Problem-based component #2

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A turbocharger is formed of a turbine and a compressor which are joined by a shaft. The compressor is powered by the turbine via this shaft (i.e. the power produced by the turbine is the power supplied to the compressor).

The turbine is adiabatic and expands air from 400 °C to 100 kPa and 100 °C. Air enters the turbine with an average velocity of 20 m/s through a 0.25 m^2 opening. Air exits the turbine at 5 m/s.

The compressor is adiabatic as well and accepts water vapour at 100 kPa and 150 °C at negligible velocity. The vapour then exits the compressor at 100 m/s, with temperature 500 °C and pressure 2 MPa. The compressor’s mass flow rate is 10 kg/s.

1. Find the power through the shaft.
2. Find he pressure at which the air enters the turbine.
3. What is the area of the opening through which steam exits the compressor?
4. Plot a PV diagram for the process through the turbine and compressor respectively.

ANS:

1. 6967 kW
2. 867.099 kPa
3. 0.017568 m^2
4. See solution document