Department of Mechanical Engineering

ME 454 – Compressible Flow

Elective

Catalog Description: **ME 454 (3-0-3)**

One-dimensional compressible flows with variable areas, friction, heat addition, normal shocks, and combination of these effects are covered in this course. Special topics in two-dimensional flows such as oblique shocks and method of characteristics are also included.

Prerequisites: ME 304 – Fluid Mechanics
ME 312 – Thermodynamics
Math 222 – Differential Equations

Textbook(s) Materials Required:

Compressible Fluid Flow. M A Saad 2nd Ed Prentice Hall, 2003

Reference(s) (Not Required):

PC Compressible Flow Software by R. Chen (Class hand out)

Course Supervisor: Dr. R. Chen

Pre-requisite by topic

1. Ordinary differential equations – 2nd order ordinary differential equation
2. Flow in a conduit – frictional flow
3. First Law and property relations – properties of an ideal gas and thermodynamic processes

Course Objectives[1]:

1. To develop the student's skills in applying the basic law of thermodynamics to a steady flow in a conduit to derive the general one dimensional flow equation. (A,B,C)
2. To provide the student with some knowledge in the compressible flow effects on flow systems. (A,B,C)
3. To develop the student's skills in applying the isentropic flow and normal shock to some flow systems such as discharge of air from tanks and nozzle configurations. (A,B,C)
4. To develop the student's skills in applying the one-dimensional compressible flows analysis to mechanical engineering designs such as piping systems and heat exchangers. (A,B,C)

Topics[2]:

1. Introduction, basic one-dimensional equations (3 hrs)
2. Ideal gas, Speed of sound and Mach number (1 hrs)
3. Stagnation conditions, Effects of variable areas (2 hrs)
4. Isentropic flows (3 hrs)
5. Subsonic and supersonic nozzles, Discharge from a reservoir. (3 hrs)
6. Normal shocks, Supersonic nozzles with shocks (5hrs)
7. Oblique shocks, Prandtle Meyer flows (3 hrs)
8. Applications to divergent-convergent nozzles (3 hrs)
9. Flows with friction and discharge of air from a tank through a nozzle and pipe (6 hrs)
10. Flows with heat transfer and effects on a heat exchanger (3 hrs)
11. Combined effects on flow (3 hrs)
12. Method of characteristics and design of a supersonic nozzle (3 hrs)

Evaluation Method:

1. Quizzes

2. Exam
3. Homework
4. Project

Schedule: Lecture Recitation: 3 hours, per week

Professional Component: Engineering Science and Design

Program Objectives Addressed: A, B, C, D, E

Course Outcomes[3] :

Objective 1

Students will demonstrate an ability to determine the compressible effects on a flow system and include such effects when needed. (1,2,3) (a,d,e,l)

Objective 2

Students will demonstrate an ability to apply the compressible flow analysis to a pipe flow and compute the pressure losses due to friction, area change or heat exchange in the system and assess the performance of the system. (1,2,3) (a,c,d,e,,k,o)

Objective 3

Students will use the PC software to make parameter changes (flow condition changes) to evaluate the effects on the flow and the combined effects on flows. The software will also assist the student in design a two-dimensional supersonic nozzle. (3,4) (a,c,e,g,i,k,o)

Prepared by: R. Chen **Date: September 25, 2006**

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[1] Capital Letters in parenthesis refer to the Program Objectives of the Mechanical Engineering Department. Listed in Sec 2 d Tables B-2-9, B-2-12. Table B-2-8 links Program Objectives with the ABET a-k Criterion

[2] Topi**c** numbers in parenthesis refer to lecture hours. (three hours is equivalent to 1 week)

[3] Outcome numbers in parenthesis refer to evaluation methods used to assess the student performance. Lower case letters in parenthesis refer to ABET a-k outcomes.