Calculation of Total Latent Heat

Posted on September 15, 2018

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Q1: (60 marks)

A piston-cylinder device initially contains air at 200 kPa and 127 0C. At this stage, the piston rests on a pair of stops, as shown in the figure below, and the enclosed volume is 200 liters. The mass of the cylinder is such that a 300 kPa inside pressure is required to move it. The air is now heated until its volume has doubled. Determine (a) the final temperature, (b) the work done by the air, and (c) the total heat transferred to the atmosphere (Ling et al., 2016).

Solutions

Piston Cylinder Heating Calculations

In such a problem, volume, temperature, mass, pressure, and friction are dependable for accessing the solution under the assumption that there is no friction between the walls of the cylinder and piston, and by assuming the volume employed by the stops. Then, the solution of the final temperature work was done by air, and the amount of heat transferred to the air should be calculated in the following ways.

a) Temperature = initial temperature multiplied by final pressure divided by the initial pressure inside the container. That is: T2 = T1(P2/P1)

Implying that, T2 = 400.5*(300/200) 0C = 537.25 0K

T3 = 537.25 0K * 2 = 947.5 0C

Therefore, the final temperature produced by heating the air in the container is twice the amount of initial temperature. The result is because of the direct proportionality of temperature to pressure and volume. Therefore, when the air in the container is heated, the volume doubles in relation to pressure; hence, the temperature could also multiply twice.

b) Work done by the air equals the integration of the change of pressure concerning the change of volume in the heated air. The change of pressure in the heated air could affect the energy produced by the piston while pressing the volume in the air downwards. Therefore, the work was done by pressing the piston solved by applying the following method. Work is done given by,

Then, let P2 = final pressure, V3 = final temperature after heating the air in the container, and V2 = the initial temperature before heating the air in the container.

Therefore, work done (W) = P2(V3-V2).

Again, letting V1 = mass multiplied by the rate of temperature and by initial temperature, then altogether divided by the initial pressure of air experienced from a piston.

That is V1 = mRT/P = [1*0.56702*(273.15+127)] / 200 = 1.13446m3

Therefore, the work done (W) = 300kPa (2*1.13446m3 – 1.341448m3) =278.2416Kj

The amount of work done to press the piston in the container depends on the pressure and the volume produced when the air is heated. Therefore, the production of energy, depending on the work manufactured while pressing the piston in the container, could also affect the amount of pressure resulting.

The total amount of heat transferred from the piston to the container could result from the change of energy plus the work done in the container. The change of energy produced is, thereby, the mass of air multiplied by a change of temperature and finally multiplied by the volume of capacity. Therefore, ΔE = M * CV (T3-T1).

Again, CV @750 0K = 0.8

The total of heat transferred (Q) = 1*0.8*(947.5 – 400.5) + 278.2416 kJ = 715.8416Kj

The sum of heat produced when the air in the container is heated depends on the mass of air resulting, and since the volume at the final stops is ignored, then the amount of mass obtained could be less compared to when the volume at the last press could be considered.

Experiment Analysis

The change of temperature in the air makes an enormous difference in the work done during the pressing on of the piston to the container. The result is due to the more significant gap created by the change of volume when the air was heated. Regarding the assumptions made during the experiment, the friction between the cylinder wall and the piston was not accounted for in the calculation, which, in real-life situations, the conduction of the two parts will produce frictional force. This results in the minimum sum of the work done and the amount of energy produced when the air is heated to double the volume in the container.

Again, the cross-sectional area of the spring could also affect the amount of energy and work done by the pressed and heated air. The occupation of air in the container could determine the total volume of the air to be heated. Therefore, the larger the cross-sectional area, the more significant the amount of

air to be heated and vice-versa. This result is due to the dependence of volume on the field across the piston area covering the air. Similarly, the cross-sectional area affects the pressure exerted by the piston in the container. The initial volume should equal the capacity of the system since no force was used at the equilibrium position of a cylinder, and the spring just touched the walls of the container.

Thereby, the displacement that occurred in the container is directly proportional to the force of the piston; then, the pressure in the spring is given by relating piston displacement to the change of the volume in the bottle.

The amount of work done depends on the sum of pressure produced when the piston is pressed, assuming no frictional forces are obtained from the container and the spring. Again, the more substantial amount of volume attained affects the total work done by pressing of the piston into the bowl.

The sum of pressures in integration depended on the components of work produced. The initial load is constant since there was no change of volume.

Therefore, the total work done in spring is calculated using the following formula.

Thus, the amount of heat transferred from the heated container to the spring depends on the amount of energy resulting from pressing the piston plus the total amount of obtained work produced.

According to the initial assumptions, the final volume in the spring could account for the amount of work done in the spring. Again, the frictional forces deduct the amount of energy released by the piston in the process of conducting it to the container. These results affect the volume and pressure exerted by the piston. Finally, with the assumption of an ideal gas to be pressed, a considerable change in temperatures and pressure was obtained.

Q2: (40 marks)

A mixture of water and steam has a pressure of 0.8 bar and dryness of 0.9. Calculate the specific volume and specific enthalpy of the steam. (Use the Thermodynamic Properties of Water to do manual calculations.)

The boiling point of water is up to 100%, and it produces drenched steams, which are due to the small foams contravening the water shells and pulling the small water droplets in accompanied by steam. Therefore, due to the lack of a superheater in use, the steam source is central to partly wet from the summed liquid.

The Portion Of Steam Dehydration

Steam dehydration fraction is used to enumerate the total amount of water within the vapor. That is if the gas contains 19% water by mass, then, its dehydration is 81% dry, naturally, have a dryness

fraction of 0.81. The primary importance of steam dehydration is that it has an unswerving outcome on the total quantity of transportable energy confined within the vapor. The result affects the heating quality and competence, especially in water.

Calculation of Total Latent Heat

The specific volume of latent heat of water is obtained using the following formula.

V = x * vg+ (1- x) * vf

Where x is dryness in percentage or fraction, vf is the specific volume of full water, and vg is the specific volume of saturated steam. Thus, the value of the specific volume of saturated water is negligible because it is likely similar to the specific volume of saturated vapor.

Therefore, specific volume of wet steam (V) = 0.9*0.1 + (1- 0.9) = 0.19cm3/g

Calculation of specific enthalpy of wet vapour

Specific enthalpy of wet steam is outputted: h = hf + x* hfg, whereby

X = dryness of steam

hf = specific Enthalpy of saturated water

hfg = specific enthalpy of saturated steam minus specific enthalpy of saturated water.

According to the steam table, 0.8 bar ranged the hf and hfg at 781kJ/kg and 2000kJ/kg, respectively. Then, h = 781 + (0.9 * 2000) =2581kJ

Analysis of Changes In Steam

The evaporation process takes place when the liquid is changing into steam. Similarly, the process of reversing the steam state to liquid is called liquefaction known as the condensing process. If the fluid is heated, the temperature increases in proportionality to the heat shifted. Therefore, the heat transferred is outputted by, Q = mcΔT. The great change of temperature and pressure affect the change of specific heat of the liquid.

The transfer of energy and heat in the liquid is more affected by the internal energy and enthalpy. Enthalpy and the specific internal energy are well known and are hence recorded in a particular table. When the fluid is heated to a boiling point, it gains sensible power, which is represented as uf or hf. When the liquid becomes saturated with heat and no more absorption of heat without changing state (from liquid to vapor and gaseous form), the process is called evaporation. The boiling point of liquid

shows the saturation temperature of the fluid; hence, such liquid is called saturated liquid.

The superheat supplied to the liquid makes the liquid evaporate, which in turn drives the vapor. The resultant gas at saturation temperature could be termed a dry saturated vapor. Therefore, by definition, steam is a gaseous state adjoining the temperature at which it determines the condensation of such fluid. Hfg and ufg symbolize the quantity of enthalpy and inner energy needed to evaporate 1 kg. This hfg and ufg of liquid are called latent enthalpy and latent internal energy fluid correspondingly.

The evaporation process depends on temperature and atmospheric pressure. The boiling point of the liquid is directly proportional to the force exerted on it. Therefore, the higher the pressure, the higher the boiling point. Again, the lower the pressure, the less the boiling point of the fluid. Keeping the temperature of a molten constant, the change of pressure could also make boil. The end at which the water boils due to change of force when temperatures are kept constant is called saturation pressure.

In increasing the heat on vapor, the latent water becomes hotter compared to boiling point, and if the temperature incremented, then the steam turns to gas, hence is known as superheated vapor.

Specific Volume of Latent Water

The specific capacity of full water(vf) and the particular quantity of a dehydrated saturated vapor (vg) determine the amount of specific volume of latent water. Again, vf is negligible because vf is too small and also slightly similar to vg. All changes of state are measured under a mass of water. The saturation curve explains the rate of temperature against the change of pressure when the pool is heated. The amount of potential internal energy depends on the superheat provided to the liquid. The curve for civil power shows an increase as the pressure increases. Such reason is due to the direct proportionality of the pressure to the latent internal heat of the liquid. All the changes in fluids depend on a shift in temperature and a change of force exerted on the liquid. Superheated vapors, which result in gas, could also be tabulated under a heat and pressure graph. In such cases, the pressure and temperature graphs accommodate all the changes in the gaseous and liquid states.

The amount of energy produced during the evaporation and condensation process depends on the pressure and the amount of temperature applied to the liquid. Again, the evaporation method requires a higher temperature and less weight compared to the condensation process, which acts vice-versa.

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total heat transferred to the atmosphere (National Institute of Standards and Technology, n.d.).

Solutions

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