1st Gas Dynamics Report

مطلوب حل التقرير بخط اليد وعدم إستخدام الحاسب (أى تقرير بالحاسب أوالإجابات المنقولة أوالمصورة درجتها ستكون صفر)
تعديل موعد تسليم التقرير بعد 4 أسابيع من تاريخه (محاضرة الثلاثاء 12مارس2024) ولن يتم قبول أى تقرير بعد الموعد.

1- Find what is wrong in each of the following statements and then re-write the full correct statement (you can also add a T-S diagram to show the correct meaning) :

a) In Gas Dynamics, we define Mach number in a C-D nozzle as a constant thermodynamic property which is equal to (a/V) where a is the vector of the gas velocity.

b) In Gas Dynamics, we have to assume that Mach number is ≥ 0.3 all the time and assume also that the speed of sound through all gases is equal to 342 m/s all the time.

c) If air velocity in C-D nozzle is less than 0.3 speed of sound we must assume the flow is isentropic and incompressible and must assume also that the air is a thermal perfect gas.

d) The speed of sound in a subsonic air flow in C-D nozzle remains constant if the flow is accelerated to a supersonic flow because we assume air is a thermal perfect gas.

e) In Isentropic flow in a converging nozzle, the flow is isentropic and the exit properties must be sonic properties for any value of back pressure and any length of the nozzle.

2- Define the physical meaning and the mathematical equation for calculating the speed of sound, a, in any gas. What are the assumptions we make to get that equation? Can we calculate the speed of sound for a gas if it is moving at M=1 or it is moving at M >1?

3- Find what is wrong in each of the following statements and then re-write the full correct statement (you can also add a T-S diagram to show the correct meaning) :

a) We cannot define the speed of sound for any incompressible flow because the density is must assumed to be constant and because the Mach Number is less than 0.3.

b) We can define the speed of sound, a, for air only and we have to assume the speed of sound a scalar quantity because it moves in the x-direction only.

c) For an incompressible flow, the speed of sound is defined as propagation of huge pressure pulse through isothermal fluid where friction and heat transfer are neglected.

d) All fluids at the same temperature must have the same speed of sound because the speed of sound is a function of the temperature only.

e) In a converging nozzle, the flow is isentropic and the exit properties must be sonic properties for any back pressure and any length of the nozzle.

4- Given that $dA/A = (1-M^2)(dp/\rho V^2) = -(1-M^2)(dV/V)$, Show that the converging-diverging nozzle is the only possible shape though which a gas may be accelerated smoothly from subsonic flow to supersonic flow without violating any of the gas dynamics relations. (use any needed equations and sketches).

5- Define the physical meaning of the speed sound. If we found that $a^2=(\partial p/\partial \rho)$, show that the speed of sound in a thermally perfect gas is $a = \sqrt{\gamma RT}$ (if we assume that sound waves are propagating isntropically). Prove that the speed of sound in a thermally perfect gas is $a = \sqrt{RT}$ (if we assume sound waves are propagating isothermally not isntropically). Which value is more accurate: ($a = \sqrt{\gamma RT}$) or ($a = \sqrt{RT}$) ? why ?

6- What is the "Mach Cone"? Define the physical meaning and the mathematical equation for calculating the half angle, α, of that cone. Can we see the Mach cone in a liquid or in an incompressible fluid ?

7- Define the physical meaning and the mathematical equations for the total isentropic stagnation properties (P_o, T_o, h_o, etc) and the critical isentropic properties (P^*, T^*, h^*, etc). Show both types of properties on T-S chart if the flow is <u>subsonic</u> and if it is <u>supersonic</u>.

8- Discuss, using the mass conservation, both the physical meaning and the mathematical relations which describe the chocking (الإختناق) in a variable area channel. Where may chocking take place? and How? What are the conditions that must exist to have a chocking? What are the possible flow conditions downstream of the chocked area?

9- Find what is wrong in each of the following statements and then <u>re-write the full correct statement</u> (you can also add a T-S diagram to show the correct meaning) :

a) All stagnation isentropic conditions (P_o, T_o, h_o, etc) of any subsonic flow must change if the flow becomes sonic or supersonic through an <u>isentropic</u> process.

b) All stagnation isentropic conditions (P_o, T_o, h_o, etc) of any subsonic flow must change if the flow becomes sonic or supersonic through a <u>non-isentropic</u> process.

c) All critical isentropic conditions (P^*, T^*, h^*, etc) of any subsonic flow must change if the flow becomes sonic or supersonic through an <u>isentropic</u> process.

d) All critical isentropic conditions (P^*, T^*, h^*, etc) of any subsonic flow must change if the flow becomes sonic or supersonic through a <u>non-isentropic</u> process.

e) For flow in a converging nozzle, the flow is isentropic and the exit properties must be sonic properties for any back pressure and any length of the nozzle.

10- What is the temperature, density, ρ, pressure, p, and speed of sound, a, on the nose of a supersonic fighter flying at a Mach number of M=2 through air at 273K and 0.7 bar.

11- Find what is wrong in each of the following statements and then <u>re-write the full correct statement</u> (you can also add a T-S diagram to show the correct meaning) :

a) All perfect gases of the same value of γ will have the same stagnation conditions (P_o, T_o, h_o, …etc) and also the same critical conditions (P^*, T^*, h^*, …etc).

b) Two perfect gases with different values of γ can not have the same stagnation conditions (P_o, T_o, h_o, …etc) and also the same critical conditions (P^*, T^*, h^*, …etc).

c) In calculating reference stagnation properties (P_o, T_o, h_o, etc) we get an adiabatic decrease in both of gas temperature and density but we get an increase in the gas pressure.

d) Inside the Mach Cone created by the subsonic flow of an airplane, the speed of sound must be constant because we assume air is a thermal perfect gas.

e) In Compressible flow in a converging nozzle, the flow is isentropic and the exit properties must be sonic properties for any back pressure and any length of the nozzle.

12- Air from a large tank flows at M=0.5 through a conduit of a cross-sectional area of 65cm^2. The conditions in the tank are 340 kPa, abs. and 10 ^{o}C. Calculate the properties, P, T, ρ, a, and the mass flow rate through that cross-section of the conduit.

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