International Journal of Engineering & Technology, 7 (3.34) (2018) 118-121

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Analysis of Energy Loss through Conventional Refractory Lining in Refinery Heater and its Conservation Measures

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Abstract

The work of this project is to analyze theinsulation materials currently used in the furnace of CPCL refinery which is a crude distillation unit heater to minimize the heat loss through the radiant wall section by substituting them with advanced insulating materials.
There are some advanced materials whose properties are well suited for the insulation purpose in the furnace wall which could apparently reduce the heat loss through the walls. The general properties which include weight, thickness, thermal conductivity, are calculated to prove that these materials can be used as a replacement to those of the regular insulation materials.
The materials which have been taken for analysis can reduce heat loss and improve thermal efficiency it will not require much maintenance activities compared to the old insulation and installing the new insulation is much easier than old as it can be handled easily.This paper will prove that replaced materials will act as an effective insulation than old type.

Keywords:*Vaporizing carburetor, Fuel blends, adiabatic vaporization, diffuser, Charcoal, limestone.*

1. Introduction

The device which has been analysed is crude distillation unit heater which is simply a furnace. This furnace is used to attain higher temperature (for industrial purpose) above 600 degree celsius which is used to heat the crude for distillation purpose
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The aim here is to solve a problem which has occurred in insulation of cdu heater which is increase in heat loss by effect in insulation so to reduce the heat loss occurred various materials have been taken account in to our analysis which is given by theoretical values. The thermal analysis is also have been taken out through ansys software and the result have been analysed.

2. Experimentation

Existing Methodology

Lining At Floor to Sidewall Junction Of An Cdu-Ii Heater Of Cpcl Refinery

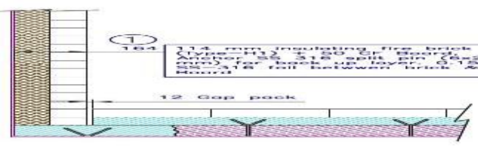

Fig.1: Lining at Floor to Sidewall Problems Faced Due To The Loss Of Heat

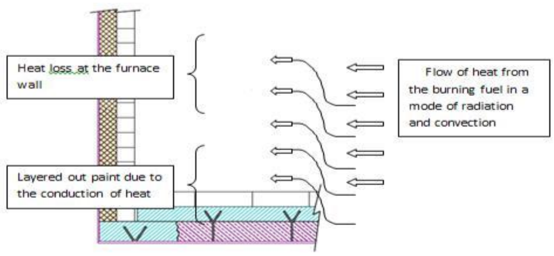

Fig.2: Heat Loss At furnace Wall

2.1Theoritial Temperature Distribution

Heat produced by convection at radiant wall = 550.20 W/m2
Heat produced b radiation at radiant wall= 290.14 W/m2
Total heat produced radiant wall =840.33 W/m^2

Table1: Properties of Existing Insulation

Insulation	Thermal	Thickness	Weight
material	conductivity		
	(w/m.k)	(mm)	Kg/m3
H1			
insulation	0.3800	115	115
brick			
Ceramic	0.0802	50	16
fibre board			

Rate of heat transfer Q = (k.ΔT) / L ...W/m2

Temperature at outer layer of ins.brick or inner

layer of ceramic board(T2)	
840.33 = 0.38 × (T1 – T2)/ 115 × 10-3	
(T1 – T2) = 254.31	[Given T1 = 850° c
850 – T2 = 254.31	k1 = 0.38 W/m.k
T2 = 595.69 °c	Q = 840.33 W/m2]

Temperature at outer layer of ceramic board (T3)		
840.33	= 0.0802 × (T2 – T3)/ 50 × 10-3	
595.69	–T3 = 523.8	[where T2 = 595.68° c]

T3 = 71.78° c

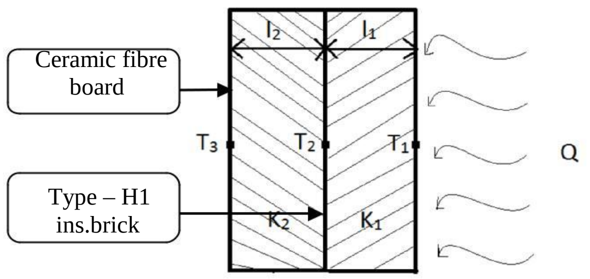

Fig.3: Temperature distribution at existing insulation

Temperature distribution at mild steel is not needed as it does not plays any role in insulation and but for accurate analysis it is calculated.

Temperature At Mild Steel Plate T4
840.33 = 0.15 × (T3 – T4)/ L3

840.33 = 0.15 × (71.78 – T4)/ 25 × 10-3 T4= 68.27° c

Calculating Theoretical Equivalent Thermal Conductivity (Keq)
Equivalent length is 190mm (including MS shield) and theoretical heat transfer value is 840.33 W/m2
Q = [(T1 – T4) ×k eq] / leq
478.63 = [(850 – 68.27) × keq] / 190 × 10-3;Keq = 0.1163 W/m.k

2.2 Heat Transfer

$$Q = \frac{(T1 - T3)}{\left(\frac{L1}{K1} + \frac{L2}{K2}\right)}$$

Where Q = Heat transfer
L1 ,L2 = Thickness of the insulating material w.r.t first and second material

K1 , k2 = Thermal conductivity of insulating material w.r.t first and second material

$$Q = \frac{(500 - 56)}{\left(\frac{115\times10\text{-}3}{0.38} + \frac{50\times10\text{-}3}{0.0802}\right)}$$

Q = 478.63 W/m2 is the heat transfer value from existing insulation

The value of Q obtained is considered as constant (or) constantly acting on the inner wall of insulation for the measured practical temperature values.
We observed the different temperature regions on the same outer wall of furnace due to some internal defects in the insulation. So keq has different values on the same outer wall and these are calculated by considering the values of Q and L as constant.

2.3 Calculating the Equivalent Thermal Conductivity (Keq)

When outer wall temperature is 56(° c)
Equivalent length = 190mm
Q = 478.6 W / m2SS
Q = [(T1 – T3) ×k eq] / leq
478.63 = [(500– 56) ×k eq] / 190 ×10-3
Keq= 0.1778 W/ m.k

Calculating the equivalent thermal conductivity (Keq)

When outer wall temperature is 88(° c)
Equivalent length = 190mm
Q = 478.6 W / m2
Q = [(T1 – T3) ×k eq] / leq
478.63 = [(500– 88) ×k eq] / 190 ×10-3 Keq=0.1916 W/ m.k
Comparing theoretical and practical values,

Table 2: Thermal Conductivities

Unit	Theoritical	Practical	
	Keq (w/m.k)	At 56° c	At 88° c
Eqvivalent thermal conductivity Keq	0.1163	0.1778	0.1916

From the above table, we observed that the theoretical equivalent thermal conductivity is almost equal to the practical equivalent thermal conductivity (outer temp. Of 56° c).So, the assumptions we made that the temperature at non eroded region is considered as ideal temperature in calculation of practical heat flow is meant to proven as a true assumption.
Also, that the theoretical equivalent thermal conductivity is not equal to the practical equivalent thermal conductivity (outer temp. Of 88° c). So , the thermal conductivity gives a slight variation in that region.
Causes for change of thermal conductivity
The replacement of burners show a rich effect on the of radiant walls due to increase in pressure, which results in cracking of the insulated bricks . While replacing or undergoing maintainace of the furnace , there might be a chance of production of shocks and vibration which results in the damaging of insulation.

2.4 Practically Measured Temperatures

Table.3: Measured Temperatures

Sl.No.	Location	Temperature (° c)			Tavg (° c)
		TA	TB	TC	
1.	Non-eroded region of outer wall	58	54	56	56
2.	Eroded region of outer wall	88	90	86	88
3.	Inner wall	520	480	500	500

2.5 Temperature Distribution

CERAMIC FIBRE HT MO + FIBRE GLASS

Table.4.1: Thermal Properties Of Cf+Fg

Sl.no.	Material	Density	Thermal	Withstand
		(kg / m3)	conductivity	Temperature(°
			(W/m.k)	c)
	Ceramic			
1	fibre	180	0.1430	2100
	Fibre			
2	glass	1522.4	0.04	1400

Table.4.2: Mechanical Properties of Ceramic Fibre+Fibre Glass

Sl.No	Material	Thickness (mm)	Weight (kg/ m2)
	Ceramic		
1	fibre	20	16
	fibre		
2	glass	32	20
	(s–type)		
3	Total	52	36

Q = [(T1 – T2) ×k1] /l1 Where k1 = 0.1430 W/m.k 840.3 = 0.143×(850 –T2) / 20×10-3 l1 = 20mm
T2= 733° c

Q = [(T2 – T3) ×k2] / l2 Where k2 = 0.04 W/m.k
840.3 = 0.04×(733 –T3) / 32×10-3 l2 = 32mm
T3 = 61° c

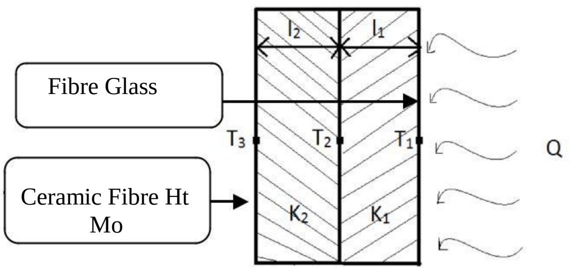

Fig. 4: Temp Distribution in New Insulation

If Mild Steel Shielding Is Considered
840.3=0.15× (61-T4)/25×10-3 where k3= 0.15 W/m.k
T4= 51.04 l3 = 25mm
SILICA AEROGEL
Calculating Temperature Distribution:
Q = [(T1 – T2) ×k1] / l1 3 Where k1 = 0.1430 W/m.k
840.3 = 0.143×(850 –T2) / 20×10-3 l1 = 20mm
T2 = 733° c
Q = [(T2 – T3) ×k2] / l2
840.3 = 0.04×(733 –T3) / 32×10-3 l2 = 32mm
T3 = 61° c

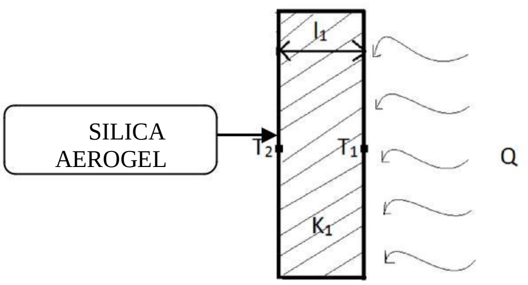

Fig.5: Temperature Distribution at Silica Aerogel

If Mild Steel Shielding Is Considered
840.3=0.15×(61-T4)/25×10-3 where k3= 0.15 W/m.k
T4= 51.04 l3 = 25mm

2.6 Thermal Analysis

2.6.1 Existing Insulation

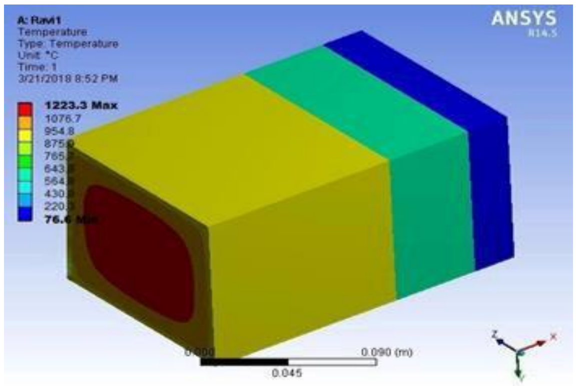

Fig. 6: Ansys workbench 14.5 Report On Old Insulation

2.6.2 Materials:

Type h1 insulation brick	:	115mm
Ceramic fibre board	:	50mm
Mild steel plate	:	25mm

2.6.3 New Insulation

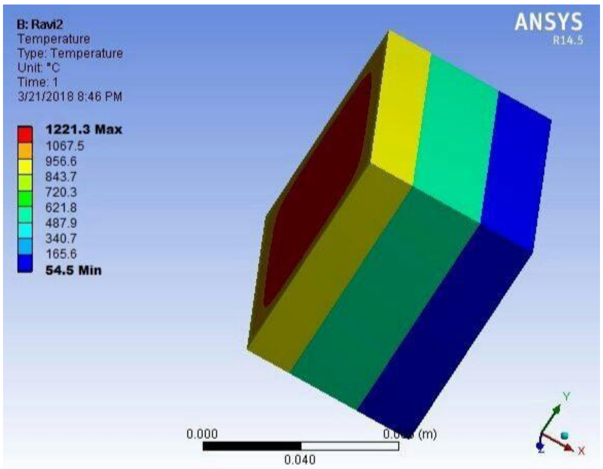

Fig.7: Ansys workbench 14.5 report on new insulation

MATERIALS:			
Ceramic fibre board htmo		:	20 mm
fibre glass	(s-type)	:	32 mm
mild steel plate		:	25 m

3. Result and Discussion

3.1 Result from Theoretical Temperature Distribution Calculation

Sl.No.		Area		Wall insulation
				(unit °c)
1		Inner wall	t1	
				850
2		Outer wall t2		
				595.69
3		Inner layer of cf		

		board		71.78
4		Outer layer of		
		ms plate		68.27
Area		Ceramic fibre + fibre glass		
				(unit °c)
Inner layer of				
fibre glass t1			850	
Outer layer of				
fibre glass t2			733	
Outer layer of				
ceramic fibre			61	
board t3				
Outer layer of				
ms plate t4			51.04	

The above given values results that ceramic fibre + fibre glass insulation will give low heat loss and have good thermal properties where from the inner layer temperature of 850°c shorts down to 68.27°c where the advanced insulation material of ceramic fibre board with fibre glass shorts down up to 51.04°c this shows that new insulation will reduce a good amount of heat loss.

3.2 Result from Ansys

Table.6: Temperature Values From Ansys

Sl.no.	Old insulation	New insulation
	°c	°c
T1	1223.3	1223.3
T2	1095.5	1067.7
T3	976.6	956.6
T4	875.9	843.7
T5	765.7	720.3
T6	643.9	621.8
T7	564.8	487.9
T8	430.9	340.2
T9	220.3	165.6
T10	82.2	54.5

The above given details about temperature distribution chart which is resulted from thermal analysis using ansys software where it starts from the maximum temperature 1223.3°c and at final stage the old insulation which consists of radiant wall insulation gives 76.6°c and the new insulation material discussed results 54.5°c

From the observation of both the results new insulation is very much needed for replacement of old type in CDU HEATER II , CPCL as it gives good thermal efficiency and reduction in heat loss.

4. Conclusion

The at present insulation is not effective as the heat loss through radiation is very high and the outer layer of the insulation shield plate is also eroded along with paint peeling so, The analysis which has been done will give thermals efficiency by minimization of heat loss through the insulation materials accounted for theoretical analysis which has resulted low heat loss and it has also been analysed in ansys 14.0 workbench software which also gives positive result as there is minimization of heat loss up to 20° c.

This insulation maybe at high cost but the life and durability will be good compared with the present insulation setup maintenance work is also easy with new insulation materials and the weight is also very low where we can install at very ease manner.

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