Air-Benzene Separation using compression

Background: Emission of volatile organic compounds from processes is closely regulated. Both the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) have established regulations and standards covering emissions and frequency of exposure. This problem concerns the first step of the removal of benzene vapor from an exhaust stream, designed to recover 95% of the benzene from air by compression. The exit pressure needs to be calculated using Raoult's Law.

Description of the flowsheet: In this example air-benzene mixture containing 0.982 mole fraction of air, at 26 degree Celsius and 1 atm pressure is sent at the rate of 1kg/s(feed) to an **adiabatic compressor** the increase in pressure is 142 atm this is calculated using Raoult's Law. Next the compressed mixture is sent to a **cooler** to bring its temperature down to 26 degree Celsius. This brings about condensation of benzene vapors, air is essentially non-condensable. The adiabatic compressor and cooler, together act as an isothermal compressor. Next the Vapor-Liquid mixture is sent to a **flash separator** to separate liquid benzene from
the vapor. Purified air is sent to a **valve** which reduces its pressure from 143 atm to 1 atm. This air can be further purified or let out depending on the safety standards.

Results:

1) Purified air at 26 degree Celsius and 1atm contains benzene in the mole fraction of 0.000904 which is very close to the desired value of 0.000916.
2) The liquid from the flash separator contains 95% of the initial benzene and very small mole fraction(0.001645) of air.
3) The energy required for the various components of the flowsheet can be readily calculated using DWSIM and the total energy required for the process is equal to 751.833KW.

Conclusion:

1) Though air is essentially non-condensable a very small mole fraction of air does get condensed.
2) The amount of benzene separated from air can be increased by increasing the pressure in the compressor.
3) Adiabatic compressor and the cooler together act as an isothermal compressor which results in the condensation of the benzene vapors.

REFERENCE:

Basic Principles and Calculations in Chemical Engineering (Eighth Edition)

- David M. Himmelblau
- James B. Riggs

Example 8.6 Condensation of benzene from a vapor Recovery unit (Pg no 424).