RIS520 Mandatory Exercise 2018

Task

A 2 m^3 tank containing n-pentane (C_5H_{12}) is leaking from a circular hole in the bottom of the tank. The hole diameter is 2 cm. The liquid head is 1.2 m at the leakage start. The ambient temperature (and initial liquid temperature) is 20 degrees C. The gas pressure (vapor pressure) in the tank is 0.57 barg. This pressure can for the sake of convenience be assumed to be constant. The fluid density is 600 kg/m^3 and the molecular weight is 72 kg/kmol The acceleration of gravity is $g = 9.81\ m/s^2$.

a) What is the initial leak rate?

b) What is the regression rate in m/s for infinitely large pools when the heat of combustion $\Delta Hc = 49$ MJ/kg, and the heat of evaporation is $\Delta Hv = 366$ kJ/kg? Assume for simplicity that the n-pentane is at its boiling point.

c) The n-pentane is ignited and burns as a pool fed from a continuous leak (assume constant leak rate). What is the equilibrium diameter of the pool and what is the time to reach this diameter?

d) Assume that the flames are not physically affected by the presence of the tank. What will be the visible flame height under quiescent (no wind) conditions?

e) Estimate the height above the pool at which soot production starts.

f) Assume now and for the rest of the exercise that the leak is caused by a catastrophic rupture of the tank. Calculate the maximum pool diameter.

g) Calculate the average diameter of the pool. Then predict the flame height based on this average pool diameter.

h) Why don't we use the maximum pool diameter to characterise the fire hazard in this situation? Explain briefly.