Delft University of Technology **DEPARTMENT OF AEROSPACE ENGINEERING**	
Course: Thermodynamics and compressible aerodynamics; Code AE2125	Course year: 2
Date: Thursday 8th April 2010	Time: 10:00 –12:00

Problem 1-a

Consider a thermally insulated compressor, as depicted in fig. 1. Air is compressed from ambient conditions (where air is assumed at rest) to a pressure of 400 kPa and a temperature of 480K. The speed of air at the outlet of the turbine is 100 m/s and the mass flow through the compressor is 1.5 kg/s.

Answer the following questions:

1) determine the power required by the compressor;
2) verify that the transformation followed by the gas is irreversible;
3) represent the transformation 1-2 in the *T-s* plane;
4) determine the power that would have been required by the compressor in case of isentropic compression from the same initial state to the same final pressure and same final speed;
5) calculate the isentropic efficiency of the compressor;

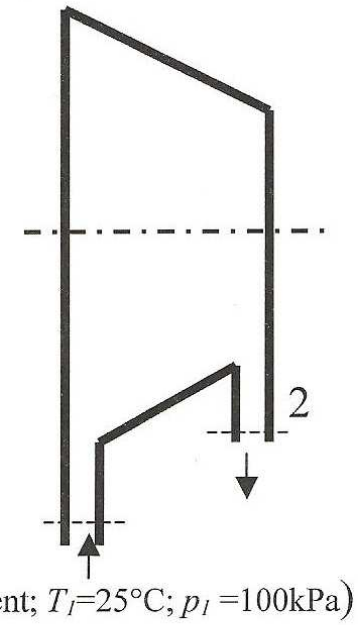

Fig. 1 –compressor schematic.

Problem 1-b

Consider a piston-cylinder device containing carbon dioxide at 300 KPa, 100 °C in an initial volume of 0,2 m^3. The piston is slowly loaded with a series of weights in such a way that the gas is compressed until it reaches a temperature of 200 °C. The compression can be considered a polytropic transformation with exponent n = 1.3. Assuming that the carbon-dioxide behaves like a perfect gas:

1) Determine the work exchanged during the transformation; is the gas receiving or providing work from/to the surroundings?
2) Determine the heat exchanged by the gas; is the gas receiving or providing heat from/to the surroundings?
3) Does the heat exchange increase or decrease when the gas is replaced by air? Justify your answer.

Problem 1-c

Consider a pure substance, e.g. H_2O, contained in a piston-cylinder device undergoing a change in its phase at constant pressure from the liquid to vapor phase.

1) Draw the schematic evolution of the transformation followed by the substance in the (T,v) thermodynamic plane as a function of the substance pressure;
2) Identify the position of the saturated liquid and saturated vapor states in the (T,v) plane as a function of pressure; is there a particular point where these states coincide?
3) Give the definition of the so called "quality of a mixture". Derive the formula relating the quality of a mixture to the mixture specific volume and the specific volumes of the corresponding saturated liquid and vapor states at the same pressure.

Appendix : Air properties: C_p = 1004 J/Kg K; γ = 1.4; Carbon dioxide properties : C_p = 844 J/Kg K; γ_{CO2}=1,289