Kaferelsheikh University
Faculty of Engineering
Department of Mechanical Engineering
Year: 2015-2016
3rd year MPE Bylaw2007

Subject: Gas dynamics
Date: /05 /2016
Time allowed: 3hr
Full Mark: 75
Final Exam: 2 pages

Allowed Tables and Charts: (*Gas Dynamics Tables and Charts*)

Assume any missing data, state your assumption clearly

-Please do not use a pencil to write.
-Assume any missing data from your point of view in the limits of what you studied

Question: 1 **[20 marks]**

(a)- Show, using neat sketches, the effect of back pressure reduction in a convergent-divergent duct isentropic flow with constant inlet stagnation pressure, p_o, on the variation of (p/p_o) and Mach number M along the duct. Show also the mass flux ratio (m/m_{max}) against (p_b/p_o) for the flow. Here p is the static pressure and p_b is the back pressure. [5 marks]

(b)- (i) A rocket stage motor is designed to operate between two altitudes. The atmospheric pressure at the low and high altitudes are 0.8 and 0.4 [bar] respectively. The rocket is designed to operate free from shocks at high altitude where the nozzle exit static temperature and velocity are 960 [K] and 1830 [m/s]. If the nozzle throat is 80 [cm^2] find, a) Combustion chamber pressure and temperature, b) Thrust produced, (ii) When the rocket operates at low altitude with the same combustion chamber pressure and temperature find:- a)Shock position (if any), b) New value thrust. [15 marks]

Question: 2 **[15 marks]**

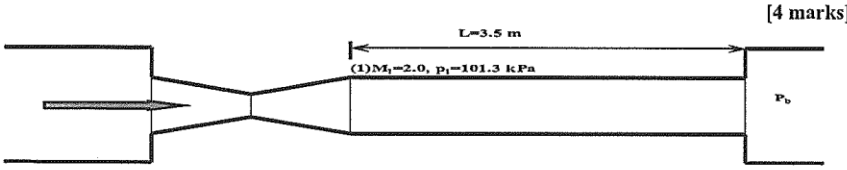
(a)- Show diagrammatically the changes of perfect gas adiabatic flow properties on T-S chart for constant mass flow rate in both subsonic and supersonic inlet flow to a frictional constant area duct. [5 marks]

(b)- Air flows steadily from a large reservoir through a convergent nozzle into a 0.3 m diameter pipe with a length of 3.5m. The conditions in the reservoir are such that the Mach number and the pressures at the inlet to the pipe are 2 and 101.3 kPa respectively. The Darcy friction factor, *f*, for the flow in the pipe is estimated to be 0.02.

1-If no shock occurs, find M and p at the exit of the pipe. [3 marks]

2-If there is a normal shock at the exit of the pipe, find the back pressure in the chamber into which the pipe is discharging. [3 marks]

3-Find the back pressure in the chamber in the pipe is discharging when there is a shock halfway down the pipe. Show the three cases diagrammatically on one T-s chart. [4 marks]



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Question: 3 [15 marks]

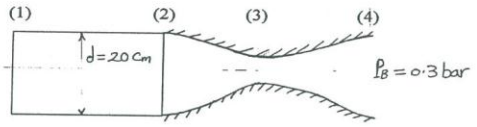
(a)-Distinguish between the ture and false statements of the following and correct mistakes, if any: For heating of an ideal gas flow in a constant area frictionless duct: [5 marks]

i)- heating will always cause an increase in entropy,
ii)-heating will always cause an increase in velocity,
iii)- heating will always cause an increase in temperature,
iv)- heating will always cause an increase in pressure , and
v)- the limiting Mach number is one for the subsonic flow.

(b)- A gaseous mixture of air and fuel enters a ramjet combustion chamber at a velocity of 63 m/s stagnation pressure and temperature of 2 bar and -23 °c respectively and a fuel to air ratio of 1:50 by weight. The combustion chamber is 20 cm in diameter after leaving the combustion chamber the exhaust gases enter a convergent – divergent nozzle. The nozzle discharge into an atmospheric pressure of 0.3 bar. Find:-

i)- the nozzle throat and exit areas in order to avoid shocks .

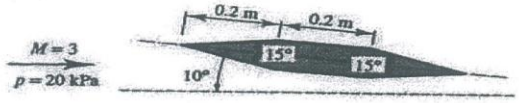
ii)- the maximum fuel flow rate which may be burned in this combustion chamber without thermal chocking. (Taking for air: Cp=1.005 kJ/kg.K, γ=1.4, R=0.287 kJ/kg.K
For gases: Cp=1.147 kJ/kg.K, C.V.=42000 kJ/kg.k) [10 marks]



Question: 4 [25 marks]

a)-Air at m=2.0 expands around a 120° sharp convex corner. Locate the slip stream. [5 marks]

b)-Consider two-dimensional flow over the double-wedge airfoil shown in the figure. Find the lift and drag per meter span acting on the airfoil and sketch the flow pattern. How does the pressure vary over the surface of the airfoil? [20 marks]



GOOD LUCK

Dr. Ismail Mohamed Sakr