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EXAMINATION OF SEAM DEFECT IN COPPER TUBING

by

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SUMMARY OF RESULTS

The seam defect in the tubing sample examined was related to presence of a refractory inclusion, which most likely originated as a piece of furnace lining contained in the billet from which the tubing was manufactured. During fabrication, break-up of the inclusion resulted in formation of the seam.

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INTRODUCTION

On October 9th, 1958 a 1-ft length of copper tubing was received from Mr. I. Betcherman of Betcherman Iron and Metal Co. Ltd., Eastview, Ontario. A metallurgical examination was requested in order to determine the cause of a pronounced longitudinal seam running almost the entire length of the sample. It was suspected that a white powdery deposit contained in the seam was in some way responsible for the defect, and identification of this material was therefore of particular interest.

X-RAY DIFFRACTION EXAMINATION

The white powder was studied by the Debye-Scherrer method but due to the complex nature of the diffraction pattern all of the constituents present could not be identified. The following substances have patterns which could be fitted on that obtained from the powder. These are: Cu, Cu_2O, $Al_2O_3.SiO_2$, Al_2O_3. The presence of alumina and silica suggests material of a refractory nature, the most likely source of which would be a piece of furnace lining which had become entrapped in the original billet stock. In the tube drawing operations this would be pulverized and distributed as a more or less continuous stringer defect. In this particular sample, the relatively gross amount and more or less uniform distribution of powder present to an appreciable depth in the seam, suggested that the original inclusion was of considerable size.

The presence of Cu_2O is explained by the fact that some particles of oxide, formed on the exposed edges of the seam during the annealing and drawing operations, must have been intermixed with or accidently removed in the powder sample taken for x-ray examination.

A diffraction pattern was also obtained for one of two large metallic inclusions found embedded at different points in the seam on the surface of the tubing. The particle examined was shown to be alpha iron.

MICROEXAMINATION

A number of samples cut from the tubing, including a section through the second iron particle, were polished, etched and examined under the microscope.

Remote from the seam area in all sections examined, the metal was clean and sound except for a number of fine radial cracks extending for a short distance from the surface. These are not unusual in copper tubing of this type. The grain structure was normal as was also the degree of work-hardening resulting from the final drawing operation.

The gross nature of the seam midway in its length, where penetration up to about two-thirds of the wall thickness had occurred, is shown in Figure 1. The cross-section shape of the opening and the more severe deformation evident around the bottom, suggests that the powder material was contained in the metal and was not subsequently deposited during the fabrication process.

A section near one end of the seam is shown in Figure 2. In this area, pronounced shearing deformation occurred beyond the end of the seam and this resulted in formation of a crack on the inside wall. The relative movement of metal in this area during fabrication thus accounts for the ridge defect which was found extending for some distance along the inside of the tubing. Microexamination of this and other samples taken at and near both ends of the seam failed to reveal any evidence of other inclusions. This suggests that the defect was caused by one discrete piece of material rather than generally poor metal quality.

A section through one of the iron particles found on the surface is shown in Figure 3. As illustrated on this typical plane the particle was essentially contained near the surface. This, and also the fact that it did not appear to be associated with the deformed metal around the base of the seam, suggests that the particle was forced into the seam at some stage when the latter was well developed.

DISCUSSION

Origin of the seam defect appears to have been related to entrapment of a piece of refractory, presumably from the furnace lining during billet manufacture; during tube drawing operations, the inclusion was distributed as a continuous stringer. The otherwise sound quality of metal in the tubing suggests that the defect in the sample submitted was an isolated occurrence and that other material from the same batch was probably not affected. Similarly, the absence of all but traces of the original inclusion suggests that it was not wetted appreciably by the metal; being brittle it would become powdered and would eventually fall free of the crack during drawing.

While no explanation can be offered for presence of the tramp particles of iron right at the seam on the surface of the tubing, it is not considered that these were directly involved in formation of the seam. This is supported by the fact that the seam extended for some distance to either side of the particles. In addition, these were located at some distance above the base of the seam, where metal deformation had been considerably affected by the unyielding material contained therein. The iron particles may have been associated with the original refractory inclusion, but a more likely explanation is that they were picked up during the final drawing operations.

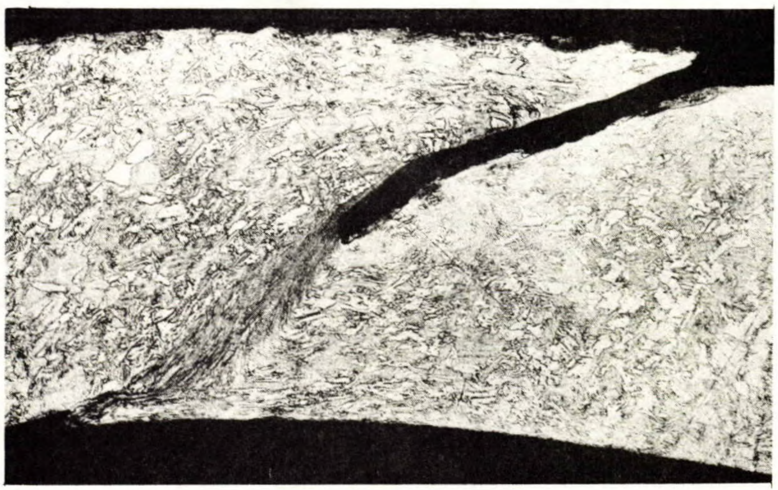
CONCLUSIONS

The powder deposit in the seam defect of the sample submitted was of a refractory nature, which most likely originated as a piece of furnace lining contained in the billet from which the tubing was made. During fabrication, the inclusion was broken-up and re-distributed as a continuous stringer causing formation of the seam. The otherwise good quality of the tubing metal suggests that this was an isolated occurrence.

JJS/RB

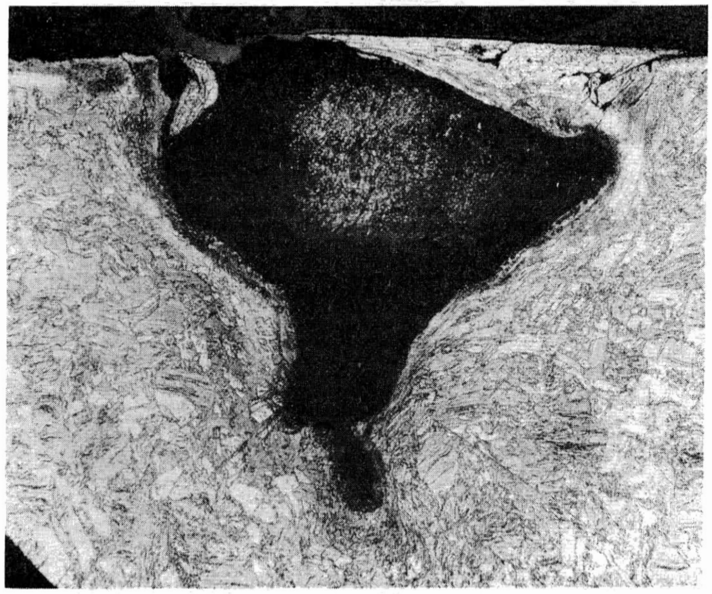
(Etched 2 sec in alcoholic $FeCl_3$; X100)

Fig. 1. - Section through seam midway in its length showing gross separation and severely deformed structure around seam walls. Penetration on this plane was almost two-thirds of wall thickness.



(Etched 2 sec in alcoholic $FeCl_3$; X50)

Fig. 2. - Section near one end of seam showing shear deformation band beyond seam front terminating in a crack and a ridge on the internal surface. This photomicrograph was taken looking towards opposite end of tubing to that for Figures 1 and 3.



(Etched 2 sec in alcoholic $FeCl_3$; X100)

Fig. 3. - Section through iron particle showing its location near surface. Most severely deformed metal around bottom of seam is some distance from base of particle.