burning high-sulphur high-vanadium fuel oil were not included in the laboratory tests.

A statistical evaluation of the metal-loss results indicated that the increase in corrosion caused by increasing the sulphur dioxide in the atmosphere from 0.02 per cent to 0.20 per cent was significant. No significance could be attached to the minor differences caused by variation in carbon monoxide content up to 0.1 per cent by volume, nor to the differences obtained by partial immersion of the specimens in an alkali metal - salt mixture during the tests. The mechanism of corrosion resulting from the presence of alkali metals in the fuels is a complex problem which requires further study.

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Discussion

M. Schreiner.[6] This series of tests is an important contribution to the literature. The similarity of the results in the present paper to those obtained in the field are remarkable. This type of test with its suggested improvements is expected to become a first step leading to a clearer understanding of the corrosion of materials at elevated temperatures. Operating experience with marine boilers generally confirms the results of the authors.

The SO_2 content of exhaust gases appears to be the same as that of the inlet gases. The writer cannot help but feel that this is an unexpected result. Should not some SO_3 have been found in the exhaust gases? It is agreed that combustion gases from high-sulphur fuels are more corrosive, but it is considered that it is more relevant to the problems to know which of the sulphur compounds is the culprit.

It is noted that the only high-silicon alloy tested is the AISI 314 alloy. Comparing this with its low-silicon counterpart, AISI 310, seems to show that silicon may inhibit subsurface attack. Similar behavior with silicon has been observed previously. Could this suggest an improvement if a high-silicon AISI 309S-type alloy were used? The reduction in nickel content afforded by use of the AISI 309S-type is of strategic importance.

The U. S. Naval Boiler and Turbine Laboratory recently started a similar test program. A small furnace fitted with tube banks is in operation. A special fuel is fired as a control to determine the effects of temperature alone. The fuel then may be modified to provide exhaust gases with high-sulphur, high-vanadium, or high-ash contents, singly or in combination, respectively.

[6] Captain, U.S.N., Commanding Officer and Director, U. S. Naval Boiler and Turbine Laboratory, Naval Base, Philadelphia, Pa.

Author's Closure

Captain Schreiner has brought out two important points in his discussion. His concern over the fate of the SO_2 certainly is justified, and we agree that some SO_3 was probably formed in the furnaces. The main objective of the work described in the paper was to study the behavior of alloys under the prescribed conditions, rather than to study the chemical reactions and the mechanism of the corrosion processes. Therefore we made careful analyses of the inlet gases, to insure that the desired conditions were present, but analyses of the exhaust gases were made merely to verify that the intended gases had passed over the alloy specimens. The exhaust-gas results are not significant in a quantitative sense, because the hydrogen in the inlet gas had burned to water, in passing through the furnace, and because our analytical procedure did not account for any SO_3 which might have been present.

We agree with Captain Schreiner's comment about a high-silicon, AISI 309S-type alloy. The results appear to make such an alloy a logical choice for further investigation. In our experiments, only commercially available alloys were selected for testing. The question of availability and fabrication into the desired shapes might also be factors in selecting alloys for superheater tubing.

We are glad to note that the U. S. Naval Boiler and Turbine Laboratory is working on a similar program. There is a great need for reliable data on corrosion and oxidation effects to provide a basis for improved designs of high-temperature steam-generation equipment.