Term paper on analyze of heat lost

Literature, Russian Literature

[Heat Lost From a 6-Inch OD Steam Line]

Analyze heat lost from a 6-inch OD steam line. The line carries high-pressure steam throughout the factory at 400 psi, 400oF. Specify type and thickness for insulating the steam line. Compare the cost of energy lost with and without pipe insulation. You can assume steam is generated 8000 hours/year. Compare energy cost reductions based upon a gas fired boiler and a fuel oil fired boiler. Assume boiler energy input at 6. 5(106) Btu/hr.

Given outer diameter OD = 6-inch, pressure = 400 psi, steam temperature = 400oF.

The following assumptions are made;

The steam pipe is made of mild steel

The steam pipe is horizontal

There is steady heat transfer as there is no indication of any change with time

The thickness of the pipe from standard table is 0. 189 inch

The external temperature is 77 oF

Therefore, the inner diameter = 6-(2 × 0. 189) = 5. 622 inch

The heat lost from a given surface is given by the following formula

$H = h \times A \times (TH-Ta)$

Where

H = heat loss, Btu/h

h = coefficient of heat transfer

Ta = average surrounding temperature, oF

TH = the temperature of the hot fluid flowing through the pipe

Calculation of surface area per square inch

Outer surface area, Ao = πDL = (π × 6 × 1)/12 = 1. 57ft2

Inner surface area, Ai = πDL = = (π × 5. 622 × 1)/12 = 1. 47ft2

The resistance of the pipe is given by;

Outer resistance Ro = 1Ao ho = 11. 57 × 5 = 0. 1274 h. oF/ Btu

Internal resistance RI = 1Ai hi = 11. 47 × 30 = 0. 02267 h. oF/ Btu

Total resistance, RT = RI + Ro = 0. 02267 + 0. 1274 = 0. 15 h. oF/ Btu

Therefore the heat lost through the pipe is given by Q = TH-TaRT

= 400-770. 15 = 2153. 3Btu/h

There are several reasons that necessitate the insulation of pipelines; the most important is the prevention of energy loss which can lead to the increase of the cost used to produce the energy. Sufficient thermal insulation is vital in reducing the energy loss from the surface of the pipelines. Insulation which is not thick enough or that which has deteriorated can undermine the overall goal of reducing heat loss. The material that is used as insulation plays a very important goal in preventing the thermal loss. The recent development in technology has led to discovery of different types of insulation materials that are superior to the traditional materials and the heat loss can be reduced efficiently at a minimal cost. The thickness of the insulation material is obtained by comparing the total cost of heat loss to the cost of insulating the pipelines. The insulation thickness at which the total cost is minimal is termed as economic cost.

There are different type of insulation materials that are commonly used, they are classified as inorganic and organic, organic insulations materials are those that use hydrocarbon polymers e. g. poly urethane. Inorganic insulation involves calcium/siliceous/aluminous materials that are in fibrous, powder or granular forms. Examples are calcium silicate, mineral wool etc.

Properties of the most commonly used insulation materials are:

Calcium silicate: it is used in industrial plant piping where there is high temperature and where compressive strength is vital. The range of temperature is 40 C to 950 C.

Glass mineral wool: good for acoustic and thermal insulation for chilling and heating system pipelines. The temperature range is -10 to 500 C

Thermopolis: they are mostly used in cold insulation piping.

Expanded nitrile rubber: it is used in the insulation of ducts that are used in air conditioning.

Rock mineral wool: they have good thermal insulation provides acoustic insulation and they are fire retardant.

The thermal conductivity of a material is defined as the heat loss per unit area per unit insulation thickness per unit temperature difference. The thermal conductivity of a material usually increases with the increase in temperature.

Calcium silicate is suitable for this insulation since it has a low thermal conductivity and can be used in high temperature areas (Turner, William).

Thickness calculation

This is the thickness at which the cost of insulating the pipeline is minimal; it can be calculated from the first principle.

The heat lost from a given surface is given by the following formula

H = h × A × (TH-Ta)

Where

H = heat loss, Btu/h

h = coefficient of heat transfer

Ta = average surrounding temperature, oF

TH = the temperature of the hot fluid flowing through the pipe

TVs = the desired surface temperature after insulation

The heat transfer coefficient for the horizontal pipelines is given by;

h = (A+0. 005(THz-Ta)) × 10

h = (0. 32+0. 005(204-25)) × 10

= 12. 17

Tm = Th+Ts2

Let the desired temperature after insulation be 125. 6 oF

Tm = 400+125. 62 = 262. 8 oF

K= the thermal conductivity of the insulating material at mean temperature, Tm

r1 = outer pipe radius

r2 = r1 + to

RS = thermal resistance of the pipe = 1h = 112. 17 = 0. 0822

R1 = thermal resistance of insulation = tkk

The flow of heat from the surface of the pipe and the surrounding can be given as

H = heat flow

= Th-TaR1+RS = TS-TaRs

= 400-125. 6R1+0. 0822 = 125. 6-770. 0822

48. 6R1 +3. 995 = 22. 56

R1 = 0. 382

The thermal conductivity is 0. 05W/mK = 0. 028895Btu/ft. h. oF

Therefore to = 0382 × 0. 028895 = 0. 01104ft

0. 13245 inch

Comparison of the cost of energy loss of insulated and bare pipeline

Calculations

The heat transfer surface coefficient of the bare surface, h = (0. 32+0.

005(204-25)) × 10

= 12. 65 W/m2 0C

The heat transfer surface coefficient of the insulated surface, h’ = (0. 32+0.

005(52-25)) × 10

= 4. 55W/m2 0C

The total heat loss from the bare surface, Q = h × A × (TH-Ta)

= 12. 65 × 4. 788 × (400-25)

22. 713KW

Cost of the energy lost = 22. 713 × 8000

= 181, 704 kWh/year

The total heat loss from the insulated surface, Q’ = h’ × A’ × (Tm-Ta)

= 4. 55 × (128-25) × 8. 568

= 4. 012 KW

Cost of the energy lost = 4. 012 × 8000

= 32, 096 kWh/year

Power that is saved by providing insulation, P = Q- Q'= 22. 713-4. 012 = 18. 70KW

Annual working hours = 8000 hrs.

Hence the total energy saved after providing insulation, E = P × n

= 18. 7 × 8000

= 149, 608 kWh/year

Compare energy cost reductions based upon a gas fired boiler and a fuel oil fired boiler. Assume boiler energy input at 6. 5(106) Btu/hr.

The type of boiler used is very important in determining the overall cost of the energy generated. Different types of boilers use various types of fuel depending on how they are designed. This gives rise to varying cost of the energy produced by the different type of boilers. The most commonly used type of boilers is gas fired and coal fired boilers (Stith, Theodore Brevik).

The gas fired boiler has many disadvantages that reduce the overall cost of energy. These advantages include;

There is reduction in oil deliveries

Reduced exposure from the oil spills.

There is reduction in the cost of labor involved in handling of the fuel.

The damaged that are likely to be caused to screen house are greatly reduced

The annual maintenance cost and the cost of operating the boiler is reduced,

the heating costs and storage tank costs are also low in gas fired boiler.

Many reasons exist on why there might be need to change the type of fuel used, some of these reasons are;

Need to reduce the amount of emission to the atmosphere.

Need to have a cheaper type of fuel in order to reduce the total cost involved in generating the energy.

Replacing an older boiler with a new one that runs on a different type of fuel, Recommendation by the consultant and scarcity of the fuel which leads to search for alternative fuel. The overall objective is to cut down the expenses involved in the generation of steam and the general reduction of energy consumption. To arrive on the decision on what type of fuel is to be used careful analysis of the positive and negative effects of the each type of fuel need to be done.

Assessment of cost/benefit of a fuel

The following steps are followed in assessing the cost/benefit of a fuel.

The present cost of steam in Baht/ton is calculated using cost calculator for steam.

Other possible side effects of the new fuel that may be important in justifying the use of the new fuel are looked into in detail.

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