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O T T A W A March 7, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1807.

Examination of Drillings from Furnace of S.S. "Albert Park".

(Copy No. 10.)

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Introduction:

On February 28, 1945, Mr. F. A. Willsher, Chairman, Board of Steamship Inspection, Department of Transport, Ottawa, Ontario, submitted drillings from the furnace of the S.S. "Albert Park" (Vancouver) for examination. In his covering letter (File No. 9562-2572), Mr. Willsher gives the following information:

> During the construction of a boiler for this vessel at the Dominion Bridge Co. Ltd., Burnaby, B.C., a crack developed in a back corrugation of the port furnace, and due to the difficulty of procuring a new furnace it has been decided to weld the crack, which extends for a distance of about 30 inches in a circumferential direction. Due to the furnace being in place and confined working space for the welder, it did not permit of satisfactory welding on both sides of the furnace. The welding has been carried out from the inside only.
>
> Physical test reports of the material of this furnace are enclosed and the results show that the physical properties of the material are in accordance with our regulations and are considered to be suitable for a furnace of this type.
>
> The cause of the fracture has not been clearly determined and, as it is not practical to take test pieces from the furnace, borings have been obtained

(Introduction, cont'd) -

from a hole drilled in the furnace close to the part that has been welded. A chemical analysis of the borings is requested, as a means of estimating the acceptability of a permanent welding repair; also, an opinion, based on the analysis, as to whether the tensile strength and elongation of the material would be as shown on the test reports.

On March 6, 1945, in a telephone conversation with Mr. R. C. Blyth of the Board of Steamship Inspection, it was learned that Brinell hardness readings had been taken on the furnace material in the vicinity of the repair area. These readings are reported to range from 145 to 175 B.H.N., with one reading of 190.

A Lloyd's Register of Shipping report accompanying the request letter showed that of four furnaces made from the same heat of steel (Bethlehem Steel Co.), three had cracked (two repaired by welding, one condemned) and the fourth had had to be built up by welding after flanging. This steel is made to the Firebox specification, requiring a minimum ultimate tensile strength of 55,000 pounds per square inch. All physical test results are within specification requirements.

Object of Investigation:

1. To determine the composition of the material used in the furnaces.
2. To estimate the acceptability of permanent welding repairs on material of this composition.

Procedure:

(1) The drillings were subjected to chemical analysis, with the following results: (There are no chemical analysis limits on this firebox-quality plate.)

(Continued on next page)

(Procedure, cont'd) -

Chemical Analysis -

		Per Cent
Carbon	-	0.29
Phosphorus	-	0.021
Sulphur	-	0.038
Manganese	-	0.53
Silicon	-	0.02
Chromium	-	None.
Nickel	-	None.
Molybdenum	-	None.

(2) Samples from the drillings were mounted, polished, etched, and subjected to a microscopic examination.

Discussion:

It cannot be emphasized too strongly that no satisfactory conclusions can be drawn from an examination of drillings only. The following remarks, then, should be read with this in mind.

The chemical analysis reveals that this is a rimmed steel with a higher-than-normal sulphur content. Steels of this general type are usually made with a specified sulphur content of 0.04 per cent maximum. In regular steel making practice, sufficient manganese is added to the steel to tie up the sulphur into manganese sulphides. If these sulphides are uniformly distributed they will cause no difficulty in a welding operation. This steel is of the rimmed type and has a pronounced tendency to produce segregations of non-metallics toward the centre of the ingot. When rolled into plate form, these inclusions may concentrate into stringer clusters. Should this happen a welding operation will be difficult, since the intense heat of the arc breaks

(Discussion, cont'd) -

down the sulphide into free sulphur, which then oxidizes to SO_2. This gas, heated to a high temperature, causes a pronounced spitting action in the molten pool and porosity in the finished weld. This type of action would be readily seen by the welder and if encountered welding should be stopped and the laminated area removed, if this is possible.

The microscopic examination is inconclusive, since the drillings are naturally severely cold-worked in removal from the furnace material. However, a typical ferrite-pearlite structure was found and no evidence of heavy inclusions. It should be pointed out that it is not known from which area of the plate the drillings examined were removed. That is, the segregation naturally tends towards the centre of the plate. If the drillings examined under the microscope came from near either surface, very few inclusions would be detected. Therefore, the above remarks regarding inclusions cannot be regarded as proof of non-segregated material.

The fact that three furnaces made from the same heat of steel have given cracking difficulties and the fourth, non-uniform flanging, would appear to be significant. It would be most interesting to have some information as to the service life of the welded repairs on the two so treated. Ordinarily, cracking is not commonly encountered in this type of steel and the possibility exists that an unknown factor, such as furnace geometry or fabricating practice, may be responsible for the troubles encountered. These elements are well worth exploration.

The hardness readings on the furnace material, ranging from 145 to 175, are normal for this type of material. The 190 Brinell is higher than would normally be expected. It is probable that this last reading is in error and as such should

(Discussion, cont'd) -

not be given too great consideration. Rough conversion of hardness to ultimate tensile strength indicates that the material would fall well within the specified limits, and it may be considered that the physical test reports are vindicated. Unfortunately, it is impossible to estimate elongation from hardness readings.

Since the welded repair has already been carried out no useful purpose can be served by recommending a welding procedure and technique. Since welding from one side only was necessary, a joint design such that complete penetration through the plate thickness was achieved was essential. It is considered that the welded repair should be acceptable as a permanent repair, provided that no indication of inclusion trouble was detected in the welding operation.

Conclusions:

1. The chemical analysis of the material indicates that it is rimmed steel with higher-than-average sulphur content. This type of steel can exhibit laminations which render welding difficult and sometimes impossible if the laminated area cannot be removed.

2. Microscopic examination of drillings shows normal ferrite-pearlite structures severely cold-worked by removal from the furnace. No evidence was found of heavy inclusions.

3. Hardness readings taken near the repair area roughly indicate physical properties within specified limits. Elongation cannot be estimated from chemical analysis or hardness readings.

4. The welded repair should be accepted as permanent provided that the welding operation encountered no evidence of

(Conclusions, cont'd) -

inclusion trouble.

5. Cracking failures in this heat of steel seem to indicate faulty fabrication practice or design geometry of furnace.

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