New evidence indicates that microscopic inclusions are not merely surface effects

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Technical Note — Microparticles in Mild Steel Weld Metal

ABSTRACT. Thin foils of mild steel weld metal have been studied by means of transmission electron microscopy. In addition to relatively large nonmetallic inclusions, microparticles have been observed which range in size up to 600 angstroms. The microparticles seem to lie inside the foil and are believed to be the small oxide particles previously observed on extraction replicas.

Introduction

It is well-known that mild steel weld metal contains nonmetallic inclusions ranging in size from a few tenths to several microns.[1-5] These inclusions, most of which are spherical in shape, have been studied by means of optical microscopy, electron microscopy (replica technique), X-ray diffraction, electron diffraction and chemical analysis. They are often observed in rows, suggesting that they are formed during the solidification process on the former grain boundaries of delta-ferrite or austenite.

In addition to these relatively large inclusions Irvine and Pickering[1] observed particles on extraction replicas in the electron microscope which are at least one order of magnitude smaller in size. Wheatley and Baker[2,6] made similar observations but suggested that the observed spots, rather than particles embedded in the matrix, are surface effects due to etching.

It was shown by Hrivnak[7] that in the case of iron and iron alloys melted and solidified in air, small oxide particles are formed in the ferrite matrix. Recently, Boniszewski[8] carried out an electron diffraction study of carbon replicas extracted from mild steel weld metal. The results of his study imply that the microspots observed on the replicas also are oxide particles. This might be considered as

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Fig. 1—Typical transmission micrograph of mild steel weld metal obtained by welding with a flux-cored electrode in CO_2

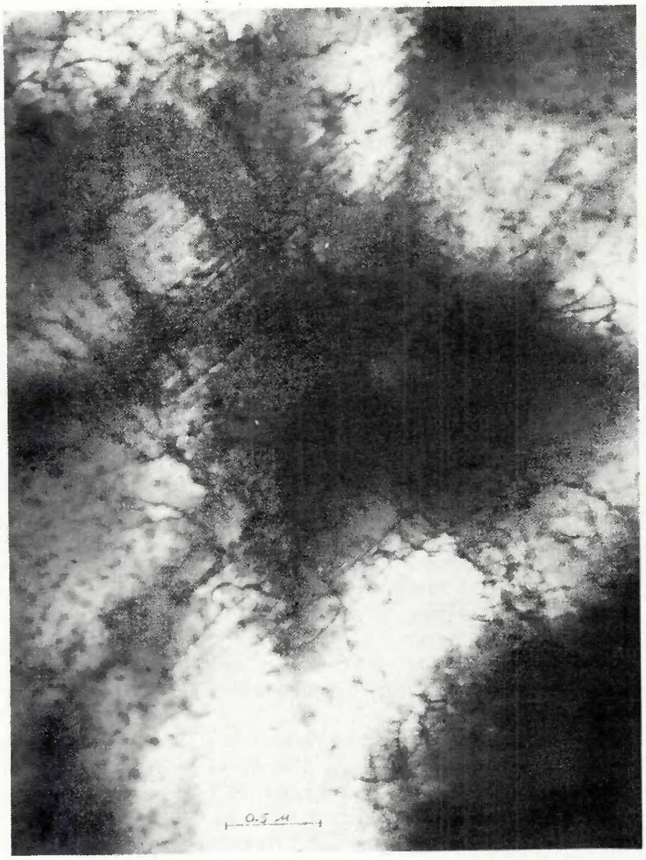

Fig. 2—Transmission micrograph similar to Fig. 1 but showing higher dislocation density and a number of slip traces

indirect evidence that, rather than a surface effect, the observed particles are a bulk feature of the weld metal.

Additional support for this conslusion is given in the present note which describes the results of a preliminary investigation of mild steel weld metal using transmission electron microscopy.

Experimental Procedure

The weld metal used was obtained from 70 deg Vee joints in 16 mm (0.64 in.) thick mild steel plates. The welds were produced by automatic welding in CO_2 with a flux-cored electrode, 1.8 mm (0.072 in.) diam, containing 1.64 % manganese and 0.39 % silicon.

Thin foils to be used for examination in the electron microscope were prepared in the following way:

Slices about 2 mm (0.08 in.) thick were taken from the weld, ground to a thickness of about 0.2 mm (0.008 in.) and mechanically polished on both sides with the help of successively finer polishing cloths. After that, electrolytical polishing was carried out at room temperature in a bath containing one part perchloric acid (70 %) and nine parts acetic acid, the voltage and current density being 12 V and 0.2 A/cm^2 respectively. The edges of the specimen were covered with a protective lacquer to prevent preferential attack by the polishing solution. Polishing was continued until holes appeared in the specimen. In most cases the edges around such holes were found to be thin enough for transmission electron microscopy. Before being used the specimens were washed carefully in alcohol and directly afterwards brought into the Philips EM 200 electron microscope for examination.

Results and Discussion

A large number of transmission micrographs were taken of different specimens. A typical example is given in Fig. 1. The figure shows the presence of a few relatively large nonmetallic inclusions and a great number of small particles which are homogeneously distributed over the photographed area. They are irregular in shape and have a size up to 600 angstroms. Figure 2 gives another example. The dislocation density is somewhat higher and also a number of slip traces are visible. It appears that with increasing dislocation density the observation of the microparticles becomes more and more difficult. This might explain the fact that Wheatley and Baker [6] dealing with foils of high dislocation density, did not observe the microparticles.

It should be realized that also in this case there is the possibility that one is dealing with a surface effect. The micrographs seem to indicate, however, that several microparticles are traversed by dislocations which would imply that they lie inside the foil. It is likely that more information about the microparticles can be obtained by carrying out diffraction contrast experiments.

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PVRC Recommendations on Toughness Requirements for Ferritic Materials

by the PVRC Ad Hoc Task Group on Toughness Requirements

One objective of the Pressure Vessel Research Committee (PVRC) of the Welding Research Council is to review and present the results of pressure-vessel research in a useful form for designers and code-making bodies. Many such reviews with recommendations have been presented. In January 1971, PVRC formed a Task Group, under the Evaluation and Planning Committee, to review current knowledge and prepare recommendations on toughness requirements for ferritic materials in nuclear power plant components. The recommendations were requested from PVRC by the ASME Boiler and Pressure Vessel Committee for their use in considering any revisions to the requirements for Class 1 Components, Subsection NB of Section III — Nuclear Power Plant Components.

Specifically, the Task Group undertook to recommend, on the basis of current knowledge, criteria for ferritic-material-toughness requirements for pressure-retaining components of the reactor coolant pressure boundary operating below 700 F. These criteria, when used in addition to the stress limits allowed by the ASME Code, should permit the establishment of safe procedures for operating nuclear reactor components under normal, upset, and testing conditions; emergency and faulted conditions should be considered on a case basis. The present report contains the recommendations of PVRC provided to the ASME, and also to the Atomic Energy Commission, in August 1971; with some revisions and additions developed since that date.