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Discussion

J. A. FELLOWS.⁷ The topic of this paper is a subject of real and active interest to all engineers dealing with the problems of industrial design employing the heat-resistant-alloy grades. It is of particular interest as a supplement to the earlier paper⁸ reporting oxidation rates in the air at 1600 to 2200 F for a similar range of Fe-Cr-Ni compositions. There are a few points, how-

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⁸ "Resistance of Iron-Nickel-Chromium Alloys to Corrosion in Air at 1600 to 2200 F," by Anton deS. Brasunas, James T. Gow, and Oscar E. Harder, *Proceedings of the ASTM*, vol. 46, 1946, pp. 870-901.

ever, which the writer would like to make in what he hopes will be viewed as constructive criticism.

The earlier paper was most concise in reporting the chemical analyses of the experimental alloys tested and their specific oxidation rates at each temperature. These values then were plotted on the ternary diagrams giving a complete display of how the contour lines had been constructed in representing constant corrosion-rate levels. The corresponding data are missing completely from the present paper, leaving us with no clue as to how many alloys were tested or as to the degree of consistency in corrosion-rate trends versus chemical composition. The background on which the corrosion-rate contours of the ternary diagrams were constructed is thus undefined.

It long has been the writer's belief that one of the primary obligations in reporting scientific data is to provide sufficient information to enable other interested workers to repeat or check the results. It is regrettable that this is not possible with this paper.

One of the interesting features of the paper on air-oxidation rates, was the inclusion of a set of graphs defining the trends in corrosion rate with increase of nickel content for each of five constant chromium levels. The writer would like to know whether a similar set of graphs could be prepared from the test results of the individual experimental heats used for this paper. This additional method of presentation has certain advantages in simplifying the task of appraising the influences of composition.

Two typical flue-gas atmosphere compositions have been reported on the basis of analysis of inlet and exit gases. The writer would like to know the degree to which the exit gases differed from the inlet compositions, if any such differences existed. The gas mixture reported as "reducing" appears at first inspection to be rather high in CO₂ and H₂O. This gas would be both oxidizing and decarburizing to carbon steels at 1800 F. The behavior of the highly alloyed Fe-Cr-Ni grades admittedly will not necessarily follow the same pattern. It would be interesting to learn the basis on which this composition was termed reducing, especially since many of the photomicrographs reveal decarburization and, in some instances, show appreciable scaling.

It also would be of interest to know whether any change in the state of the H₂S occurred in passing through the test furnace. Did the authors check whether any appreciable fraction of H₂S was converted to SO₂ and H₂O by the flue gas alone and if so, can they comment on the probable behavior of the alloys versus the residual content of H₂S? In other words, would greater corrosion occur if the flue gas were more highly reducing, especially for the lower levels of H₂S addition?

The rather outstanding behavior of the HE grade in these tests would seem to deserve somewhat additional emphasis. For installations where high-temperature strength is not a principal requisite, the choice of this alloy merits special consideration for sulphur-bearing atmospheres.

AUTHORS' CLOSURE

Mr. Fellows' comments on this paper are appreciated. His concern about the omission of detailed data tabulations and data points on the various graphs is understood. However, the purpose of this paper was to present the findings of this research in a concise form which would be of value to those who wished to use this information. The magnitude of this research can be appreciated when it is noted that forty figures were required to present the data collected. It is the authors' opinion, supported by the comments of other qualified metallurgists, that the purpose of the paper would have been defeated if the same data had been presented in several different forms. Complete test data are

available in the research reports in the files of all ACI member foundries. Others wishing to review these data at Battelle are welcome to do so.

The terms "oxidizing" and "reducing" that were used to identify the atmospheres were intended to refer only to the presence of free O_2 or CO in the inlet gases, and do not necessarily refer to the chemical effects of the gases on metals. It is well known in fuel technology that atmospheres produced by burning fuels with a deficiency of air may actually be oxidizing in their effect on metals. The ratios CO_2/CO and H_2O/H_2 in the water-gas shift

reaction determine whether oxidizing or reducing conditions prevail at various temperatures.

With regard to H_2S , the object in these tests was to introduce a typical reducing atmosphere containing sulphur into the furnaces. The reactions within the furnace would depend on the temperature and the reducing effect of the atmosphere. It is possible that under certain conditions, some of the H_2S would be oxidized to SO_2 and H_2O . Tests were not made under the strongly reducing conditions that are required to prevent completely the oxidation of H_2S .