Compressible Flow Components Ideal vs Real Operation Analysis

An Online Continuing Education Course for Engineers

Course Number: M-1040

Credit: 1 Hour / 1 PDH / 1 CPD

Compressible Flow Components Ideal vs Real Operation Analysis

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Course Description

The subsonic nozzle, diffuser and thrust analysis is presented only for the air 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 velocity (Mach Number) and isentropic nozzle and diffuser efficiency.

This one 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 velocity (Mach Number).

In this course, the student gets familiar with the compressible flow components (nozzle, diffuser and thrust), their T - s diagrams, ideal vs. real 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 ideal vs. real 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

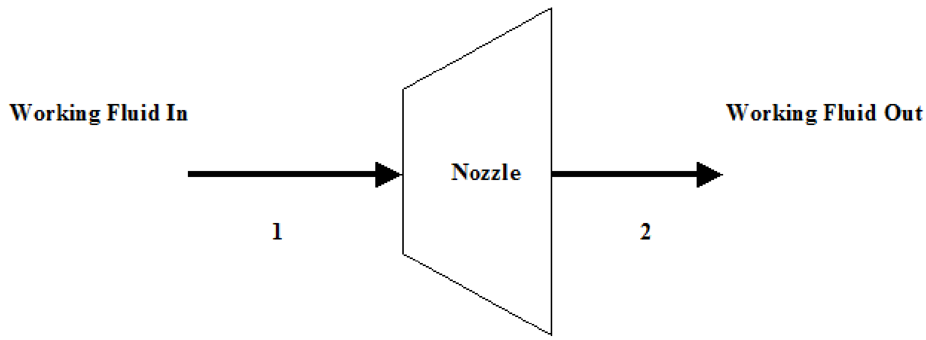
This section provides an adiabatic nozzle analysis when the working fluid is air.

Analysis

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

Air enters a nozzle at point 1 and it exits the nozzle at point 2. Isentropic and adiabatic expansion is considered.

Figure 1 presents a nozzle schematic layout.



Nozzle Schematic Layout

Figure 1 - Nozzle Schematic Layout

Figure 2 presents a nozzle temperature vs. entropy diagram.

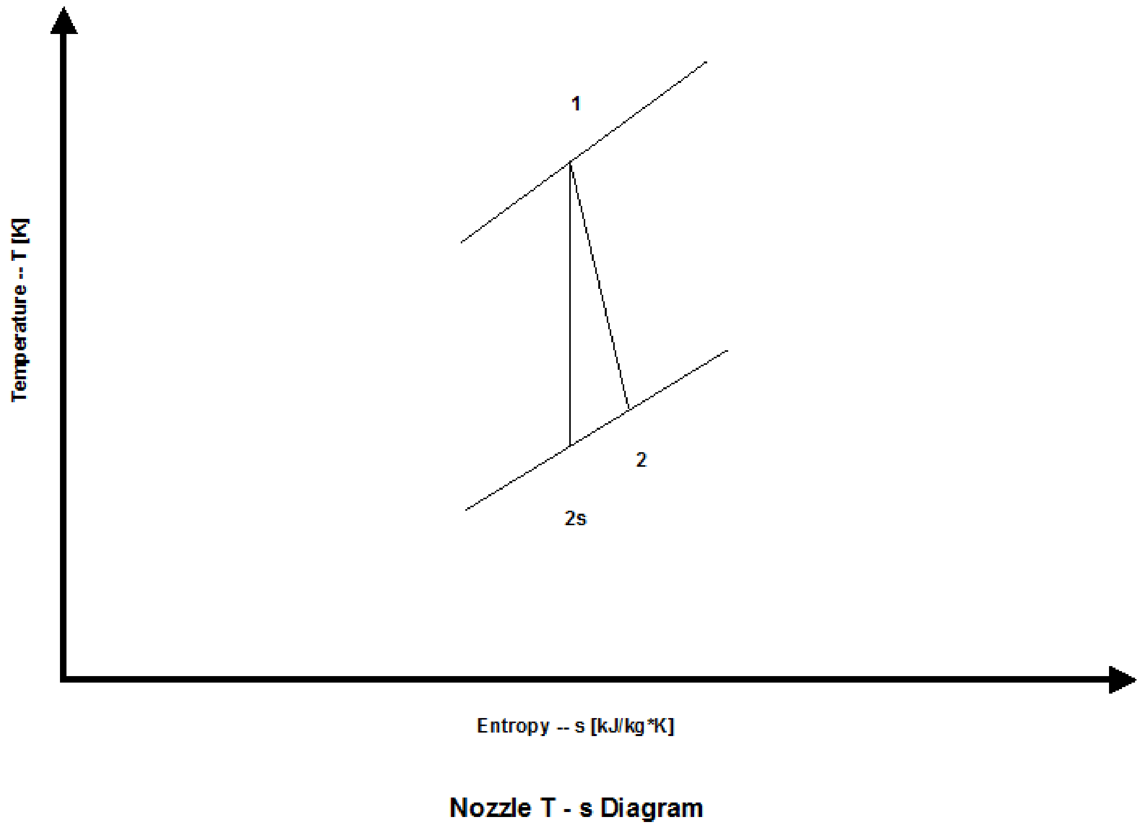


Figure 2 - Nozzle Temperature vs. Entropy Diagram

Figure 3, Figure 4 and Figure 5 present nozzle performance as a function of nozzle efficiency -- Mach Number, stagnation over static temperature and pressure ratio values are provided as a function of the velocity. 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.

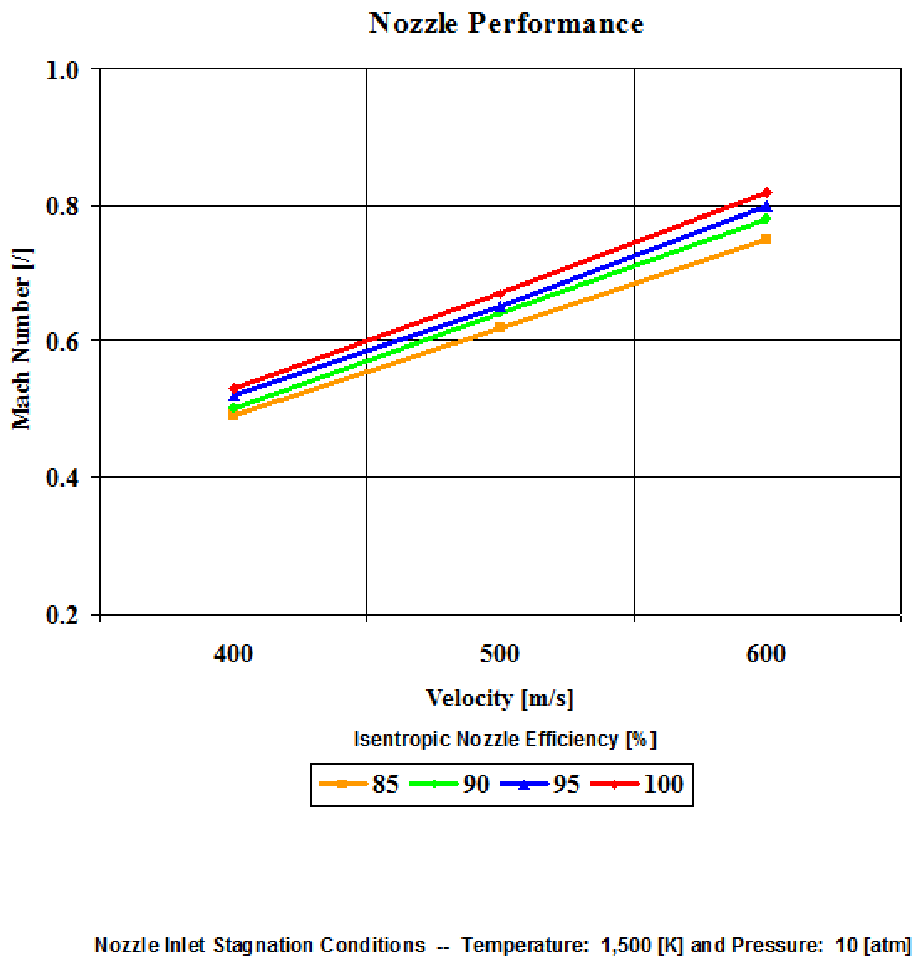


Figure 3 - Nozzle Performance

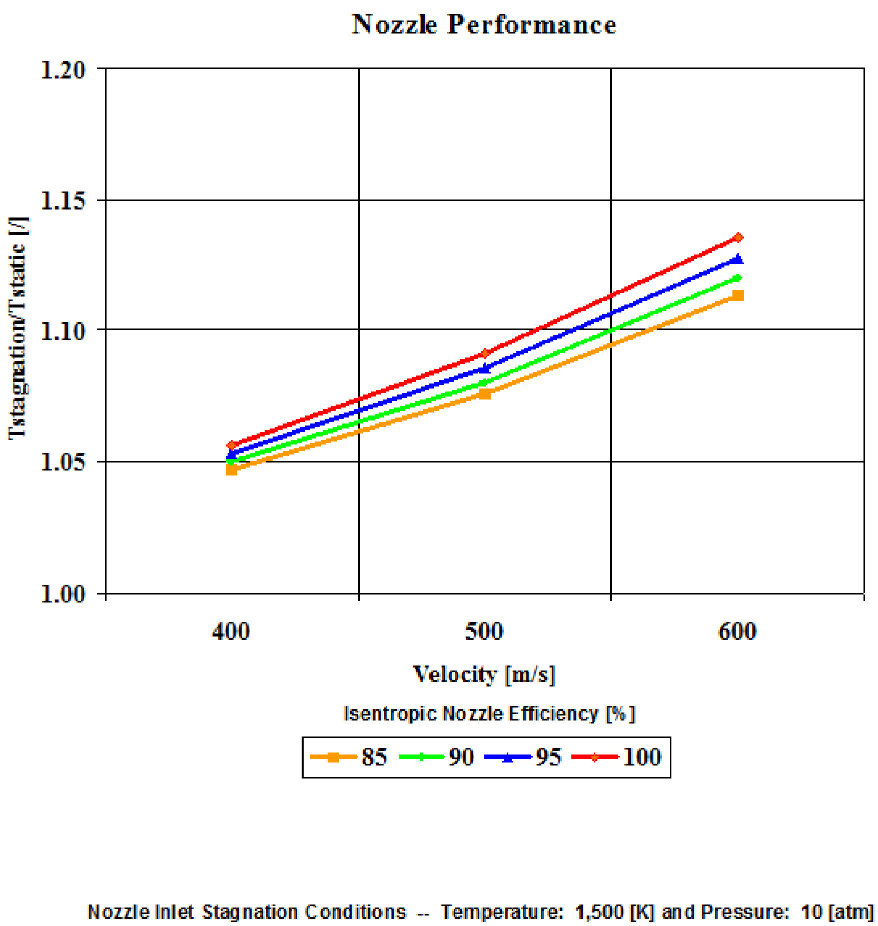
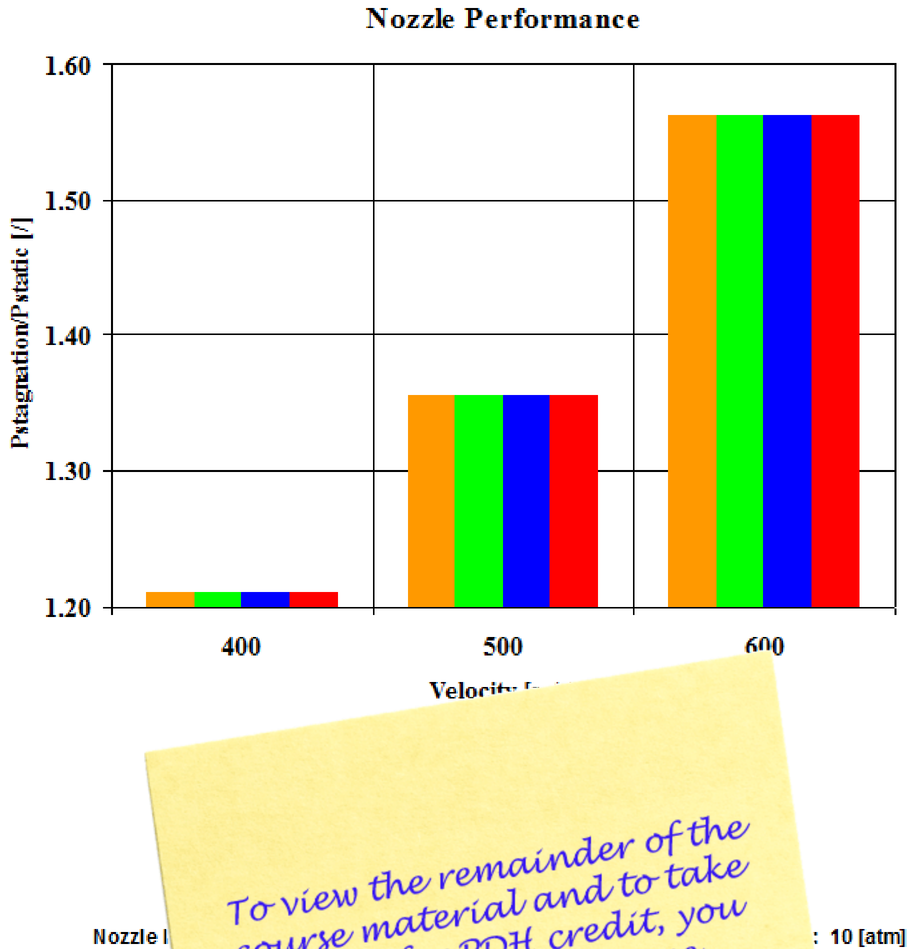
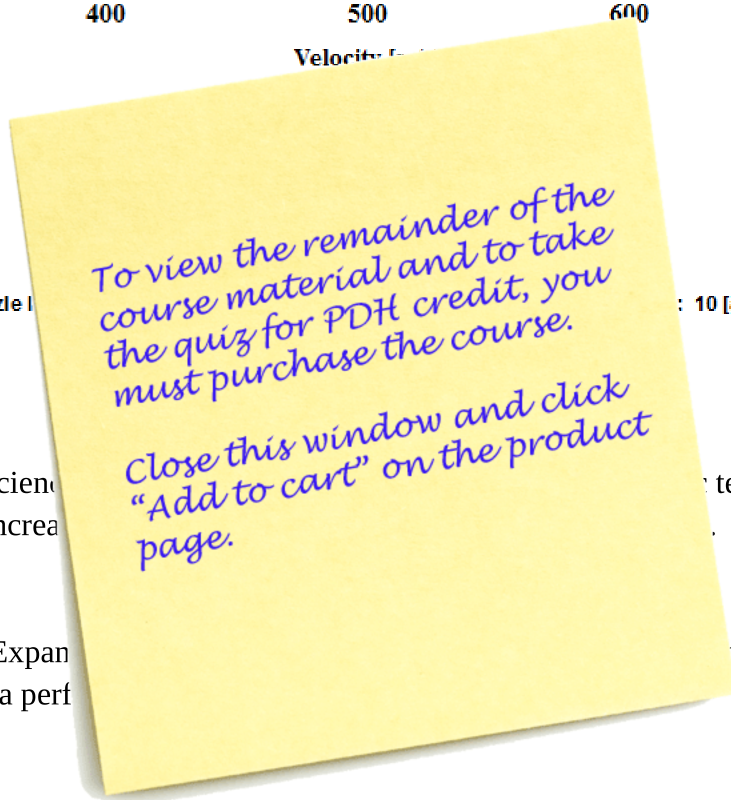


Figure 4 - Nozzle Performance





For a fixed nozzle efficien temperature and pressure ratio values increa .

Assumptions

Working fluid is air. Expan ation is valid -- pv = RT. Air behaves as a perf