DESIGN AND OPERATING EXPERIENCE WITH HIGH TEMPERATURE AND HIGH PRESSURE REFUSE-FIRED POWER BOILERS

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The authors are to be congratulated for a success story of utilizing high pressure and temperature steam conditions. The industry needs continual success stories, and clearly this is one we can all applaud. If I may, I would like to address a few comments to the printed paper and raise a few questions.

In the Background section, the authors suggest that as of 1976 only 16% of the European MSW plants were designed specifically for the generation of electric power from high pressure steam. I would venture that, if those statistics were arrayed on the basis of waste fired or steam flow, the percentage could well be a higher value. My point is that there have been and are a number of European plants firing MSW alone with steam conditions above 600 psig and 750°F, and also a number operating above 900 psig and 830°F, such as Dusseldorf, Oberhausen, Mannheim, Ivery and Nurnberg, with success. A number of these have been reported at this conference in previous years.

In the paper, Fig. 2 presents a corrosion rate of Cl_2 and HCl against metal temperature. We would caution that such a curve is perhaps only a trend, and we might suggest that some qualifiers be included even though no values are given on the ordinate. We would guess that the curve is based on 100% Cl_2 or 100% HCl in the absence of a deposit. In the actual furnace, such corrosion is generally accompanied by the formation of a deposit.

With the latter observation and the authors' discussion about Superheater Design, especially their comments about tube metal and flue gas temperature, I would venture a question. Have the authors made any effort to identify surface skin temperature of the superheater and other surfaces exposed to high temperature gases? It is generally assumed that the tube metal temperature is the fluid temperature plus 50°F for saturated steam and 100 to 150°F for superheated steam. However, there is reason to suspect that the outside tube temperature may well be higher than the temperatures as I've just described. Perhaps another way of phrasing the question is whether the outside flue gas temperature influences the outside temperature of a deposit near the tube surface or the tube surface itself.

If I may — another question, regarding studding as shown in Fig. 3. With such a studding array and cooling effect of the stud, does the refractory temperature really get high enough for full bonding strength at its appropriate curing temperature?

In closing, I wonder if the authors might dare to suggest how high a steam pressure and temperature could be achieved in the near future. Once again, my congratulations to the authors for a success story and a well written paper.

AUTHORS' REPLY

Mr. Sommerlad's first question concerns the number of refuse boilers operating in Europe at steam conditions of 900 psig and 830°F or higher. In our research we identified 29 individual refuse boilers that had steam conditions of 900 psig and 830°F or higher. This represents less than 2% of the total number of non-U.S. refuse boilers identified. Eleven of those 29 are located at the Dusseldorf, Oberhausen and Ivery refuse facilities.

The 1979 report, prepared by Battelle Laboratories for the US EPA, entitled "Evaluation of European Refuse-Fired Steam Generator Design Practices, Dusseldorf–Flingern Plant, West Germany," discusses various superheater corrosion problems in 1970 through 1973 time frame and discusses various options of alloy tube material, tube shields and ceramic coatings that they had tried or intended to try, to prevent this corrosion. In the 1982 ASME National Waste Processing Conference paper by K. S. Feindler and K. H. Thoemen entitled, "Completion of the Dusseldorf Refuse Power Plant," it is stated that ". . . a substantial portion of the superheater section is protected by studding and massed refractory".

In the 1980 ASME National Waste Processing Conference paper by K. S. Feindler and R. Plur entitled, "From Coal to Refuse Power: The Successful Retrofit at Oberhausen," in discussing the superheater design it states that ". . . studded tubes with protective cups were installed upon which type SIC 90 plastic refractory was tampered to form a shield similar to the furnace ceiling construction . . ."

In the early 1980s, B&W had extensive discussions with D.I.T.T. concerning the technology utilized at the Ivery plant for corrosion protection of the superheater. It involved the pin studding and refractory coating of the entire individual superheater sections.

We did not consider pin studding and refractory coating to be an acceptable long term solution to superheater corrosion problems and therefore embarked on the design process that ultimately resulted in the superheater design and material selection utilized in the Westchester boiler design.

The second question relates to Fig. 2 in the paper on corrosion rates relative to Cl_2 and HCl. The curves are based on laboratory data and are based on 100% Cl_2 and 100% HCl and are only meant to be illustrative that the corrosion rate for carbon steel tubes is metal temperature dependent.

The third question relates to the influence of flue gas temperature to the superheater outside tube metal temperature. Our experience is that the flue gas temperature does affect the temperature of any deposit on a tube and the outside tube metal temperature itself. The real issue is whether those metal temperatures can be accurately predicted analytically. We did install chordal tube sections in the Westchester boilers to measure the superheater metal outside skin temperature. Our field data confirmed our predicted design metal temperatures and for this particular superheater design the actual tube metal temperatures were less than the 100–150°F delta above the inside fluid temperature.

The fourth question asks if the lower furnace pin stud arrangement allows the refractory to reach its full bonding strength at the appropriate curing temperature. This is entirely dependent on the particular bonding agent. A typical phosphate bond mix requires temperatures in excess of 100°F to cure and achieve sufficient strength. A typical calcium bond mix requires only air drying to achieve maximum strength. This subject is discussed in detail in the 1988 National Waste Processing Conference paper by L. Strach entitled "Operating Experience of Refractory Linings in Mass-Refuse Fired Waterwall Boilers."

The last question asks what steam pressures and temperatures can be achieved in the near future. We have had superheater test loops in continuous operation at one of the Baltimore refuse boilers for 27 months where we were operating with steam temperatures of 950°F. The superheater test loops were manufactured from a variety of different tube materials. The results of that test program allow us to be confident that a 1500 psig, 925°F cycle is achievable in a refuse fired boiler.

ERRATA

On page 93 the affiliation for M. P. Hepp should read Wheelabrator Environmental Systems, Inc. In the right hand column, third line from the bottom, "incinerations" should read "incinerators."

On page 94, right hand column, seventh line from top, eliminate "WES operated." On the thirteenth line from the top, change "[4]" to "[5]." On the seventh line from the top, change "[5]" to "[6]."

On page 96, left hand column, the following Fig. 2 replaces the old Fig. 2. In the left hand column, last line, change "[6]" to "[7]."

On page 97, right hand column, first paragraph, second line from bottom, insert the words "we believe"

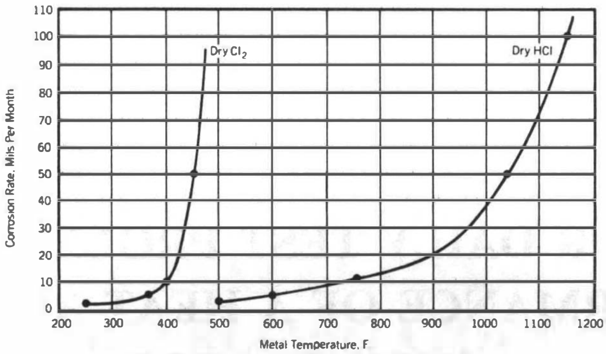

FIG. 2 CORROSION OF CARBON STEEL IN CHLORINE AND HYDROGEN CHLORIDE

just before "mechanical."

On page 99, right hand column, insert "[4] Ibid." right after the last line of [3]. Change "[4]" to "[5];" change "[5]" to "[6];" and change "[6]" to "[7]."