FEASIBILITY OF 100 PERCENT RDF FIRING FOR POWER GENERATION

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Discussion by

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The title of the paper purports to discuss the feasibility of 100% RDF firing for power generation. It is implied that it is possible to fire 100% RDF in a single boiler. However, for the case study cited, the author suggests a much more elaborate system for a 16 MW system. The flow sheet suggests 80% heat input from RDF and 20% from coal. He also suggests that three boilers handle the RDF. This means each boiler fires 1475 lb/hr (9 tpd) of RDF and this should reflect 80% MCR in each boiler. In other words, each of the three units would be sized for $88.5 \times 10^6$ Btu/hr and the coal fired unit would be sized for $55 \times 10^6$ Btu/hr. If this is what the author intended, it is not a very cost effective design. There are ample references to previous papers in the proceedings of this conference that describe MSW and RDF power generating schemes. There are units operating here and abroad that generate more than 16 MW with heat inputs of fossil fuel of less than 20% and in most areas this is accomplished in a single waste fired or combined fired boiler. Some plants use coal for trimming but generally trimming is accomplished with pulverized coal firing.

The author states that “RDF-fired boiler volume must be up to approximately three times greater than coal-fired boiler volumes to be able to generate the same amount of steam.” I disagree with this statement as written.

The paper devotes more space to current status and an overview of RDF firing, which contains a great of opinion and several points with which one can take issue, than it does to the topic as described in the title. The author also claims this is a cogeneration plant but shows no other energy output other than power. I would ask the author to illustrate a more detailed mass and energy balance showing the four individual boilers, their maximum capacity. I would ask the author to compare heat rate costs of the four-boiler train to a single boiler train.

Discussion by

Balu A. Kamat
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This paper, though well written, is very general in nature. The author is correct in his referral to very recent and limited experience of 100% RDF fired units in the U.S. Almost all plants in the U.S. using such RDF have been plagued with various types of problems, some of serious nature, at the feed end and in the combustion chambers. The author has correctly addressed the problem of corrosion but has made no reference to erosion of tubes. The problem of corrosion of boiler walls and superheater tubes have been associated mainly with combustion temperature, proximity to radiant heat, extent of protective coatings on the wall tubes, gas velocity and retention time. Such problems need further studies and a bolder approach in new prototype plants.

The author’s statement regarding “first major attempt to recover energy from USA started in early 1970” probably refers to use of RDF. Tynan Incinerator Co., in 1958, was the first to build an incinerator at Oyster Bay, New York, with an energy recovery system utilizing a
steam turbine and generator using mass burning technology.

1. If the total quantity of incoming air is decided, how can the ratio of OFA to UF A be kept constant?

2. How did the author determine that the RDF fired boiler volume is approximately three times greater than the coal-fired boiler volume?

**SUMMARY**

It would be interesting, in the future, to read a “follow-up paper” on the actual working experiences gained from this U.S. Navy plant, now under design.

**Discussion by**

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The author has provided a comprehensive discussion on the use of RDF-3 (shredded beneficiated fuel fraction derived from mixed municipal refuse) as a fuel for semi-suspension firing for steam generation.

The arbitrary use of the term “dedicated boiler” implies there is some other kind of designation. To operate any boiler, a heat source(s) must be provided and once committed to this heat source or combination sources (burning or otherwise) whether a new unit or retrofitted, it is then “dedicated” to the use of this fuel(s) until it is committed or rededicated to some other(s). Therefore, the use of the term “dedicated” contributes to confusion rather than clarity.

When reference was made that the building volume required for an RDF fired boiler can be up to three times greater than that for a coal fired unit, it would have been appropriate to mention that this would also apply to all relatively high moisture fuels such as sub-bituminous, brown coals, lignites, peats and all biomass fuels.

Table 2 would be more informative if it also indicated for each plant the number of steam generators, their capacity when burning fossil fuel and the type of fossil fuel; whether the plant generates principally low pressure steam for heating and process or superheated steam for power alone or for cogeneration. In all probability, prudence prevailed and capability of full capacity with fossil fuel was incorporated in most if not all of these designs. Of the projects listed only the City of Columbus is a utility.

It is acknowledged that RDF can be highly variable in moisture and bulk density. The problem is aggravated by its nonuniform compressibility, and therefore fuel feeders which are strictly volumetric cannot be considered as a metering device for providing even reasonable fuel flow and unit energy input predictability.

Effective control of combustion also becomes increasingly difficult as the furnace becomes wider, requiring a multiplicity of fuel distributors. Each additional fuel distributor or spreader aggravates the problem of getting equal quantities of similar material to each distributor. Uniform distribution of fuel is required for uniform combustion, avoiding thick and thin fuel accumulations on the grate with the corresponding clinkering, blow torching, gas stratification and conditions prompting high velocity particulate entrainment.

When sensing and monitoring combustion gas character to maintain the desired combustion parameters, air flow control is usually more responsive than fuel flow.

In addition to the need for more effective fuel feeder-distributor mechanisms, the conventional locations and methods of combustion air introduction and control must be improved if semi-suspension firing is to be a viable method for consuming refuse derived fuels. These developments should provide acceptable load following capabilities while routinely satisfying the criteria for combustion gas and residue quality and with improved stoker-furnace boiler system availability.

Although many of the generalized statements made by the author were not meant to be universal and could have been better qualified, his presentation does provide an excellent perspective and his conclusions coincide with most practitioners who have been involved in designing, constructing and operating refuse fuel fired systems. The essence being that it is possible to fire RDF alone within a specific capacity range but to maintain system stability, sustain controlled quality combustion gas and follow steam demand while maintaining pressure and temperature could best be accomplished by burning a support (trim) fossil fuel for effective response to change in load or change in character of the refuse derived fuel.

Efforts to control combustion of RDF must be directed at coping with the variability of fuel character, fuel distribution and fuel flow by endeavoring to hold these as stable as practical.

**AUTHOR’S REPLY**

To R. E. Sommerlad

According to the flowsheet (Fig. 1) each boiler is designed for 180,000 lb/hr of superheated steam at 100% MCR and sized for 265.6 x 10^6 Btu/hr. This quantity of heat input is supplied by 44,275 lb/hr (531 tpd) of RDF and 4138 lb/hr of coal which amounts to a fuel mix of 80% RDF/20% coal, respectively.
The reviewer has stated that each boiler fires 1475 lb/hr (9 tpd) of RDF with a boiler heat input of 88.5 \times 10^6 Btu/hr. These numbers are incorrect and it is not clear how they have been derived.

Furnace volume and the proportions selected are being influenced by many factors, including: fuel type, steam capacity and conditions, load range, type of firing, excess air, flame length, grate area, and furnace-wall and arch construction.

Furnace volume partly controls the furnace heat release rate, 
\[ V \times HR = M \times HHV \]
where, 
- \( V \) = furnace volume, ft\(^3\)
- \( HR \) = heat release rate, Btu/ft\(^3\)-hr
- \( M \) = fuel firing rate, lb/hr
- \( HHV \) = heating value, Btu/lb

Comparing volume of RDF-fired boiler to that of coal-fired boiler which generates the same amount of steam, the following relation can be derived:

\[
\frac{V_{RDF}}{V_{coal}} = (1.1667) \times \frac{30,000}{15,000} = 2.33
\]

The heat release rates assumed by the boiler manufacturer depend on the fuels and his previous experience with those fuels. For RDF-fired boilers, a heat release rate of 15,000 Btu/ft\(^3\)-hr is used by most manufacturers, and for the case of coal-only it can vary from 20,000 to 30,000 Btu/ft\(^3\)-hr. Therefore, the ratio of RDF-fired boiler volume to coal-fired boiler volume will vary from 1.56 to 2.33, respectively, as shown below:

\[
\frac{V_{RDF}}{V_{coal}} = (1.1667) \times \frac{20,000}{15,000} = 1.56
\]

The navy RDF/coal-fired project is a cogeneration plant consisting of four boilers and three steam turbine generators. (One steam turbine is used as standby.) The boilers will be fired by co-combustion of RDF (up to 80% MRC) and coal or all coal. The rated output of the steam turbine is 20 MW with 160,000 lb/hr extraction steam at 150 psig to be used in the shipyard. With no extraction, the rated output is 16 MW. The mass flow diagram (Fig. 1) depicts the case of no export steam to the yard. The steam cycle for both cases is presented in Figs. 2 and 3.

To Balu A. Kamat

(1) The total incoming air is controlled by boiler controls. The boiler control system automatically regulates the flow of RDF and/or coal by adjusting the speed of fuel feeders and regulates the flow of combustion air by adjusting FD fan speed. Fuel flow always lags air flow on load increase and lead airflow on load decrease. The underfire air is also controlled by the boiler control system. The balance is fed through several overfire air ports. Control of the ratio of overfire to underfire air then can be accomplished by controlling total air and underfire air with properly installed fans and dampers.

(2) The boiler volume is determined by the heat input required divided by the heat release rate selected for the fuel. Because of higher boiler efficiency for a coal-fired boiler, the heat input required to generate the same amount of steam is less than that of a RDF-fired boiler. Furthermore, the heat release rate selected for coal-fired boiler is higher than that for a RDF-fired boiler. Further discussion is provided in the author's response to comments by R. E. Sommerlad.

To Herbert J. Hollander

In this paper the term “dedicated boiler” is intended to mean a new boiler designed to burn RDF as a primary fuel, whereas “retrofitted boiler” means an existing coal-fired boiler modified to burn supplemental RDF. The use of these terms is very common among the boiler manufacturers and the utility industry.

The author agrees in principle with the reviewer’s comments on RDF combustion problems and boiler stability.
FIG. 2 HEAT BALANCE – NO EXTRACTION CASE
FIG. 3 HEAT BALANCE – FULL EXTRACTION CASE