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Design And Case Study Of Combustion Of Muncipal Solid Waste And Refuse-Derived (Msw And Rdf) With Conventional Fuels

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Abstract:
Energy Production for used materials can be performed as mixed municipal solid waste (MSW) incineration or as fuel for combustion. Recovered fuels are refuse-derived fuel (RDF), which is mechanically separated and processed from MSW.which is the source-separated, processed, dry combustable part of MSW. A one-year combustion of RDF with peat and coal was carried out in a 25 MW garbage boiler gratepower plant. The efficiency of the combustion temperature, boiler efficiency and the corrosion behaviour of the boiler were particular focuses of attention in this study. The combustion calculations and the MSW boiler design is carried out for three different cases in which combustion temperature is varied from 850°C to 950°C and fuel HHV varying from 1500 to 2500 Kcal/kg in the same power plant.. All RDF performed technically well and the emissions were low. Small particle size and stable feeding of RDF were important for effective combustion. Low CO emissions showed clean and efficient combustion. SO2emissions decreased, because part of the coal was replaced by RDF. HCl emissions increased when the chlorine content of the fuel mixture increased, because limestone injection was not used. Heavy metals concentrated to the fly ash in unreachable form.. Long-term co-combustion of 10% RDF with peat and coal did not cause any high temperature chlorine-induced corrosion of the super heater materials (420°C). The results showed that it is useful and technically possible to combustion temperature and boiler efficiency varies in the form of energy production in the normal power plants

Keywords: Co-combustion; energy recovery; refuse-derived fuel(RDF);Waste disposal; emissions;boiler corrosion.

I. INTRODUCTION

Processing of Municipal Solid Waste to generate energy is an emerging technology which incorporates a wide variety of diversity of systems designed both for processing of solid waste as well the combustion of the same.

Traditionally two technologies have been used for the combustion, (a) MSW mass burning and(b) RDF firing. The technologies are distinguished by the degree of preparation the refuse undergoes before it is fed into the boiler.

(a) In MSW burning, the garbage is burnt in as-received and un-prepared state. Only large or non-combustible items such as free stumps, discarded appliances and other bulky items are removed.

(b) In RDF firing process, the garbage / MSW received is separated, classified and reclaimed in various ways to yield high calorific value fuel - RDF in Fluff / Pellet from RDF can be burnt without auxiliary fuel support, hence economical also.

I. REFUSE COMBUSTION ALTERNATIVES:

In mass burn technology, the MSW is burnt in its as-received, unprepared state. Only large or non-combustible items such as tree slumps, discarded appliances and other bulky items are removed. The MSW is stored in a large pit and overhead cranes equipped with grapples move the MSW from the pit into the stoker charging hopper. Hydraulic rams in the charging hopper move the refuse from the charging hopper onto the reciprocating grate stoker. The combustibleportionofthe refuse is burned while the non-combustible portion travels along the grate and drops into the ash handling system for reclamation or disposal.

The second burning technique uses processed refuse or refuse derived fuel (RDF), where the as-received refuse is first separated, classified and reclaimed in various ways to yield salable or otherwise recyclable products. The remaining refuse material is then shredded into a relatively uniform fuel known as RDF. The RDF is conveyed from a storage building to the boiler and fed through multiple feeders onto a travelling grate stoker. The RDF is burned partially in suspension and partially on the grate.

II. RDF COMBUSTION TECHNOLOGY:

RDF combustion technology was developed in North America by B&W in the early 1970s as an alternative to the mass burning method. The use of RDF combustion technology requires a rather significant investment in an RDF processing facility as well as the operating and maintenance expenses that arc associated with this facility. The benefit received for this investment is the ability to use RDF rather than MSW as a boiler fuel.

RDF is a much more uniform fuel than MSW with regard to fuel particle sizing and heating value resulting in a more efficient combustion process. In addition, a majority of the non-combustible material is removed from the RDF before the fuel is fed into the boiler which reduces the size of both the fuel and ash handling systems. These fuel characteristics result in a RDF boiler system which is generally less expensive than a mass- burn system, thereby offsetting the cost of the RDF processing equipment.

But the combustion of RDF poses its own set of unique problems to a boiler designer in the following areas, which can be quite different from those encountered in a mass burn boiler system.

Fuel handling system, combustion, staging/fouling, Corrosion/Erosion.

The RDF fuel properties/characteristics influence the design features of the following boiler components.

Fuel feeder, Fuel spreader, Stoker, Furnace configuration, Corrosion protection in the heating surfaces

III. FUEL FIRING SYSTEM:

MSW fuel firing energy plant facilities are complex and regardless of size, hence the design, automatic control sophistication and construction. Materials handling, fuel feeding, ash removal, air pollution control and overall operating procedures are far more complicated than those of a similarly sized biomass based power plant. Special emphasis should be accorded to the fact that unlike biomass, and fossil fuels, waste derived fuel vary daily and seasonally in not only moisture, but also in composition and thus have fluctuating calorific value.

IV. FUEL FEED SYSTEM: METERING FEEDERS AND AIR- SWEPT FUEL SPOUTS:

The fuel feeding system is one of the most critical elements of a successful RDF-fired boiler. Virtually all RDF feeders are of the volumetric type. In order to satisfy a boiler heat input demand in a controlled manner, the feeder must be capable of varying the mass flow rate of the fuel while maintaining the uniform bulk density (i.e. uniform energy content per unit of volume) of the RDF. A successful RDF metering feeder must also provide liberal maintenance access to deal with pluggage problems due to oversized material, be maintainable in place, and be equipped with fire detection and suppression devices.

Multiple RDF metering feeders are used to provide side-to-side distribution of RDF onto the grate. One feeder is used for each air-swept fuel distributor spout. Each feeder has an upper feed bin which is kept full at all times by an overrunning conveyor to ensure a continuous fuel supply. The fuel in this hopper is transferred to a lower hopper by a hydraulic ram. The ram feed from the upper hopper is controlled by level control switches in the lower hopper. The RDF is fluffed into a uniform density by a variable speed inclined pan conveyor which tumbles the RDF in the lower hopper. The pan conveyor delivers a constant volume of RDF per flight which is carried up the pan conveyor and deposited into the air-swept spout. The rate at which the fuel is deposited into the spout is based on fuel demand.

Multiple fuel spouts are installed across the furnace front wall to provide a uniform side-to-side distribution of RDF on the grate. Front-to-rear distribution of the RDF onto the grate is accomplished by continuously varying the pressure of the air sweeping the floor of the fuel spout. A major feature of the fuel spout design is its simplicity.

V. STEAM CYCLE:

Like any other conventional power plant, the steam cycle works on Rankine cycle. The Boiler furnace is to be lined with membrane water walls and integrated with super heater. Super heated steam will be delivered to turbine at 420°C, 45 atm. to drive an alternator. As usual, a small portion of steam to be extracted for feed water heating. Exhaust steam shall be condensed and returned to the boiler feed water system, with the heat rejected to atmosphere in an induced draft cooling tower.

VI. BOILER CONFIGURATION:

A water tube boiler is a type of boiler in which water circulates in tubes heated externally by the fire. Water tube boilers are used for high-pressure boilers. Fuel is burned inside the furnace, creating hot gas which heats water in the steam-generating tubes. In smaller boilers, additional generating tubes are separate in the furnace, while larger utility boilers rely on the water-filled tubes that make up the walls of the furnace to generate steam.

The heated water then rises into the steam drum. Here, saturated steam is drawn off the top of the drum. In some services, the steam will reenter the furnace through a superheater to become superheated. Superheated steam is used to drive turbines. Since water droplets can severely damage turbine blades, steam is superheated higher to ensure that there is no water entrained in the steam.

Cool water at the bottom of the steam drum returns to the feed water drum via large-bore 'downcomer tubes', where it pre-heats the feed water supply. (In 'large utility boilers', the feed water is supplied to the steam drum and the down comers supply water to the bottom of the water walls). To increase economy of the boiler, exhaust gases are also used to pre-heat the air blown into the furnace and warm the feed water supply. Such water tube boilers in thermal power station are also called steam generating units. The layout of the MSW boiler is shown below:

II. OPERATING PROCEDURE

MSW BOILER DESIGN CALCULATIONS:

The combustion calculations and the MSW boiler design is carried out for three different cases in which combustion temperature is varied from 850°C to 950°C and fuel HHV varying from 1500 to 2500 Kcal/kg as given below.

COMBUSTION AIR ESTIMATION:

The combustion air constitutes primary and secondary air. to achieve a combustion air temperature of about 950°c, the primary air is injected at the bottom of the grate after it is preheated to about 250°c,by means of air preheater and steam preheater. the secondary air is injected into the boiler through the secondary nozzle on the top of the front/rear nose of the furnace.

The primary air is drawn by the FD fan and is transported into the common air chamber at the bottom of the grate and then goes into the furnace.The secondary air from the refuse pit is drawn through SA fan and is injected into the furnace through secondary air nozzle.

BY PERFORMING COMBUSTION CALCULATIONS FOR THE CHEMICAL REACTIONS GIVEN BELOW

$C + O_2 \rightarrow CO_2$

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$

$S + O_2 \rightarrow SO_2$

$$RBL = \frac{4 (ST \times SL - \pi/4do2) \times 0.85}{\pi\, do}$$

$$\text{Gas mass velocity (GMV)} = \frac{\text{Flue gas quantity}}{\text{Free gas area}}$$

Arrangement factor = FA = C RNE

Where RE = 195 X GMV (OD) (920 + LMTG + TS)-0.67

1/u = 1/RT + 1/hi (A2/A1) +hfi (A2/A1) + hfo (X/Km) in (A2/A1)

Heat released during combustion = m x HHV

The total energy input to produce combustion gases and for drying
= total heat input - heat lost in carbon - heat lost in ash

HHV of the MSW fuel as per Dulong’s formula and given fuel data

= 14544+62028 x (H2-O2/8) + 4050 x S Btu/lb

INPUT PARAMETERS:
Various input parameters are taken from the plant

PROXIMATE+ULTIMATE ANALYSIS OF FUEL

SI.NO	COMPOSITION	MSW
01	Carbon	18.24
02	Hydrogen	3.62
03	Nitrogen	0.32
04	Sulphur	0.17
05	Moisture	38.26
06	Ash	34.36
07	Oxygen	5.05
08	GCV Kcal/kg	2500

TABLE 1: PROXIMATE AND ULTIMATE ANALYSIS OF FUEL

III. RESULTS AND DISCUSSIONS:

CORROSION IN RDF BOILERS
Corrosion has several definitions. To simply say it is the gradual wear of a material. For purposes corrosion can be defined as a chemical or an electrochemical reaction between the material, usually a metal, and its surrounding environment which causes the gradual wear. It is a natural tendency of the material to corrode just to reach the lowest possible energy state like every other natural process
Corrosion in furnaces and super heaters see the fig(1):

Corrosion rate= Vk(2f1Cso2 + CHCI) X 10-6/Lmol X MFe/n X t/(A X sd)

Vk ventilation in boiler house
C concentration of SOZ and HCl in the boiler house, before the gasses dissolve in the condensed water (vppm);
Lmol amount of litres per mol
f1 fraction of SOZ that dissolves in the condensed water
MFe Molecular weight of Fe
n electron valency of Fe ion
t operation time
A surface in boiler house that is assumed to be corroded (mmZ); sd - specific density of steel.

The common type of corrosion which generally occurs in these cases is called Pitting Corrosion. This type is a highly localised form of corrosion and difficult to be detected in earlier stages. Every engineering metal or alloy is susceptible to pitting. Pitting occurs when one area of a metal becomes anodic with respect to the rest of the surface or when highly localized changes in the corrodent in contact with the metal, as in crevices, cause accelerated localized attack.
One more type is called the impingement. Steam erosion is a type of impingement it occurs when a jet of wet steam touches a metal surface at a high velocity this attack results in a roughened metal surface with the formation cones whose pointed edges face in the direction of flow.
Galvanic corrosion occurs when composite metals or alloys exist with a common electrolyte and conducting electric path but the driving force is the potential difference between the composite metals or alloys.
These being the types of corrosion the agents of corrosion are mainly
1 Hydrochlorides in the combustion gas
2. Chlorides of alkali metals which deposit on the surface. Under suitable conditions attack the metal surface by converting to corresponding reactive ions. Pitting Corrosion is mainly by these reactive chlorides
3. Low melting point chlorides like ZnCl2 and PbCl2 also attack at high temperatures in their ionic forms. Chloride ions being the corrodents and the metals get replaced by noble metals like Zn and Pb.
4. Finally the wet salts on the tube surface

In these three cases will studied about that For mass burning grates the primary air is to be injected from the bottom of the gate. The air usually passes through the block and then discharged usually through two ports at the front face of the grate. The purpose of this distribution is to perform two important functions, first, the air flow through the blocks and cools the grate metal to increases its life, second, the pressure loss through the grate block minimizes the short circuiting of air through the burning MSW bed. Prevention of short cutting of air reduces the probability if incomplete burnout CO-formation and boiler metal corrosion, while increasing efficiency of combustion.
Primary air is to be drawn from a FD fan through ducts under side of the grate system .Secondary air fan is meant for over fire air for the furnace. The secondary air injection is to be done in such a way that it must promote turbulence and complete the combustion of the volatiles distilled from the drying and combustion zones. The practice worldwide is, the combustion air is always drawn from the MSW storage pit area, thereby maintaining storage area under little negative pressure to prevent odours and dust.

The reason for higher combustion efficiency in the present study is due quantity of excess air supplied in this section.

Calculated on two different temperatures like 850 and 900deg centigrade and the graphs are shown between efficiency and primary air.

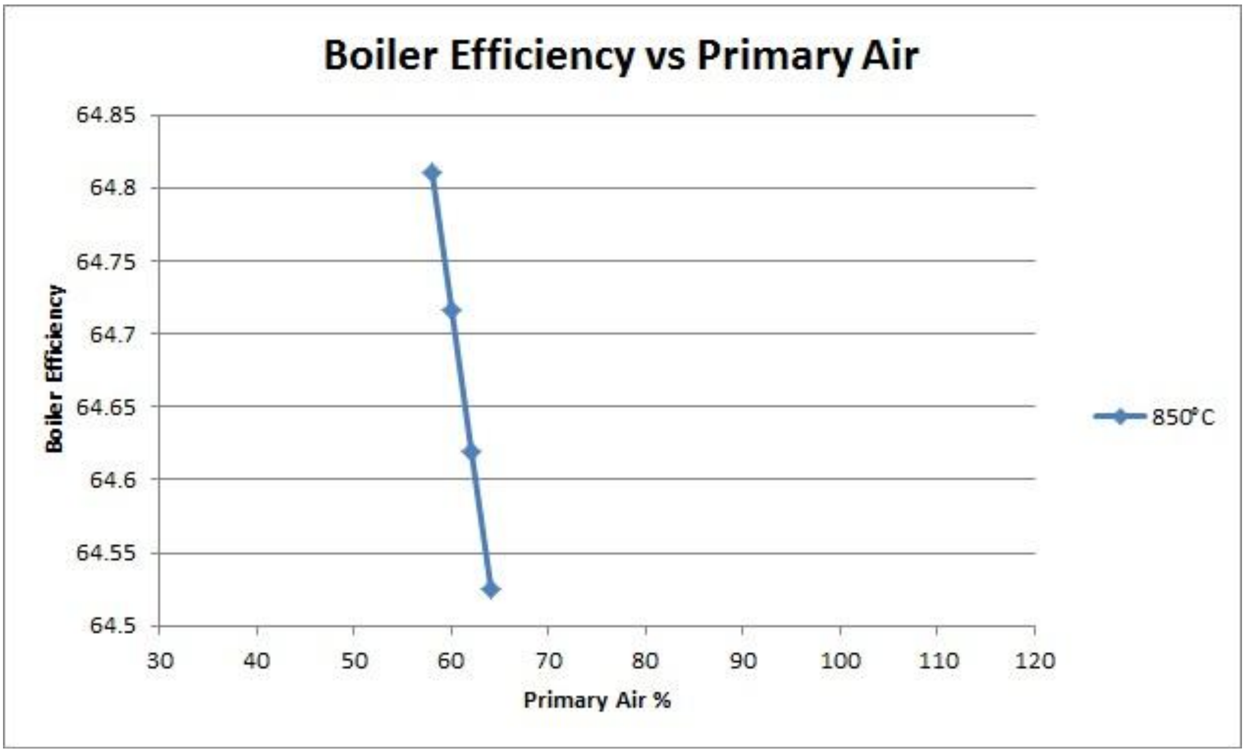

Fig: 1 Primary air vs Boiler efficiency for 850 deg C

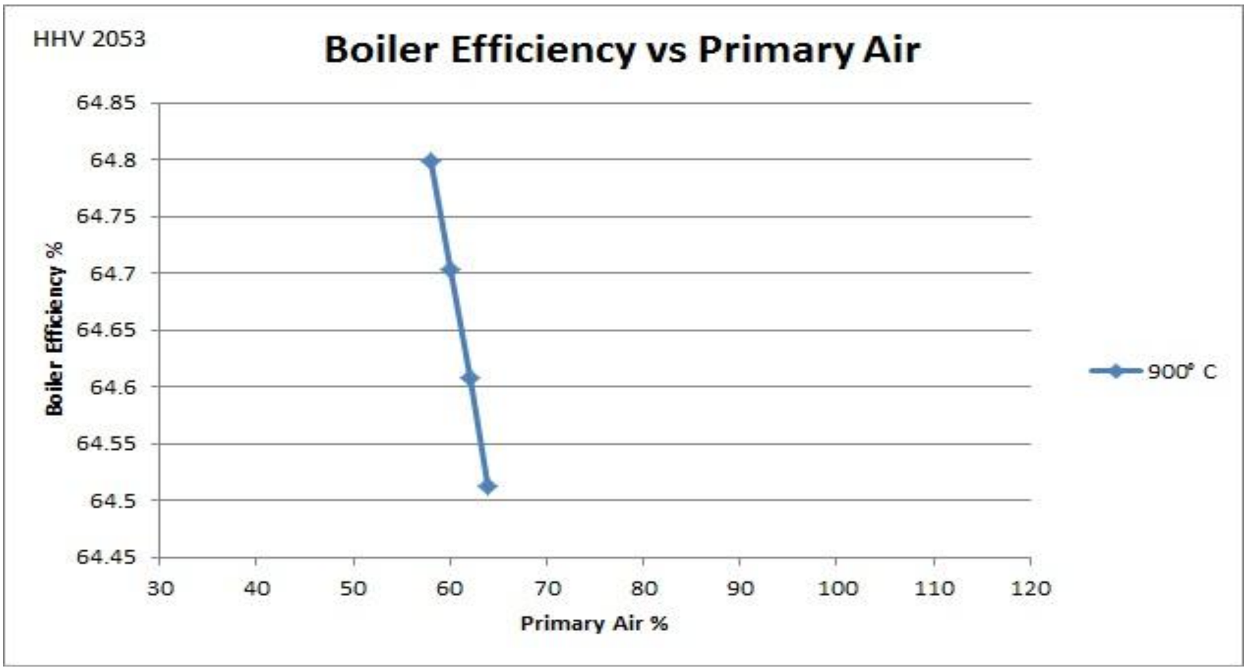

Fig: 2 Primary air vs Boiler efficiency for 900 deg C

IV. CONCLUSION

From This Work We Can Conclude That The boiler efficiencyIncreasesWith decrease In primary airboilerefficiencyDecreases With Increase In combustion Temperature, heating value Increases With Increase In boiler efficiencyAnd Almost Constant Temperature Throughout The Reactor. This process offers considerable energy recovery and reduces the emission of potential pollutants. It is considered an interesting alternative to the conventional technology for the thermal treatment of solid wastes.The grate assemble plays an important role in the gas–fuel mixing (and therefore biomass conversion) in the fuel bed as well as the control of overall excess air in the boiler. The key combustion temperature in the fuel bed on the grate is also discussed, which not only determines the release of heat and combustibles into the freeboard but also affects the release characteristics of the formation precursors of NOx, aerosol and ash particles. Advanced secondary air systems are widely used in modern grate-fired boilers in order to enhance the mixing and combustion in the freeboard, lower the pollutant emissions, and mitigate other operational problems (e.g., deposition and corrosion). Advanced secondary air systems may include air-staging for favourable combustion environment sequences and optimized SA jets for enhanced mixing, for example, using staggered SA jets, tangentially arranged SA jets, or static mixing devices to form local recirculation zones or rotating flow or to increase the jet penetration into the centre of the freeboard.

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Nomenclature

M.S.W	Municipal Solid Waste
R.D.F	Refused Derived Fuel
H.H.V	High Heating Value
G.C.V	Gross Calorific Value
N.C.V	Net Calorific Value
T.P.H	Tonne per Hour
U.B.C	Unburnt Carbon
Cp	Specific heat at constant pressure
A.P.H	Air Preheater
Ts	Saturation Temperature
M.W	Mega Watt
Lt	Thickness
Lb	breadth
Lh	height
fqua	Shape factor

Greek symbols

Pr. No	Prandtl number
Nu.no	Nusselt's number
Re. no	Reynold's number

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