.4	0.9	22
0.2	1.0	0.6	9.3	10	27.5
0.3	2.3	0.7	12.9		
0.4	4.1	0.8	17.0		

In the above table, when M increases, the compressibility factor also increases from the initial value 1. Thus the role of mach number is a measure of compressibility.

18. What is meant by isentropic flow with variable area?

A steady one dimensional isentropic flow in a variable area passages is called "variable area flow". The heat transfer is negligible and there are no other irreversibilities due to fluid friction, etc.

19. Define zone of action and zone of silence with neat sketch.

20. Find the sonic velocity in oxygen when it is at 110° C, γ=1.4 and molecular weight 32.

a = $\sqrt{\gamma RT} = \sqrt{1.4 x 259.8125 x 383} = 373.244 m/s$

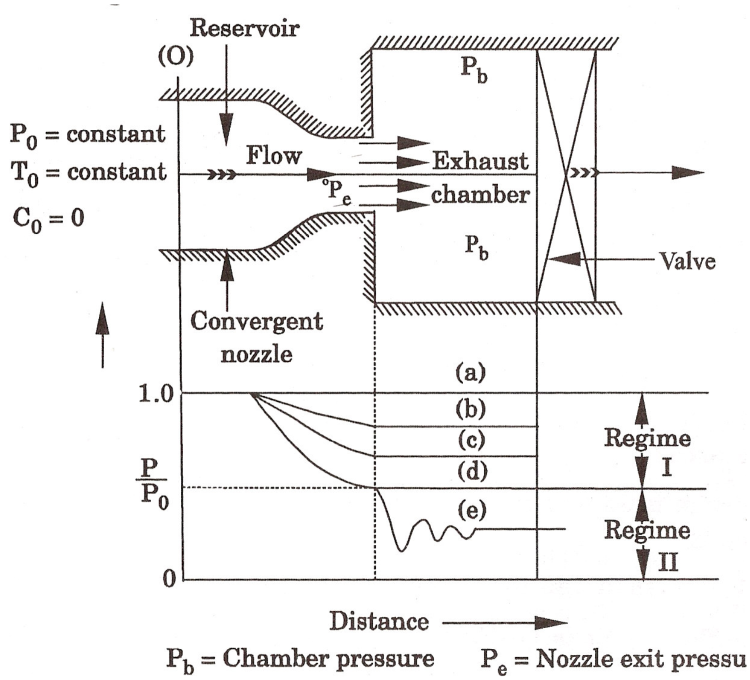
Unit - II

21. Give the expression for $\frac{T_0}{T}$ and $\frac{T}{T^*}$ for isentropic flow through variable area in terms of Mach number.

$$\frac{T}{T_0} = \frac{1}{1 + \frac{\gamma - 1}{2} M^2}$$

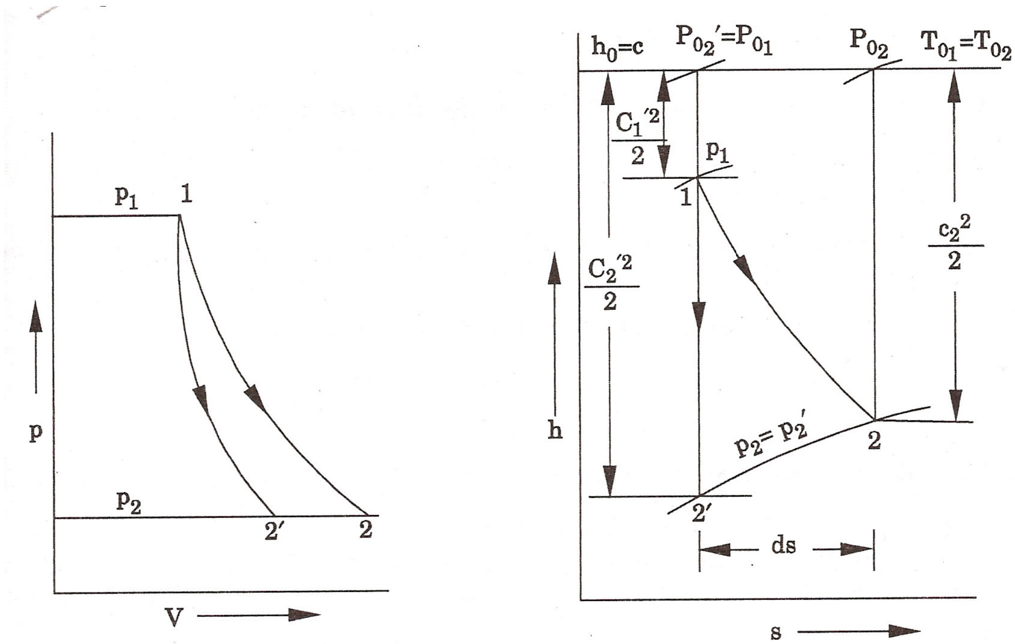
$$\frac{T}{T^*} = \frac{(\gamma - 1)}{1 + \frac{\gamma - 1}{2} M^2}$$

22. Sketch the isentropic and adiabatic expansion process in P-V and T-S diagram}.

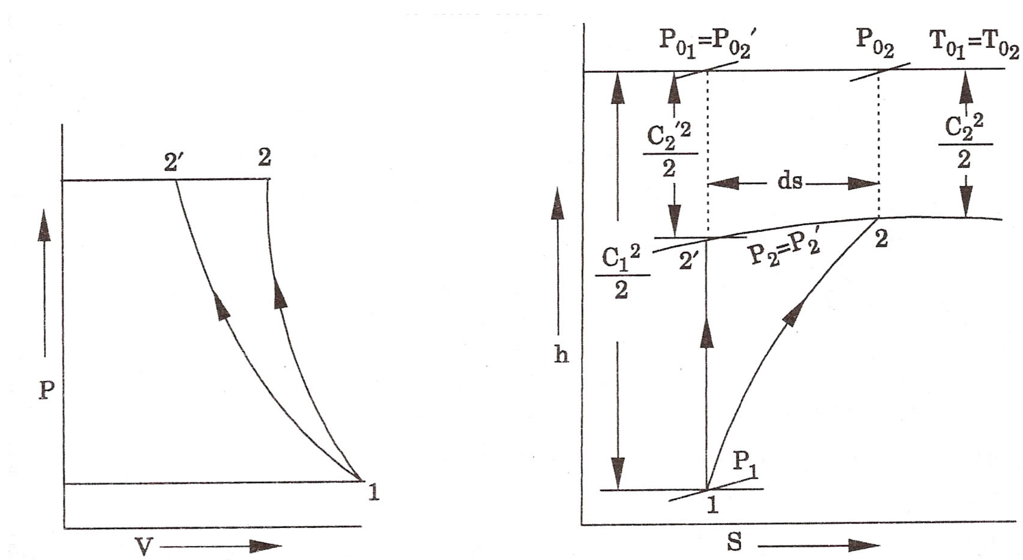


Isentropic flow through a convergent nozzle

23. Represent the adiabatic flow through a diffuser on T-S diagram. Label the different states, the initial and final points.



24. Air from a reservoir is discharged through a nozzle. Show the variation of pressure along the axis of the nozzle.



25. What will happen if the air flowing through a nozzle is heated?

When the flowing air is heated in a nozzle, the following changes will occur.

Velocity of air will increase.

Increase in temperature and enthalpy

Pressure increases

Increase in entropy

26. Write the Fliegner's formula.

$$\frac{m_{\max}}{A^*} X \frac{\sqrt{T_0}}{P_0} = \sqrt{\frac{\gamma}{R}} \left(\frac{2}{\gamma +} \right)^{\frac{\gamma+1}{2(\gamma-1)}}$$

For air γ = 1.4 and R – 287 J / Kg° K [SI units]

$$\therefore \frac{m_{\max}}{A^*} \frac{\sqrt{T_0}}{P_0} = 0.0404 \Rightarrow \text{Fliegner's formula}$$

27. Write the equation for efficiency of the diffuser.

Diffuser efficiency $= \dfrac{\text{static pressure rise in the actual process}}{\text{static pressure rise in the ideal process}}$

$$\frac{P_2 - P_1}{P_2' - P_1}$$

28. What is impulse function and give its uses?

Impulse function is defined as the sum of pressure force and intertia force. Impulse function F = Pressure force ρA + intertia force ρAc^2

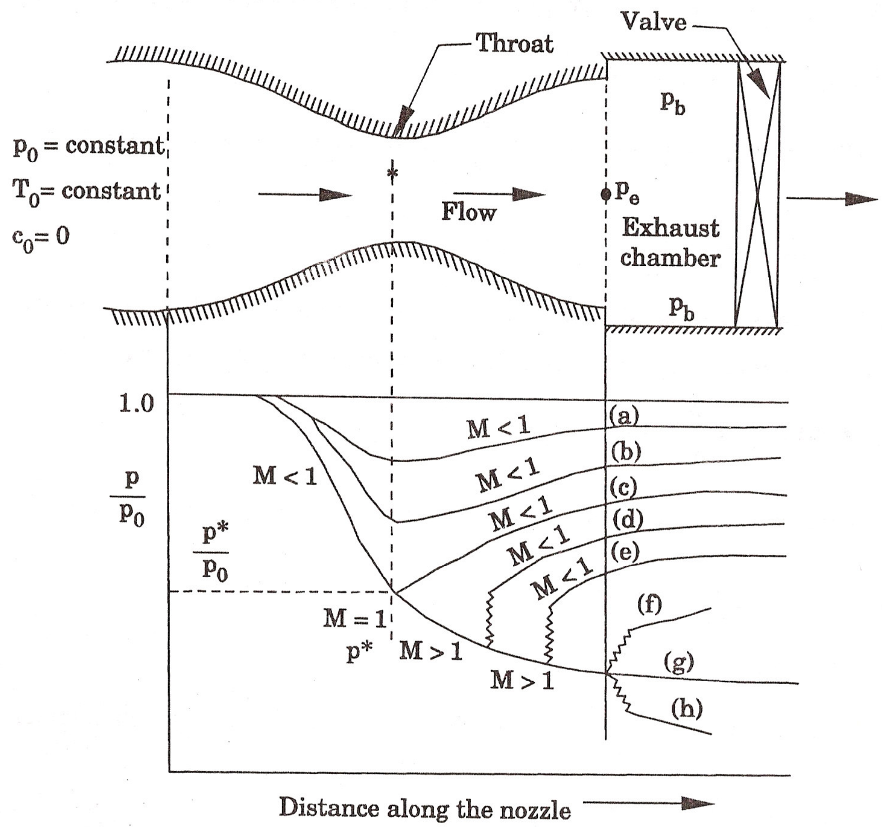
Since the unit of both the quantities are same as unit of force, it is very convenient for solving jet propulsion problems. The thrust exerted by the flowing fluid between two sections can be obtained by using change in impulse function.

29. What is chocked flow? State the necessary conditions for this flow to occur in a nozzle.

When the back pressure is reduced in a nozzle, the mass flow rate will increase. The maximum mass flow conditions are reached when the back pressure is equal to the critical pressure. When the back pressure is reduced further, the mass flow rate will not change and is constant. The condition of flow is called "chocked flow". The necessary conditions for this flow to occur in a nozzle is

* The nozzle exit pressure ratio must be equal to the critical pressure ratio where the mach number M = 1.

30. Draw the variation of $\frac{P}{P_0}$ along the length of a convergent divergent device when it functions as (a) diffuser, (b) nozzle and (c) venturi.



Curves

a, b, c $\Rightarrow$ venture

d, e $\Rightarrow$ diffuser

g $\Rightarrow$ nozzle

31. Give the expression for nozzle efficiency and diffuser efficiency with h – s diagram.

Nozzle efficiency $\eta N = \dfrac{\text{actual enthalpy drop}}{\text{ideal enthalpy drop}} = \dfrac{T_1 - T_2}{T_1 - T_2'}$

Diffuser efficiency $\eta D = \dfrac{\text{ideal enthalpy rise}}{\text{actual enthalpy rise}} = \dfrac{T_2' - T_1}{T_2 - T_1}$

32. Give the important difference between nozzle and venturi.

NOZZLE	VENTURI
1. The flow is accelerated continuously i.e., Mach number and velocity increases continuously. 2. Used to increase velocity and Mach number. 3. Generally convergent portion is short.	1. The flow is accelerated upto M = 1 and then Mach number is decreased. 2. Used for flow measurement (discharge) 3. Convergent and divergent portions are equal.

33. What is the normal shock?

When the shock waves are right angles to the direction of flow and the rise in pressure is abrupt are called normal shock waves.

34. What is meant by normal shock as applied to compressible flow?

Compression wave front being normal to the direction of compressible fluid flow. It occurs when the flow is decelerating from supersonic flow. The fluid properties jump across the normal shock.

35. Shock waves cannot develop in subsonic flow? State the reason.

Shocks are introduced to increase the pressure and hence it is a deceleration process. Therefore, shocks are possible only when the fluid velocity is maximum. In a subsonic flow, the velocity of fluid is less then the critical velocity and hence deceleration is not possible. Thus, shock waves cannot develop in subsonic flow.

36. Define strength of a shock wave.

Strength of a shock wave is defined as the ratio of increase in static pressure across the shock to the inlet static pressure.

$$\text{Strength of shock} = \frac{p_y - p_x}{p_x}$$

37. Calculate the strength of shock wave when normal shock appears at M = 2.

From normal shock table M = 2, $\gamma = 1.4$. $\dfrac{p_y}{p_x} = 4.5$

$$\therefore \text{Strength of shock} = \frac{p_y}{p_x} - 1 = 4.5 - 1 = 3.5$$

38. Define oblique shock where it occurs.

The shock wave which is inclined at an angle to the two dimensional flow direction is called as oblique shock. When the flow is supersonic, the oblique shock occurs at the corner due to the turning of supersonic flow.

39. Give the difference between normal and oblique shock.

NORMAL SHOCK	OBLIQUE SHOCK
(a) The shock waves are right angles to the direction of flow.	(a) The shock waves are inclined at an angle to the direction of flow.
(b) May be treated as one dimensional analysis.	(b) Oblique shock is two dimensional analysis.

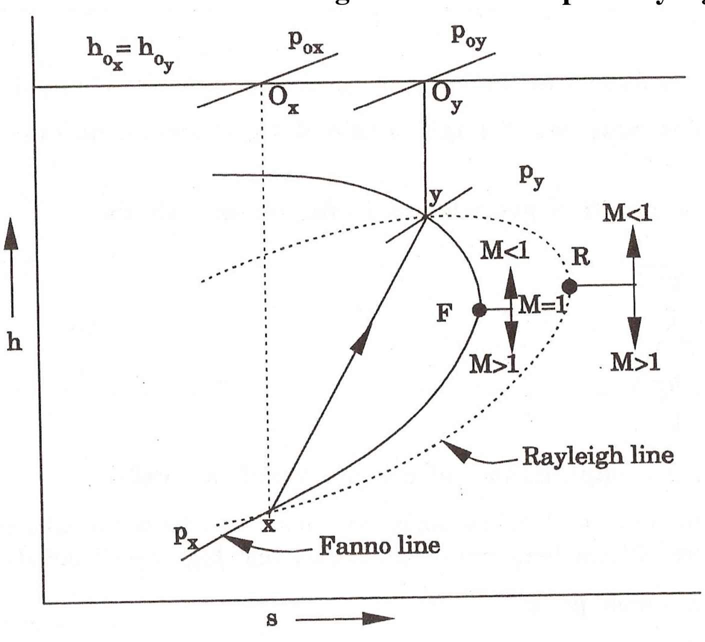
40. What is Prandtl-Meyer relation? What its significance?

The fundamental relation between gas velocities before and after the normal shock and the critical velocity of sound is known as Prandtl-Meyer relation.

i.e., (i) $c_x \times c_y = a^{*2}$ and (ii) $M^*_x \times M^*_y = 1$

it signifies the velocities (before and after the shock) with the critical velocity of sound and the product of mach numbers before and after the shock is unity.

41. Shown a normal shock in h-s diagram with the help of Rayleigh line and Fanno line.



42. Define the term "Fanno flow".

A steady one-dimensional flow in a constant area duct with friction in the absence of work and heat transfer is known as **"fanno flow".**

43. Define Fanno line.

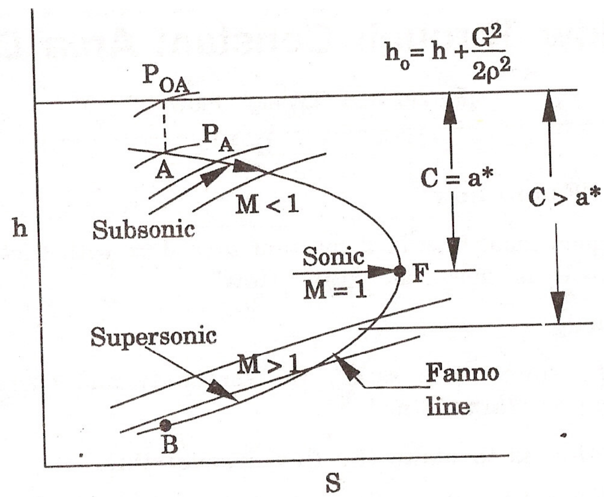
The locus of the state which satisfy the continuity and energy equation for a frictional flow is known as **"fanno line".**

44. Give fanno line in h – s diagram with isentropic stagnation line and show various mach number regions.

A to F - heating process
F to A - cooling process
} M < 1

B to F - heating process
F to B - cooling process
} M > 1

Point F is critical point where mach number M = 1.



The equation which yields the fanno line for the given values of h_0 and G is called "fanno flow equation".

i.e., $h = h_0 - \frac{G^2}{2[f(h,s)^2]}$ $\Rightarrow$ Fanno equation

45. Explain briefly the chocking in fanno flow.

In a fanno line, any heating process (both subsonic and supersonic) will increase the enthalpy, entropy and mass flow rate. This will go upto the limiting state where mach number M* = 1. Further heating is not possible, because the entropy change will be negative which violates the second law of thermodynamics. Hence the mass flow rate is maximum at the critical state and is constant afterwards, then the flow is said to be **"chocked flow".**

46. Give two practical examples where the fanno flow occurs.

Flow occurs in gas ducts of aircraft propulsion engines, flow in air-conditioning ducts and flow of oil in long pipes. etc.

47. Give the effect of increasing the flow length after reaching critical condition in a fanno flow.

The mass flow rate will increase only upto the critical condition and is constant afterwards. Therefore, if the length of pipe is increased afterwards will not give any effect.

48. Write down the expression for the length of duct in terms of the two mach numbers M1 and M2 for a flow through a constant area duct with the influence of friction.

$$\frac{4fL}{D} = \left(\frac{4fL_{\max}}{D}\right)_{M_1} - \left(\frac{4fL_{\max}}{D}\right)_{M_2}$$

49. Define isothermal flow with friction. Give the applications.

A steady one dimensional flow with friction and heat transfer in a constant area duct is called isothermal flow with friction. Such a flow occurs in long ducts where sufficient time is available for the heat transfer to occur and therefore the temperature may remains constant. Hence the friction factor may be assumed constant along the duct. The applications of isothermal flow are oil or water flow in buried pipe.

50. State assumptions made to derive the equations for isothermal flow.

i. One dimensional flow with friction and heat transfer.
ii. Constant area duct
iii. Perfect gas with constant specific heats and molecular weights
iv. Isothermal flow i.e., the temperature is constant
v. On account of constant temperature the friction factor may be assumed constant along the duct.

51. Differentiate between isothermal flow and fanno flow.

ISOTHERMAL	FANNO FLOW
a) Static temperature is constant	a) Static temperature is not constant
b) With heat transfer.	b) Without heat transfer.
c) Flow occurs in a long ducts where sufficient time is required for heat transfer.	c) Long ducts are not required.
d) On account of constant temperature, the friction factor is assumed as constant.	d) Friction factor is constant.

52. Define the term "Rayleigh flow".

The one-dimensional flow in a constant area duct with heat transfer and without friction is called **"Rayleigh flow".**

55. Define Rayleigh line.

The locus of the points of properties during a constant area frictionless flow with heat exchange is called **"Rayleigh line".**

54. What is diabatic flow?

It is the flow which deals with the exchange of heat from the system in the absence of friction (Rayleigh flow).

55. Give the assumptions made in Rayleigh flow.

i. Perfect gas with constant specific heats and molecular weight.
ii. Constant area duct,
iii. One dimensional, steady frictionless flow with heat transfer.
iv. Absence of body forces.

56. What do you understand by chocking in Rayleigh flow.

When the fluid is heated in a subsonic region, the entropy increases and the mach number and fluid properties move to the right unitil the maximum entropy is reached where M* = 1. When the fluid is heated in a supersonic region, the entropy increases and the mach number and the fluid properties move to the right until the maximum entropy is reached where M* = 1. Further heating is not possible because, if it is heated the change in entropy is negative which violates the second law of thermodynamics. Therefore, the type of flow when the limiting condition M* = 1 is called **"chocked flow".**

57. Differentiate between Fanno flow and Rayleigh flow.

FANNO FLOW	RAYLEIGH FLOW
a) One dimensional steady frictional flow.	a) One dimensional steady frictionless flow.
b) Stagnation temperature is constant.	b) Stagnation temperature is not constant
c) Because of considering the wall friction forces it is accurate.	c) Less accurate.
d) Without heat transfer.	d) With heat transfer.

58. What is meant by a jet propulsion system?

It is the propulsion of a jet aircraft (or)other missiles by the reaction of jet coming out with high velocity. The jet propulsion in used when the oxygen is obtained from the surrounding atmosphere.

59. How will you classify propulsive engines?

The jet propulsion engines are classified into

i. Air breathing engines and

ii. Rocket engines which do not use atmospheric air.

60. What is the difference between shaft propulsion and jet propulsion?

SHAFT PROPULSION	JET PROPULSION
a) The power to the propeller is transmitted through a reduction gear	a) There is no reduction gear.
b) At higher altitude, the performance is poor. Hence it is suitable for lower altitudes.	b) Suitable for higher altitudes.
c) With increasing speeds and size of the aircrafts, the shaft propulsion engine becomes too complicated.	c) Construction is simpler.
d) Propulsive efficiency is less.	d) More.

61. List the different types of jet engines.

i. Turbo-jet

ii. Turpo-prop engine,

iii. Ram jet engine,

iv. Pulse jet engines.

62. Define the principle of Ram jet engine.

The principle of jet engine is obtained from the application of Newton's law of motion. We know that when a fluid is accelerated, a force is required to produce this acceleration is the fluid and at the same time, there is an equal and opposite reaction force of the fluid on the engine is known as the **thrust**, and therefore the principle of jet propulsion is based on the reaction principle.

63. Give the components of a turbo jet.

i. Diffuser

ii. Mechanical compressor,

iii. Combustion chamber,

iv. Turbine and

v. Exhaust nozzle.

64. Give the difference between pulse jet and ram jet engine.

PULSE JET	RAM JET
a) Mechanical valve arrangements are used during combustion. b) The stagnation temperature at the diffuser exit is comparatively less.	a) Works without the aid of any mechanical device and needs no moving parts. b) Since the mach number in Ram jet engine is supersonic, the stagnation temperature is very high.

65. Give the difference between turbojet and ram jet engine.

TURBO JET	RAM JET
a) Compressor and turbine are used. b) Lower thrust and propulsive efficiency at lower speeds. c) Construction cost is more.	a) Compressor and turbine are not used but diffuser and nozzle are used. b) It provides high thrust per unit weight. c) In the absence of rotating machines, the construction is simple and cheap.

66. What is specific impulse?

Specific impulse is the thrust developed per unit weight flow rate through the propulsive device. It is a useful performance parameter in aerospace propulsion systems.

$$I_{spe} \frac{F}{W}$$

67. Give the difference between Jet propulsion and Rocket propulsion.

JET PROPULSION	ROCKET PROPULSION
a) Oxygen is obtained from the surrounding atmosphere for combustion purposes. b) The jet consists of air plus combustion products. c) Mechanical devices are also used.	a) The propulsion unit consists of its own oxygen supply for combustion purposes. b) Jet consists of the exhaust gases only. c) Mechanical devices are not used.

68. What is the difference between turbo prop engine and turbo jet engine.

TURBO – PROP	TURBO - JET
a) The specific fuel consumption based on thrust is low.	a) TSFC is comparatively higher at lower speeds and altitudes.
b) Propulsive efficiency within the range of operation is higher.	b) Propulsive efficiency is low.
c) On account of higher thrust at low speeds the take-off role is short and requiring shorter runway.	c) Take – off role is longer and requiring longer run way.
d) Use of centrifugal compressor stages increases the frontal area.	d) Lower Frontal area.
e) Higher weight per unit thrust.	e) Lower weight per unit thrust.

69. Write the formula for propulsive efficiency and define the same.

The force which propels the aircraft forward at a given speed is called **thrust** (or) **propulsive force**.

Propulsive efficiency is defined as the ratio between propulsive power (or) thrust power to the power output of the engine.

$$\eta_P = \frac{\text{Thrust power (or) Propulsive power}}{\text{Power output of the engine}} = \frac{Fxu}{P_{output}}$$

$$= \frac{2\sigma}{\sigma - 1} where,$$

$$\sigma = \frac{u}{C_j} \Rightarrow$$

Effective speed ratio (or) flight to jet velocity

70. What is ram effect?

When an aircraft flies with high velocity, the incoming air is compressed to high pressure without external work at the expense of velocity energy is known as "**ram effect**".

71. Explain specific thrust as applied to jet engines.

Specific thrust is defined as the thrust produced per unit mass flow rate through the propulsive device.

$$F_{spec} = \frac{F}{m}$$ where, F = thrust and m = mass flow rate

72. Differentiate between pressure thrust and momentum thrust.

Pressure thrust is mainly depends on the difference in pressure between the nozzle exit pressure and the ambient pressure and is given by

Pressure thrust = $(P_e – P_a)$ A

Momentum thrust depends on the difference in velocity between the aircraft velocity and jet velocity is given by

Momentum thrust = m $(c_j – u)$ where,

P_e = nozzle exit pressure

P_a = ambient pressure

A = Area of cross section at the nozzle exit

C_j = jet velocity and

u = forward speed of aircraft

73. What is "thrust augmentation"?

To achieve better take-off performance, higher rates of climb and increased performance at altitude during combat maneuvers, there has been a demand for increasing the thrust output of aircraft for short intervals of time. This is achieved by during additional fuel in the tail pipe between the turbine exhaust and entrance section of the exhaust nozzle. This method of thrust increases the jet velocity is called "**Thrust Augmentation**".

74. Why after burners are used in turbojet engine?

Exhaust gases from the turbine have large quantity of oxygen, which can support the combustion of additional fuel. Thus if a suitable burner is installed between the turbine and exhaust nozzle, a considerable amount of fuel can be burned in this section to produce temperatures entering the nozzle as high as 1900°C. The increased temperature greatly augments the exhaust gas velocity, and hence provides the thrust increase.

75. Why a ram jet engine does not require a compressor and a turbine?

In general, the speed of a ram jet engine is supersonic (the range of Mach number) is very high. At this flight speed the contribution of the compressor to the total static pressure rise is insignificant. Hence, arm jet engine does not require compressor and turbine.

76. Define Rocket propulsion.

If the propulsion unit contains its own oxygen supply for combustion purposes, the system is known as "**Rocket propulsion**".

77. Define thrust for a rocket engine and how it is produced.

The force that propels the rocket at a given velocity is known as thrust. This is produced due to the change in momentum flux of the outgoing gases as well as the difference between the nozzle exit pressure and the ambient pressure.

78. What are the types of rocket engines?

Rocket engines are classified in the following manner.

a) On the basis of source of energy employed

i. Chemical rockets,
ii. Solar rockets
iii. Nuclear rockets and
iv. Electrical rockets

b) On the basis of propellants used

i. Liquid propellant
ii. Solid propellant
iii. Hybrid propellant rockets.

79. Compare solid and liquid propellant rockets.

SOLID PROPELLANT	LIQUID PROPELLANT
a) Solid fuels and oxidizers are used in rocket engines	a) Liquid fuels and oxidizers are used.
b) Generally stored in combustion chamber (both oxidizer and fuel).	b) Separate oxidizer and fuel tanks are used for storing purposes.
c) Burning in the combustion chamber is uncontrolled rate.	c) Controlled rate.

80. What are the types of liquid propellants used in rocket engines?

i. Mono propellants

ii. Bi – propellants

81. Give two liquid propellants.

Liquid fuels : Liquid hydrogen, UDMH, hydrazine

Solid fuels : Polymers, plastics and resin material

82. What is mono-propellants? Give example.

A liquid propellant which contains both the fuel and oxidizer in a single chemical is known as “mono propellant”. e.g.,

i. Hydrogen peroxide
ii. Hydrazine

iii Nitroglycerine and

iv Nitromethane, etc.

83. What is bi-propellant? Give Example.

84. Name some oxidizers used in rockets.

A liquid propellant which contains the fuel and oxidizer in separate units is known as bi-propellant. The commonly used bi-propellant combinations are:

OXIDIZER	FUEL
a) Liquid oxygen	a) Gasoline
b) Hydrogen peroxide	b) Liquid bydrogen
c) Nitrogen tetroxide	c) UDMH
d) Nitric acid	d) Alcohol, ethanol

85. Name few advantages of liquid propellant rockets over solid propellant rockets.

i. Liquid propellant can be reused or recharged. Hence it is economical.
ii. Increase or decrease of speed is possible when it is in operation.
iii. Storing and transportation is easy as the fuel and oxidizer are kept separately.
iv. Specific impulse is very high.

86. What is inhibitors?

Inhibitors are used to regulate (or prevent) the burning of propellant at some sections.

87. Give the important requirements of rocket engine fuels.

i. It must be able to produce a high chamber temperature. It should have a high calorific value per unit of propellant.
ii. It should not chemically react with motor system including tanks, piping, valves and injection nozzles.

88. What is meant by restricted burning in rockets?

In this case, the inhibition material (or) restrictions prevent the propellant grain from burning in all directions. The propellant grain burns only at some surfaces while other surfaces are prevented from burning.