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Design And Development of Waste Heat Recovery In Furnaces

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Abstract: *In the present era of fastly growing technology, Engineers are looking towards the Non-Conventional energy sources. This is because of deplication level of conventional energy sources. Humans are consuming the conventional resources with a rapid acceleration. He uses land, wind, water, mineral, etc. in every task. Moreover, on other hand the rate of pollution is also rising due to these reasons. Controlling wastage in daily life can control this.In industries there are several applications in which there is huge amount of wastage of energy. Wastage of energy means wastage of resources and increase in pollution. Thermal systems have working efficiency of not more than 20% to 30%. This is because of wastages taking place in systems in form of heat. This waste heat can be recovered by different methods. For example condensers used in thermal power plants in condenses in condenser and makes preheated feed water to feed to boilers and thus increases the efficiency of power plant. In this project paper, the heat wasting out in from of flue gases will be captured and reused to increase the thermal efficiency of the furnaces. Thus this project will help in pollution control as well as conserving the conventional fuels also.*

Keywords *: Furnances, Waste Heat,Recovery,*

I. Introduction

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then "dumped" into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its "value". The strategy of how to recover this heat depends in part on the temperature of the waste heat gases and the economics involved. Large quantity of hot flue gases is generated from Boilers, Kilns, Ovens and Furnaces. If some of this waste heat could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered[1].

Here we are trying to minimize the energy losses by reusing the waste heat in industrial furnaces. Depending upon the type of process, waste heat can be rejected at virtually any temperature from that of chilled cooling water to high temperature waste gases from an industrial furnace or kiln[2]. Usually higher the temperature, higher the quality and more cost effective is the heat recovery[3]. In any study of waste heat recovery, it is absolutely necessary that there should be some use for the recovered heat[4]. Typical examples of use would be preheating of combustion air, space heating, or pre-heating boiler feed water or process water. With high temperature heat recovery, a cascade system of waste heat recovery may be practiced to ensure that the maximum amount of heat is recovered at the highest potential[5].

Thus this project will serve the nature by reducing the wastage of conventional energy sources.

II. Ease of Use

1.1.Furnaces.

Definition: -

A furnace is an equipment to melt metals for casting or heat materials for change of shape (rolling, foring etc) or change of properties (heat treatment).

1.2 Types and Classification of Different Furnaces.

Based on the method of generating heat, furnaces are broadly classified into two types namely combustion type (using fuels) and electric type. In case of combustion type furnace, depending upon the kind of combustion, it can be broadly classified as oil fired, coal fired or gas fired. Based on the mode of charging of material furnaces can be classified as (i) Intermittent or Batch type furnace or Periodical furnace and (ii) Continuous furnace. Based on mode of waste heat recovery as recuperative and regenerative furnaces. Another type of furnace classification is made based on mode of heat transfer, mode of charging and mode of heat recovery as shown in

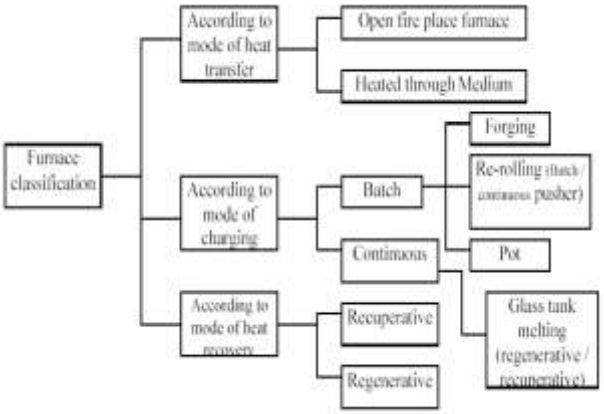


Fig:1.1

2.1 Types of Wastages in Furnaces.

- Heat Loss in Flue Gas.
- Loss Due to Evaporation of Moisture Present in Fuel.
- Loss Due to Evaporation of Water Formed due to Hydrogen in Fuel.
- Heat Loss due to Openings.

III. Commercial Waste Heat Recovery Devices

3.1 Recuperators.

In a recuperator, heat exchange takes place between the flue gases and the air through metallic or ceramic walls. Duct or tubes carry the air for combustion to be preheated, the other side contains the waste heat stream. A recuperator for recovering waste heat from flue gases is shown in

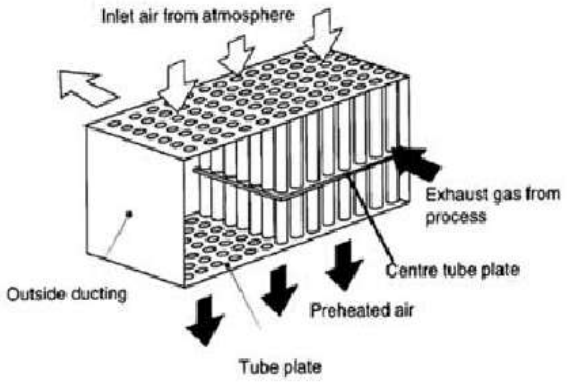


Fig:1.2

3.2Heat Wheels

A heat wheel is finding increasing applications in low to medium temperature waste heat recovery systems. Figure 2.3 is a sketch illustrating the application of a heat wheel. It is a sizable porous disk, fabricated with material having a fairly high heat capacity, which rotates between two side-by-side ducts: one a cold gas duct, the other a hot gas duct. The axis of the disk is located parallel to, and on the partition between, the two ducts. As the disk slowly rotates, sensible heat (moisture that contains latent heat) is transferred to the disk by the hot air and, as the disk rotates, from the disk to the cold air. The overall efficiency of sensible heat transfer for this kind of regenerator can be as high as 85 percent. Heat wheels have been built as large as 21 meters in diameter with air capacities up to 1130 m^3 / min.

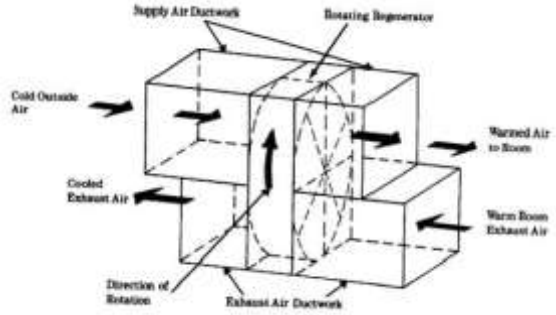


Fig:1.3

Every project has to follow the path of crosscheck the failure possibilities, which is called as designing. While designing the heat recovery system for the furnaces, the following consideration are made: -

1. The system should be designed according to the furnace.
2. The system should be portable so that roadside smithy shop should be able to use that.
3. The system should response like an industrial furnace.

According to all the above consideration, it is being decided that the heat recovery unit will mounted on the scaled working model of the furnace. Now the designing can be divided into following parts: -

1. Designing the furnace.
2. Designing the heat recovery system.
3. Designing the miscellaneous parts.

3.3 Designing the furnace.

The project is mainly for the heat recovery systems for furnaces so it is decided to build a scaled furnace, which is a photocopy of a hearth furnace present in our college's smithy shop. So the parameters like length, width etc is taken 1/6th of the original furnace. The thicknesses of the pillars, walls hearth etc are take nearly same that of original to avoid unwanted accidents. Blower is taken $1/7^{th}$ of the original capacity because coal requires excess air for burning.

3.4 Designing Of Heat Recovery Unit.

As the height of the chimney calculated is of three feet's, the height of heat recovery jacket and heat sinks is taken two feet's. The chimney is manufactured from the square aluminum channel because it is good conductor of heat so it will transfer the heat rapidly to the fresh air available in the jacket. Similarly the heat sinks are also manufactured from the aluminum 'I' section, which does not make contact with the outer wall of the heat recovery unit. The fig shows the details of the project. The outer wall is made of asbestos sheet to minimize losses.

3.5 Designing of miscellaneous parts.

After confirming all the arrangements and assembly of heat recovery unit the miscellaneous parts like mountings of temperature gauge, Tap valves etc are made one the back wall of the furnace.

Thus the heat recovery unit and arrangements for analysis for change in the efficiency of the furnace is made and thus the designing part of the project is completed. The following figures show the details of the project.

IV. Block Diagram Of Heat Recovery Unit

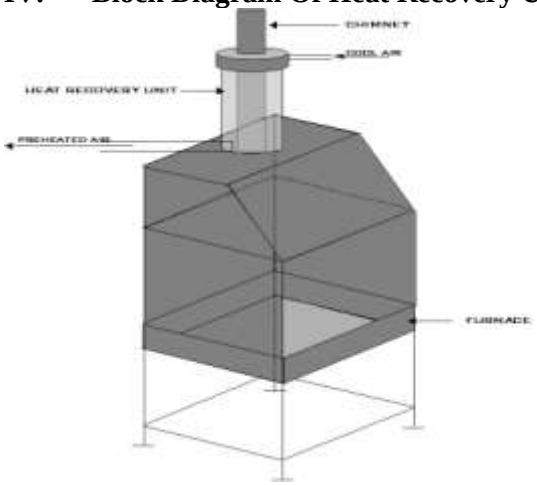


Fig:1.4

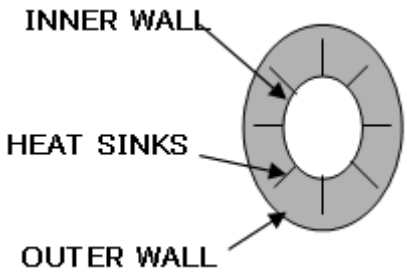


Fig:1.5

5.1 Block Diagram Of System

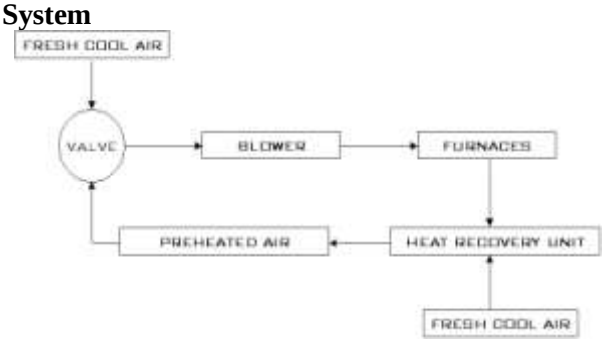


Fig:1.6

For Testing following points are considered: -

1. A Billet of 1kg mild steel is taken.
2. Flue gas temperature is taken.
3. Intel air temperature is taken.
4. Readings are taken after every 5 minutes, so the furnace stabilizing time can be calculated.
5. Billet is heated up to Red hot i.e. temperature of Billet is maintained constant up 1080-1090.
6. Coal input & output quantity is measured.

1) Procedure: -

To verify the heat recovered by heat recovery system, Testing is carried out in two places as follows: -

1. Bypassing the heat recovery system
2. With heat recovery system

2) STEP

1. A charge of 1kg coal is fired.
2. A Billet of 5kg mild steel is placed.
3. Exhaust flew gas temperature is measured.
4. Billet is heated up till it turns red hot
5. As the temperature starts falling down the charge is removed of weighted.

The following table describes the testing results: -

Testing Without heat recovery unit

Table:1.1

Time	Exhaust Flue Gas Temperature (Degree Celsius)		
	Testing – 1	Testing 2	Testing 3
5	80	82	80
10	90	94	88
15	120	120	122
20	180	176	182
25	250	248	252
30	330	334	328
35	335	335	338
40	285	282	288
45	215	220	218
50	150	160	155
Coal recovered (kg)	0.130	0.150	0.140
Inlet Air Temp. (Degree Celsius)	30	30	30

-Thermal Efficiency of Furnace

=18.3139 %

-Heat Lost in Flue Gases

= 6991.497 Kcal/hr

Testing with heat Recovery Unit

Table:1.2

Time	Testing – 1		Testing – 2		Testing - 3		
	E.T	I.T	E.T	I.T	E.T	I.T	
5	130	50	125	48	134	52	
10	160	58	160	55	162	60	
15	180	60	185	62	184	62	
20	190	66	195	68	192	70	
25	220	80	222	78	224	80	
30	250	86	250	84	252	84	
35	250	80	252	84	254	86	
40		250	72	248	70	250	70
45		210	70	218	68	220	65
50		150	64	165	64	160	62
Coal Recovered (Kg)		0.320		0.325	0.322		

-Thermal Efficiency of Furnace with heat recovery unit

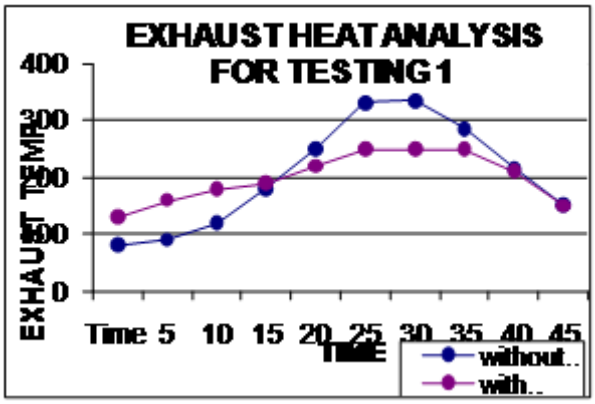
= 23.33 %

- Heat lost in flue gases= 5088.893 Kcal/hr

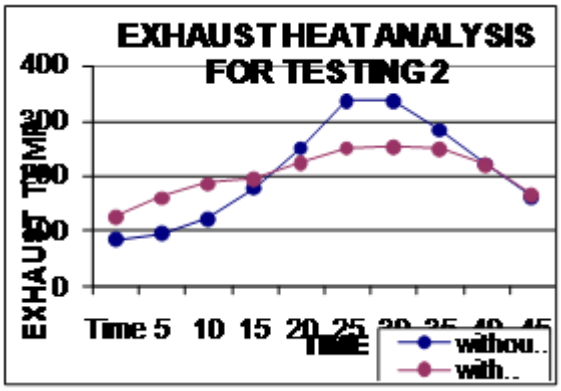
- Heat recovered from flue gases = 27.2131 %

Further studying the following graphs carries on more testing and advantages of the heat recovery unit, which are not calculated: -

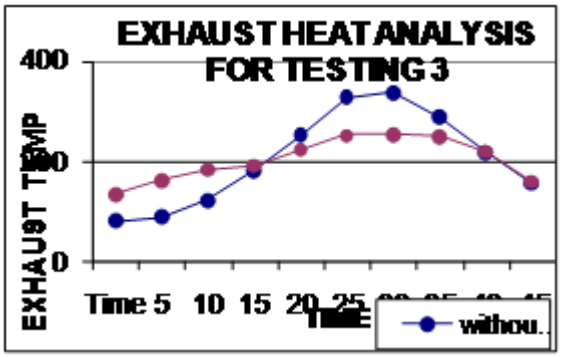
GRAPH – 1.1



GRAPH – 1.2



GRAPH – 1.3



By studying the above graph it is found that
The platoon of furnace stabilization increases by application of heat recovery unit.
The heat required for warming of furnace components is saved.
Thus: - the efficiency of furnace used increases by 5.02 % with application of heat recovery unit, The heat recovery unit recovers 27.2131 % of waste heat going waste in the form of flue gases.

Result: As the testing was carried out on scaled working furnace. It is found that he efficiency of the furnace increased by approximately 6% by the application of waste heat recovery system. This increase in efficiency reduces coal consumption rate.

V. Conclusion

1. Due to heat recovery system the efficiency of furnace increases by Approximately 5.02%.
2. Rate of coal consumption reduces.
3. Applying insulating material like asbestos sheet etc can reduce Heat loss due to walls.
4. Heat recovery system works more efficient by the application of insulating material on outer walls.
5. The flue gas from chimney does not mix with the preheated air input.
6. Proper oxidation of charge takes place.
7. Pollution & global warming problem reduces as the combustion rate reduces. The heat recovery system design is easy to implement.

References

[1]. Zhang H, Wang H, Zhu X, Qiu YJ, Li K, Chen R, et al. A review of waste heatrecovery technologies towards molten slag in steel industry. ApplEnergy2013;112:956e66.https://doi.org/10.1016/j.apenergy.2013.02.019.

[2]. RobertoPilia,AlessandroRomagnolib,HartmutSpliethoffa,ChristopWieland. Techno-Economic Analysis of Waste Heat Recovery with ORC from Fluctuating Industrial Sources. Energy Procedia 129 (2017)503–510

[3]. Hussam Jouharaa, Sulaiman Almahmoud,Amisha Chauhan, Bertrand Delpech, Giuseppe Bianchi, Savvas A. Tassou, Rocio Llera, Francisco Lago, Juan Jos Arribas. Experimental and theoretical investigation of aflat heat pipe heatexchanger for waste heat recovery in the steel industry. Energy 141 (2017) 19281939

[4]. A. M. Pantaleo, J.Fordham, O. A. Oyewunmi, C. N. Markides. Intermittent waste heat recoveryvia ORC in coffee torrefaction,Energy Procedia 142(2017) 1714-1720

[5]. M. Ramirez,M. Epelde, M. Gomez de Arteche, A. Panizza, A. Hammerschmid, M. Baresi, N.Monti,Performance evaluation of an ORC unit integrated to a waste heat recovery system in a steel mill