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# R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1407.

Examination of Failed Superstructure
Hoop Bow Pipe.

(Copy No. 10.)

Bureau of Mines
Division of Metallic Minerals
Ore Dressing and Metallurgical Laboratories

CANADA
DEPARTMENT OF MINES AND RESOURCES
Mines and Geology Branch

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Origin of Material and Object of Investigation:

On May 6th, 1943, under Analysis Requisition No. O.T. 3475, Mr. R. L. Martin, I.(M.T.), of the Inspection Board of the United Kingdom and Canada, Ottawa, Ontario, submitted two samples of Superstructure Hoop Bow pipe for examination. Of these two pieces, reported to be from the same lot of tubing, one sample was "as received" and the other had failed during a cold-bending operation.

The drawing for the part specified: "1 standard steel pipe, all worked parts to be hot-forged and air-cooled. Annealing not necessary." It was reported that if the pipes were not harder than 138 Brinell they could be bent cold, otherwise they must be heated. Request was made for an examination of the tubes in order to determine the cause of failure.

Chemical Analysis:

Turnings taken from the pipe after the surface had been removed were chemically analysed. The results follow:

| | | Per cent |
|---|---|---|
| Carbon | - | 0.08 |
| Manganese | - | 0.39 |
| Silicon | - | 0.22 |
| Sulphur | - | 0.046 |
| Phosphorus | - | 0.099 |

Physical Examination:

Hardness tests (taken on a Vickers machine with a 10-kilogram load) on the broken and unused tubes showed that they were both about 161 to 178 Vickers.

Tests for Ageing Susceptibility:

Two rings (designated Nos. 1 and 2) from the broken tube were water-quenched from 1255° F. No. 1 was left at room temperature, while No. 2 was drawn for 3½ hours at 400° F. This latter drawing operation after subcritical water-quenching pre-(quench)ages (overages) the steel. The following hardness results were obtained from these samples:

| | Vickers Hardness Number |
|---|---|
| Tube No. 1, as quenched - | 180 |
| After air-ageing three days | 206-224 |
| Tube No. 2, as quenched - | 165-181 |
| After drawing 3½ hours at 400° F. - | 145-160 |

Microstructure:

The structure of the tubes was of the normalized type.

Discussion of Results:

Chemical analysis results show that phosphorus content is considerably higher than would be expected in quality steel. However, it is probabl that the steel under examination is of the Bessemer type in which high phosphorus contents may be expected. Excessive phosphorus causes cold shortness but in steels below 0.10 per cent carbon, phosphorus contents up to about 0.10 per cent generally do not exert a very great embrittling effect. Since phosphorus is very prone to segregation, however, and since the chemical analysis was taken from turnings from the tube, it is possible that some locations may be higher in phosphorus than chemical analysis results show. Incidentally, phosphorus segregation may be responsible for the fact that the hardness of the pipes varies considerably, as phosphorus affects hardness in much the same way as does carbon. Because of its effect on the hardness, phosphorus must be regarded as contributing to the failure. However, it is understood that Bessemer steel must be used for this type of pipe if satisfactory production welding is to be obtained. Consequently, it is probable that little can be done about the high phosphorus content, the effect of which must be counteracted by fabrication technique.

Since the hardness of the tube after the subcritical quench-and-draw, which would remove all the effects of quench ageing, was 145 to 160, the tube as it came from the factory was probably not soft enough to permit cold bending. This heat treatment also shows (since there was no evidence of serious cold work) that the tubes probably quench-aged after leaving the mill, because their 'as received' hardness is greater than that of our pre-(quench)aged sample.

In the final analysis, however, the most important

(Discussion of Results, cont'd) -

factor in the breakage of the pipes is the fact that they were bent cold when much harder than the allowable 138 Brinell.

Conclusion:

In the type of material received for examination, it would appear to be essential to heat before bending.

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