Experimental setup and methodology engineering essay

According the first law the amount of energy remains constant and cannot be destroyed, only changed from one form to another. The total energy entering in the system must be equal to the energy leaving the system. Therefore Ein = Eout, and the change in energy is equal to the heat added in the system minus the work done by the system. E = Q - W

E is the stored energy of the system which is equal to the sum of KE, PE, U in the system.

(McConkey & Eastop, 2009, pp. 21-35) , (NASA, 2012)

Terms of steady flow equation

In a steady flow process of an open system, the energy flow is steady and remains constant. The properties of the flow remain unchanged with time, but these properties may vary from one point to another. For example the temperature at the inlet may be different from that at the outlet of the system, but the temperature will remain constant at both points in a steady flow process.

A fluid mass with internal energy u, moving with a velocity (c) and changing height by a distance z will have a total energy per unit mass of .

Is the specific kinetic energy, Z * g is the specific potential energy, and u is specific internal energy.

For a fluid mass flowing through a system with a mass flow rate, the total energy can be found by multiplying the above expression by. Pushing the fluid across the boundary at the inlet and outlet requires energy, this energy is equal to, at the inlet and similarly for outlet . Supplying a steady flow of heat and work will also affect the energy of the system.

By combining the above information and considering that the energy entering in the system, must be equal with the energy leaving the system, we have the equation:

Energy entering =

Energy living + + =

The sum of the terms u and pv can be replaced by specific enthalpy (h), this is because

u + pv = h. Substituting h into the above equation and rearranging gives:

This is the steady flow energy equation

(McConkey & Eastop, 2009, pp. 35-36)

(NASA, 2012)

Experimental Set up and Methodology

Description of system

The system described is an open system, the experiment is to analyze, using the steady flow energy equation, the heat transferred between the system and surroundings.

The experiment take place on an open system model TD1 specialized for thermodynamics heat measurement purposes.

One inlet fan runs at constant speed and draws air from the environment, through a flow control valve into the system.

The air moves through u-shaped duct tube, and is connected to an insulated electrical copper heater which heats the air into the pipe. On the instrument panel of the system, we record the values of pressure drop and temperature gauges via thermocouples at different points inside the pipe. The instrumentation panel, include also manometers that are connected to the duct tube, to display the pressure across the pipe. Operation temperatures are +5 to +40 degrees Celsius and humidity range 30% to 95%.

(TecQuipment, 2012)

Methodology

To fulfill the formulas requirements, we took some measurements, we use tape measure tool to measure height z1 and z2 which are from datum to inlet (middle of the fan Z1) and outlet from datum to middle of pipe (Z2). We take the temperature from thermometer and pressure drop. We note the diameter of the pipe and diameter of circumferential air inlet using a caliber meter, and also the voltage and current of the heater.

Discussion

About the result of Q according the steady flow energy equation.

The energy equation states, the energy entering the system must be equal to the energy leaving Ein = Eout.

In energy equation

+ =

Some factors are able to effect the result of Q, such as values of each part of equation like KE, PE, U.

For Kinetic energy, when the velocity changes, then the total kinetic energy also changes, for potential energy, when Z (height) changes, potential energy also changes and internal energy u varies with temperature.

Because velocity, temperature and height increased, then the amount of stored energy in the system increased.

According to the equation the energy is entering the system at a rate of 1. 795 kw and the energy that is stored in the system is increasing at a rate of kw. Because the energy entering the system is greater than increase in stored energy, the must have been a loss of energy from the system.

The final result should be negative or positive. The sign represents, the energy direction, in or out of the system. Negative sign means energy directed from inside the system, to the atmosphere, and positive sign, means the energy is directed from atmosphere into the system.

Because the final answer is the negative sign means we have energy loss which should be expected because of the difference between energy entering and the increase in stored energy of the system.

(McConkey & Eastop, 2009, pp. 21-36)

Error analysis

Air analysis

A friction factor occurs across the whole system. The air which is entering through fan has kinetic energy, but sum amount of KE is converted to heat energy because of friction and compression on the fan blades of the fan. Additionally the air friction or drag is dependent on the velocity of air. For lower speeds the air resistance is approximately proportional to velocity according the equation and for higher speeds .

Where Ï = density of air, A = cross-sectional area, and C = drag coefficient. And as we know heat loss = work done against the force of friction.

(Hyperphysics, 2012) , (Colorado, 2012)

We also have friction in pipes. Friction increases in angled pipes, and also in small diameter pipes with higher velocity. This happens because the molecules of air press against the inside of the pipes increasing friction, and as a result the friction the KE is converted into heat energy. The amount of heat energy released to the atmosphere depends on the insulation of the system

(Fundamentals, 2012)

System errors

When reading were taken the temperatures values were fluctuating, because the insulation of the pipe and whole system plays a role in keeping the values constant.

The pressure drop gauge was a water gauge, and the scale of the gauge was in mm which restricted the accuracy of the reading.

Human errors

The may be errors in the measurements recorded, for example the height of the inlet and outlet from the floor used tape measure, this may be inaccurate because wasn't possible to guaranty that the tape was in correct and precise position.

Results

Examination of air flow in a heated duct

Test observation

Air Temperature at inlet t1 [°C]

21. 7

Air Temperature at outlet t2 [°C]

61. 7

Pressure difference across orifice Î” H0 [cm water gauge]

0. 08m

Height of air inlet above datum line z1 [m]

0. 44m

Height of air outlet above datum line z2 [m]

1. 30m

Diameter of circumferential air inlet d1 [m]

0. 131m

Width of circumferential air inlet w1 [m]

0. 004m

Diameter of air outlet pipe d2 [m]

0. 0331m

Heater Voltage VH [volts]

205v

Heater current AH [amperes]

4A

Fan motor voltage VF [volts]

415v

Fan motor current AF [amperes]

2. 35A

Density of air , [kg/]

1. 2 kg/

Orifice Diameter [mm]

40mm

Specific Heat of Air [kJ/kg. K]

1. 005 kJ/kg. K

Density of Water [kg/]

1000 kg/

Net heat Q [kw]

0. 498 kw

= Orifice Pressure Drop

=

=> = 735. 75 N/

1

= Orifice area

=

= 3. 141 * = 0. 00126

or

1. 26 *

2

Air Mass Flow Rate

3

A1 = Air Inlet Area

Or

1. 65 *

4

A2 = Air Inlet Area

A2 = 22

A2 = *

A2 = 0. 000860

860 *

5

C1 = Velocity of Air at Inlet

C1 =

C1 = C1 = 16. 161 m/s

6

C2 = Velocity of Air at Inlet

C2 =

C2 = C2 = 31. 007 m/s

7

WF = Power of Fan

WF = VF * AF * 10-3

WF = 415 * 2. 35 * 10-3

WF = 0. 975 kw

8

WH = Power of Heater

WH = VH * AH *10-3

WH = 205 * 4 * 10-3

WH = 0. 820 kw

Therefore, apply the above equations values into the steady flow energy equation, could be found the net heat energy transferred from the system and surroundings Q . KE and PE divided by 2000 and 1000 respectively to obtain values in kw.

- (- -) = (-)

- (-0. 975 - 0. 820) = (- 294. 7) + =>

- (- 1. 795) = + =>

- (- 1. 795) = =>

- (- 1. 795) = =>

+ 1. 795 = =

The net heat on surroundings is - 0. 498 kw, and indicate heat transferred out of the system.

Conclusion

The result of steady flow energy application shows that, the net heat on surroundings transferred out of the system. Also according the work and heat of the equation shows, amount of the total internal energy converted to heat, because the friction and insulation in the system. Additional we investigate how the Kinetic Energy, Potential Energy and Internal Energy are able to affect the work of the system

Recommendations

Recommendations provide for stable and accurate operation of the system.

The environmental temperatures maybe effect the performance of the system, and as solution the operation of the system is good to be in specific and controlled environment.

Tools which are designed for better accuracy and precision.

Friction into the system need to be considered.

Insulation of whole system and pipe need to study carefully to reduce heat loss.

Better insulation of the electronics parts like fan and heater.