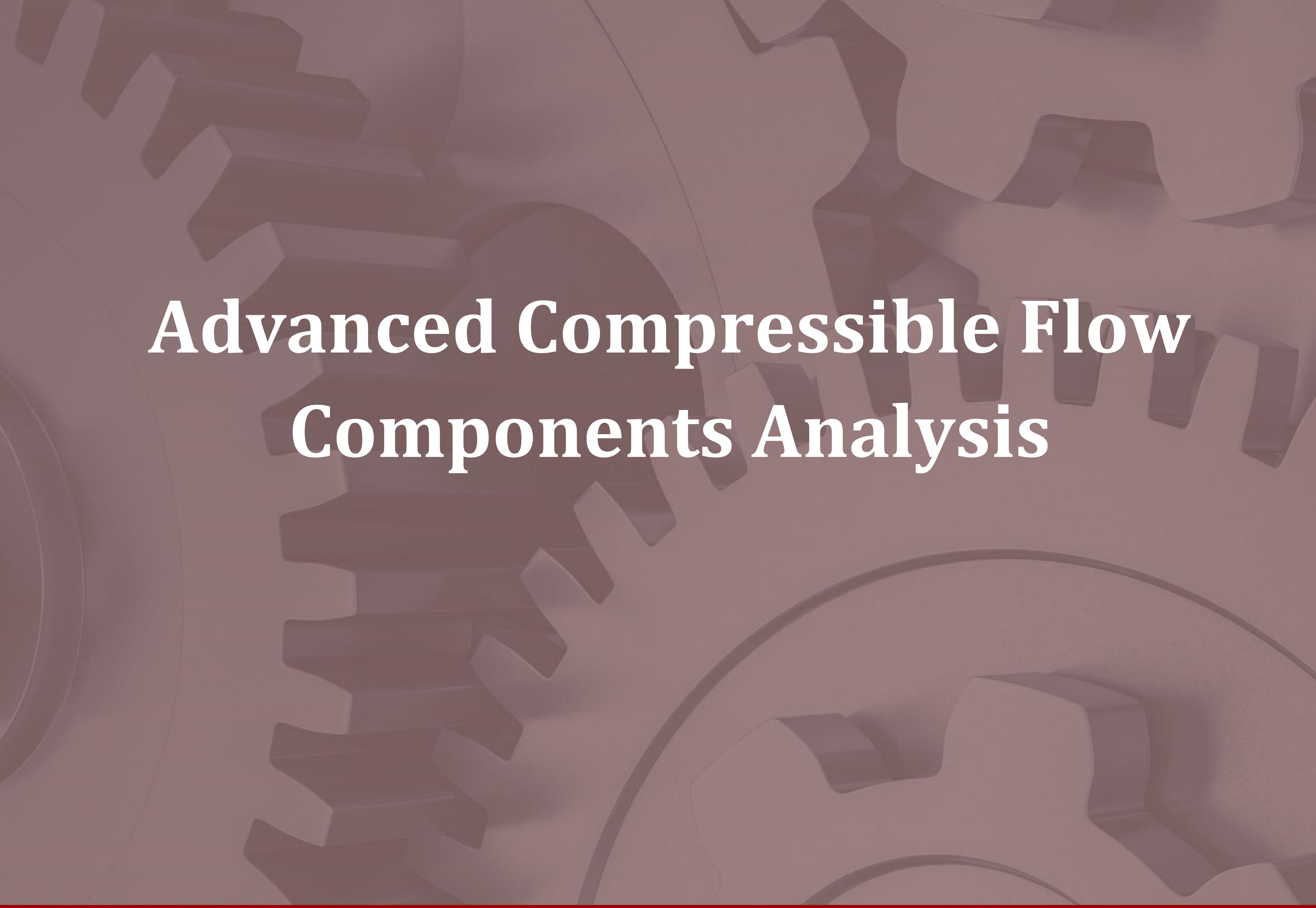

Advanced Compressible Flow Components Analysis

An Online Continuing Education Course for Engineers

Course Number: M-1053

Credit: 1 Hour / 1 PDH / 1 CPD

Advanced Compressible Flow Components Analysis

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Course Description

The ideal subsonic nozzle, diffuser and thrust analysis is presented when air, argon, helium and nitrogen are considered as the working fluid. The technical performance of mentioned compressible flow components is presented with a given relationship between temperature and pressure as a function of the Mach Number.

This two-hour course provides the compressible flow components T - s diagrams and their major performance trends (stagnation over static temperature and pressure ratio values) are plotted in a few figures as a function of the Mach Number.

In this course, the student gets familiar with the compressible flow components (nozzle, diffuser and thrust) and their T - s diagrams, operation and major performance trends.

Performance Objectives

At the conclusion of this course, the student will:

- Understand basic energy conversion engineering assumptions and equations
- Know basic components of the compressible flow for subsonic conditions - nozzle, diffuser and thrust and their T - s diagrams
- Be familiar with the nozzle, diffuser thrust operation
- Understand general nozzle, diffuser and thrust performance trends

Introduction

Compressible flow primarily deals with gases where density changes occur as a result of the flow.

Most propulsion devices can be considered to comprise a number of simple components. The most common are: nozzle, diffuser and thrust. Therefore, basic compressible flow components such as nozzle, diffuser and thrust are present in engineering gas flow applications.

Nozzle

This section provides an isentropic nozzle analysis when air, argon, helium and nitrogen are considered as the working fluid.

Analysis

In the presented nozzle analysis, air, argon, helium and nitrogen are considered as the working fluid behaving as a perfect gas -- specific heat has a constant value. Ideal gas state equation is valid -- pv = RT.

Working fluid enters a nozzle at point 1 and it exits the nozzle at point 2. Isentropic expansion is considered with no entropy change.

Figure 1 presents a nozzle schematic layout.

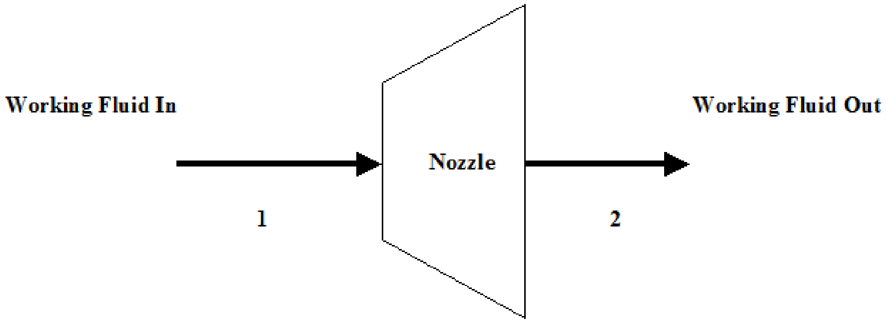


Figure 1 - Nozzle Schematic Layout

Figure 2 presents a nozzle temperature vs. entropy diagram.

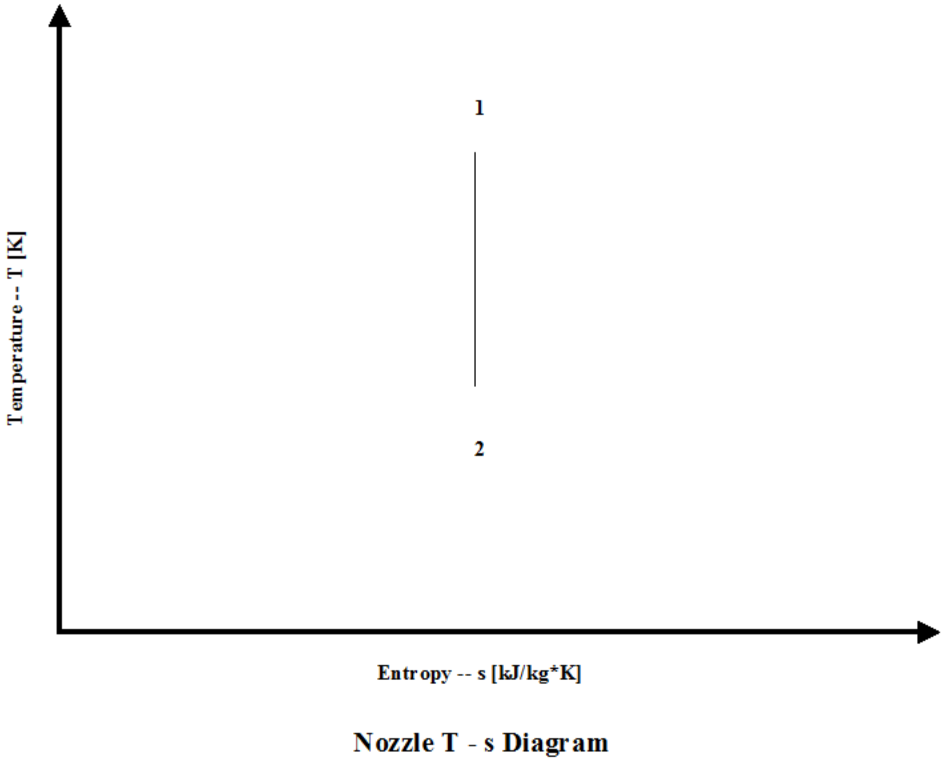
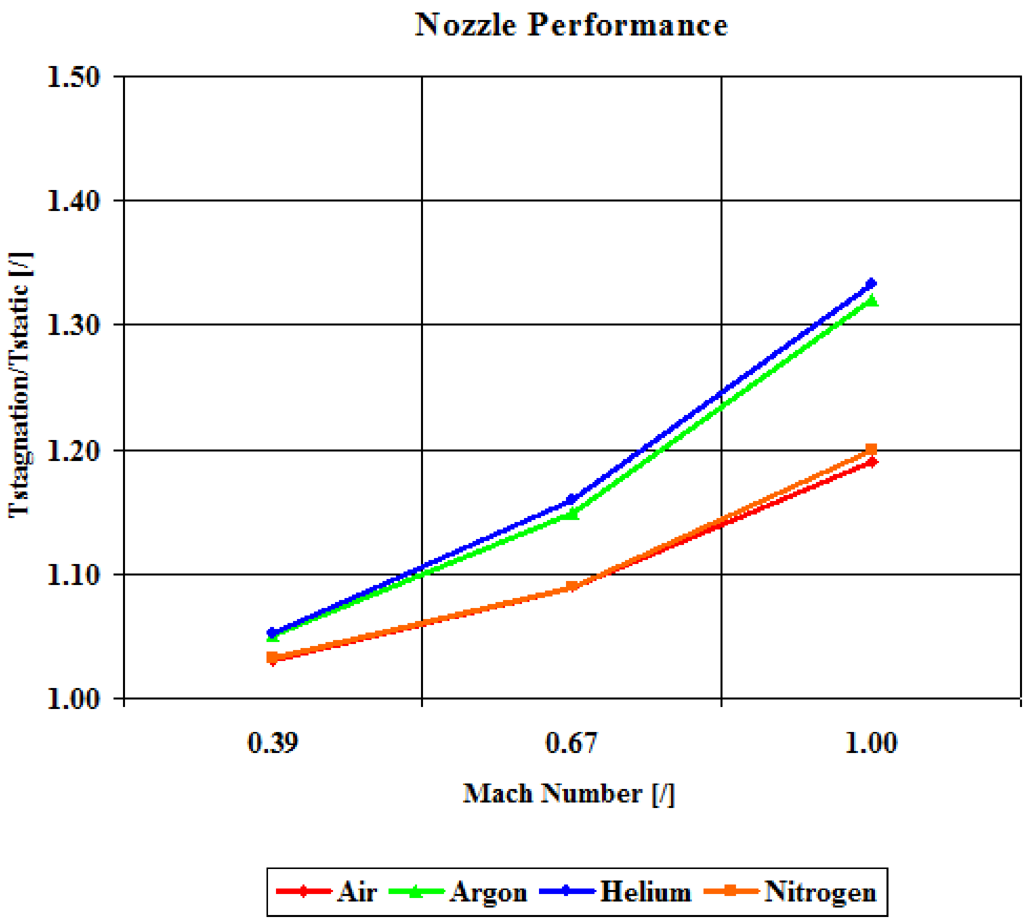


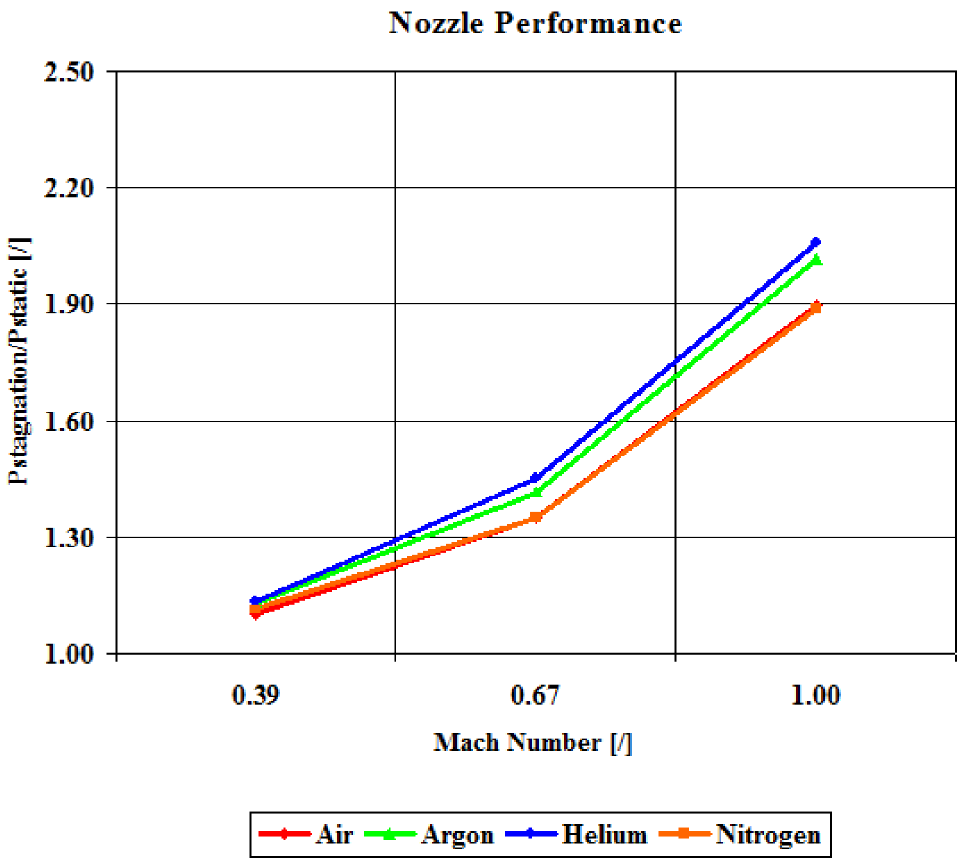
Figure 2 - Nozzle Temperature vs Entropy Diagram

Figure 3 and Figure 4 present nozzle performance -- stagnation over static temperature and pressure ratio values are provided as a function of the Mach Number. Only subsonic nozzle operation is considered. It should be noted that air enters the nozzle at the stagnation conditions of 1,500 [K] and 10 [atm] of absolute pressure.



Nozzle Inlet Stagnation Conditions -- Temperature: 1,500 [K] and Pressure: 10 [atm]

Figure 3 - Nozzle Performance



Nozzle Inlet Stagnation Conditions -- Temperature: 1,500 [K] and Pressure: 10 [atm]

Figure 4 - Nozzle Performance

One can notice that nozzle stagnation over static temperature and pressure ratio values increase with an increase in the Mach Number.

The nozzle performance increases for the working fluid having higher specific heat values.

Assumptions

Air, argon, helium and nitrogen are considered as the working fluid. There is no friction and heat transfer. Expansion is isentropic -- there is no entropy change. Ideal gas state equation is valid -- pv = RT. Working fluid behaves as a perfect gas -- specific heat has a constant value.

Governing Equations

$T_t / T = (1 + M^2(\varkappa - 1)/2)$

$p_t/p = (1 + M^2(\varkappa - 1)/2)^{\varkappa/(\varkappa-1)}$

$T_t/T = (p_t/p)^{(\varkappa-1)/\varkappa}$

$v = (2c_p(T_t - T))^{1/2}$

$v_s = (\varkappa RT)^{1/2}$

$M = v/v_s$

$\varkappa = c_p/c_v$

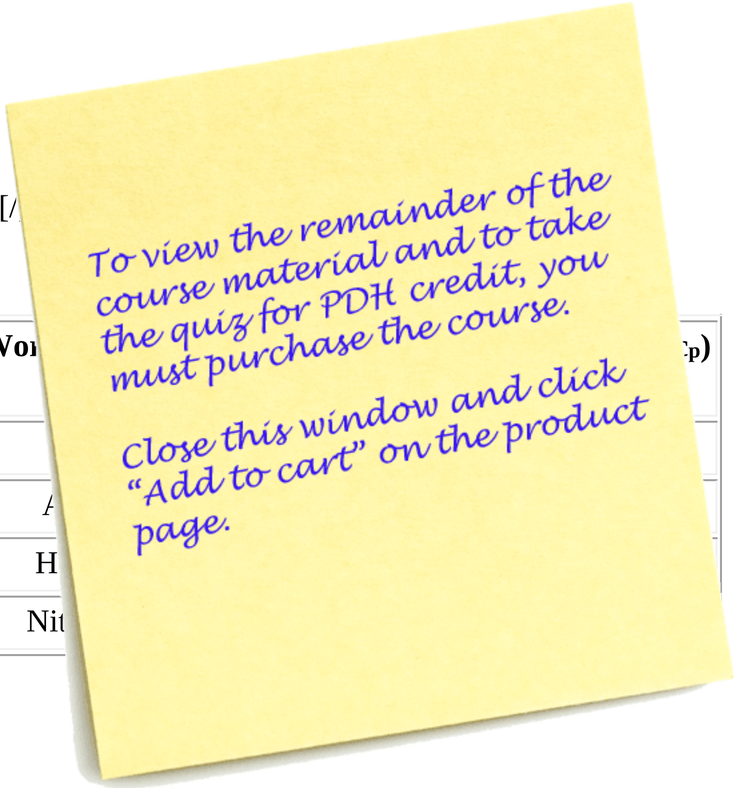
$pv = RT$

Input Data

$T_1 = 1{,}500$ [K]

$p_1 = 10$ [atm]

M = 0.39, 0.67 and 1 [/



To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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