

DEPARTMENT OF ENGINEERING RESEARCH
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REPORT

on

INVESTIGATION OF IMPACT PROPERTIES
OF CARBON-MOLYBDENUM STEEL
IN THE AS ROLLED CONDITION AND
AFTER SELECTED HEAT TREATMENT
AT ROOM TEMPERATURE AND AT 925 F

by

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INVESTIGATION OF IMPACT PROPERTIES OF CARBON-MOLYBDENUM STEEL
IN THE AS ROLLED CONDITION AND AFTER SELECTED HEAT TREATMENT
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In accordance with The Detroit Edison Company Purchase Order No. M 48565, Requisition No. E751, dated October 30, 1940, impact tests were made on various samples of carbon-molybdenum steel at room temperature and at 925 F. This work was undertaken to supplement the findings of an investigation recently completed on "Comparison of Creep Test Values and Grain Size and Structure of Carbon-Molybdenum Steel Pipe as Rolled and after Heat Treatment with and without Simulated Fabrication," since certain outside interests had intimated that under certain conditions the impact properties of carbon-molybdenum steel might be adversely affected, even though the structure was of such a type as to produce good high-temperature creep properties.

FINDINGS

Four different heats of carbon-molybdenum pipe were examined, with each heat, for the most part, in different conditions of heat treatment; also, an all-weld section was examined. The impact tests were made at room temperature and at 925 F.

Heat 4299 was examined in the as-received condition, in the annealed state, in the normalized state, and

in the normalized state followed by three different drawing temperatures. All of the specimens were in a coarse-grained condition, with the grain structure of the Widmanstätten type except in the case of the annealed specimens. The impact values were high at room temperature and relatively high at 925 F in all cases except with respect to the room temperature properties of the annealed specimens. These were low.

With regard to Heat 4493, which was tested in the as-received condition and after having been normalized from 1650 F followed by a 1200 F draw, the impact properties were good except for the room temperature specimens in the as-received condition.

Regarding Heat 4129, which was examined after being normalized from 1650 F followed by a 1200 F draw, all of the values were good, irrespective of whether the notch was through the wall of the tube or tangential to the radius.

Specimens from Heat 7011 were examined in the as-received condition. Sections that were fine-grained, showing a pearlitic structure, showed good impact values, whereas sections from another piece of the same heat which had been heat treated so that coarse grains resulted, with the coarse grains of a pearlitic type, showed poor impact properties at room temperature.

The all-weld section showed good impact properties, considering the type of material examined.

DISCUSSION OF RESULTS

The results of the impact tests that were made on the various materials examined are given in Table I. Attention is specifically directed to the results on Heat 4299. The specimens which were in a large-grained annealed state showed very low impact properties at room temperature, although the impact properties of the other specimens from this same heat, whether they were in the as-received condition, a normalized state, or a normalized state followed by a draw, all showed good properties. It should be pointed out in this connection, however, that the grain structure of all of these last three conditions was reasonably large to large, with the carbide structure of the Widmanstätten type.

The structures of the steel in Heat 4299 at 100 and 1000 diameters in the water quenched from 1800 F followed by a normalizing from 1700 F condition, and after having been drawn at 1300 F, are given in Charts 1 and 2. It will be noted that none of the structures show an appreciable difference.

Heat 4493 showed the advantage of a heat treatment, so far as this heat is concerned, since the impact properties of this heat when in the as-received condition were low, whereas after the specimens had been normalized from 1650 F, followed by a 1200 F draw, the impact properties were of a high order.

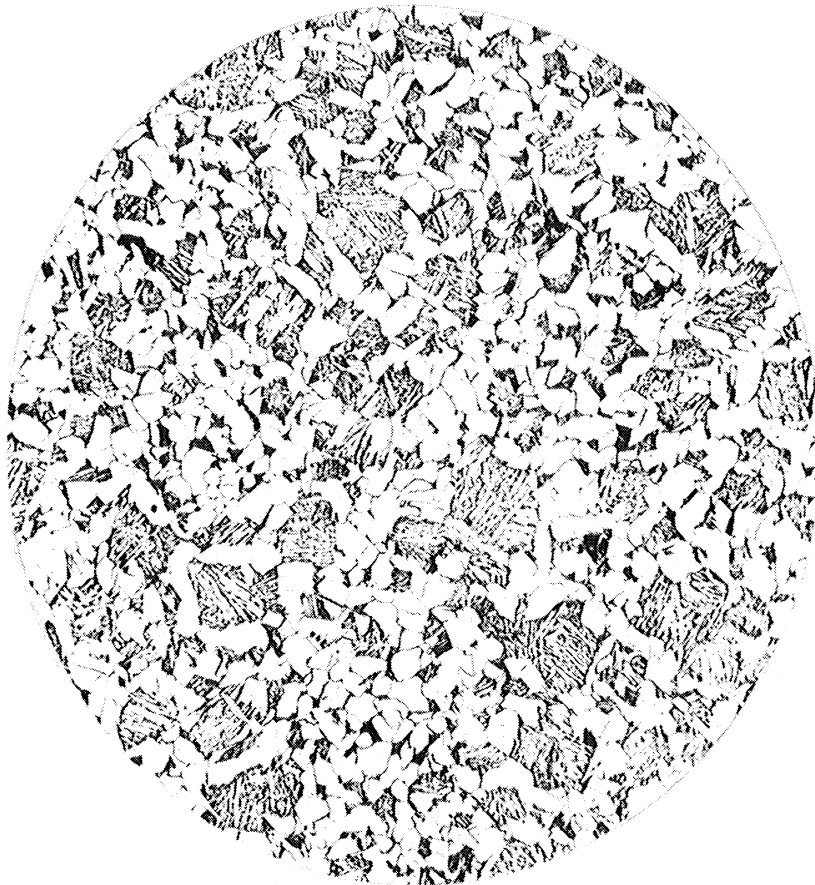
Impact tests were made on Heat 4129 for the purpose of determining whether or not there was any appreciable difference in impact values, depending on whether the notch was tangential to the radius or through the wall of the tube. No difference, however, was found.

The determination of the impact properties on the all-weld section was undertaken for the primary purpose of determining whether or not satisfactory impact properties would be found in all-weld sections. The results show that satisfactory properties were obtained.

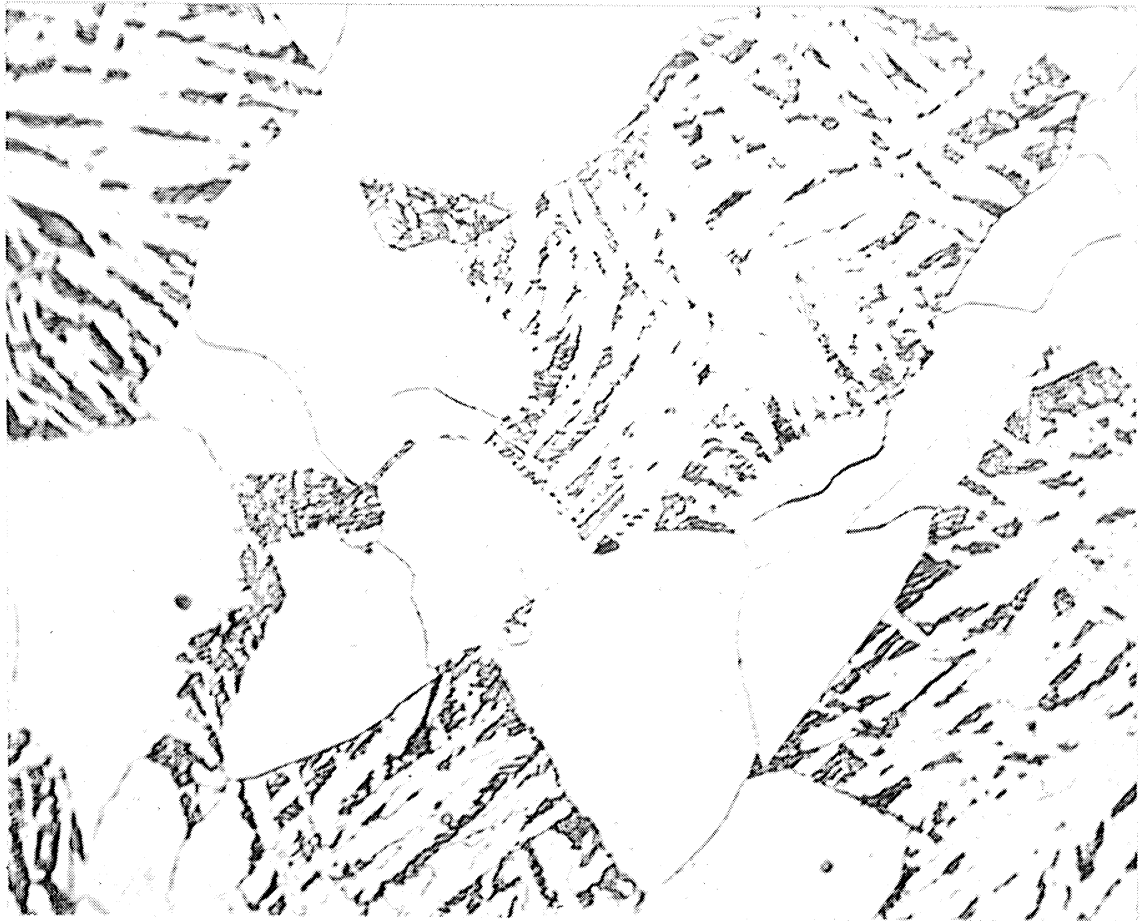
TABLE I

Heat	Condition	*Charpy Impact, Ft.-Lbs.	
		Room Temp.	925 F
4299	As Received	125, 122, 132	59, 60, 60
4299	2 Hr. - 1700 F Cooled 50 F/Hr.	11, 14	52, 43
4299	1 Hr. - 1800 F - Water Quenched	112, 128, 116	41, 42, 40
	2 Hr. - 1700 F - Air Cooled		
4299	1 Hr. - 1800 F - Water Quenched	124, 96, 123	40, 46, 42
	2 Hr. - 1700 F - Air Cooled		
	1 Hr. - 1200 F		
4299	1 Hr. - 1800 F - Water Quenched	117, 112	47, 49
	2 Hr. - 1700 F - Air Cooled		
	1 Hr. - 1250 F		
4299	1 Hr. - 1800 F - Water Quenched	113, 118	55, 60, 44
	2 Hr. - 1700 F - Air Cooled		
	1 Hr. - 1300 F		
4493	As Received	14, 13, 13	54, 53, 47
4493	1 Hr. - 1650 F - Air Cooled	122, 128, 118	60, 56, 56
	1 Hr. - 1200 F		
7011	As Received (Coarse Grained)	25, 30, 26	50, 50, 47
	As Received (Fine Grained)	97, 107, 104	58, 56, 62
4129	1 Hr. - 1650 F - Air Cooled	118, 110, 109	48, 39
	1 Hr. - 1200 F	117, 126, 106	
All Weld As Received Section		88	30

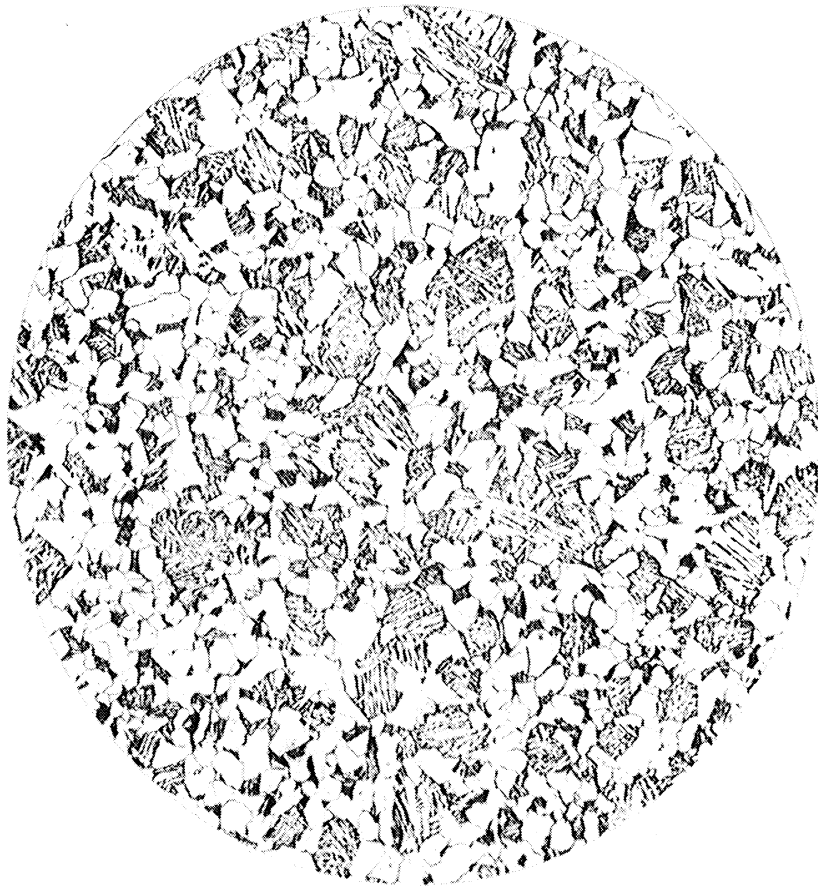
*V-notch specimens



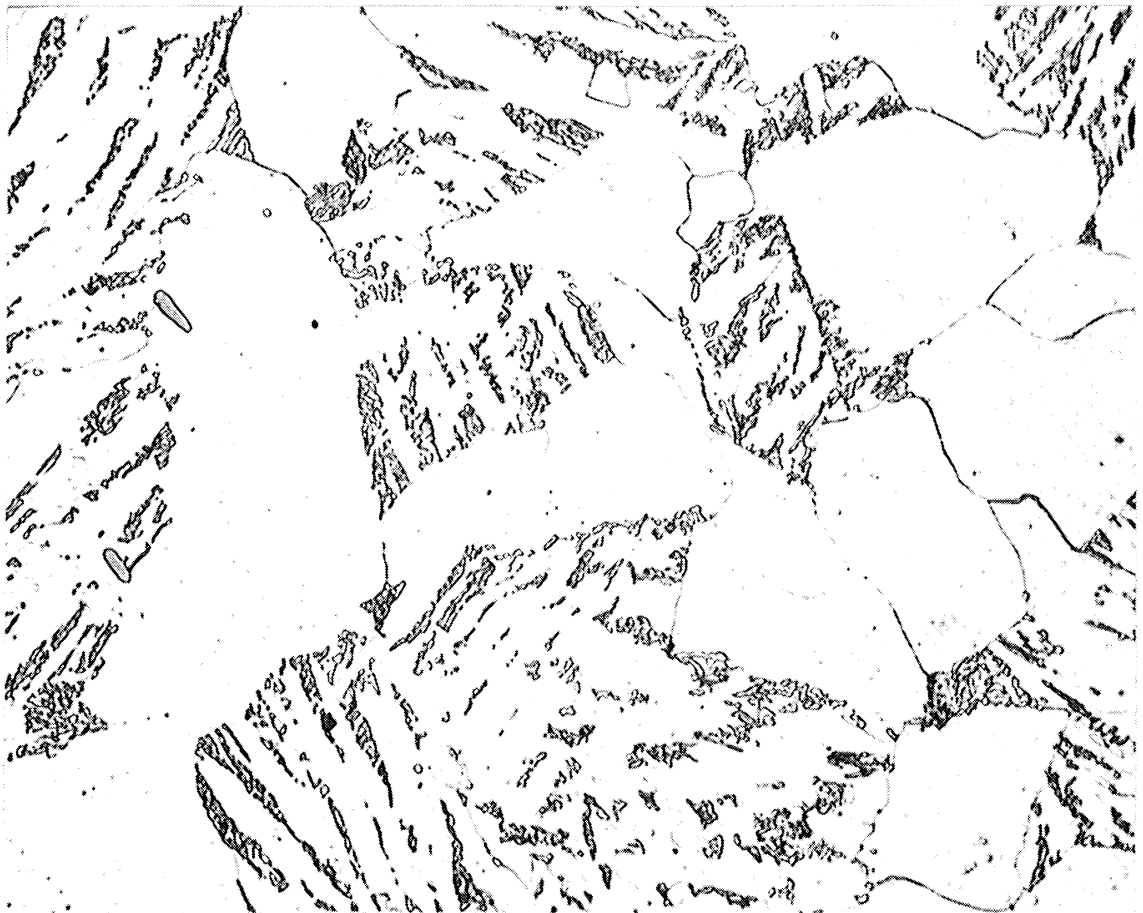
Heat 4299. Water Quenched from 1800 F, Followed by
Normalizing from 1700 F X100



Heat 4299. Water Quenched from 1800 F, Followed by
Normalizing from 1700 F X1000



Heat 4299. Water Quenched from 1800 F, Followed by Normalizing from 1700 F with Draw at 1300 F X100



Heat 4299. Water Quenched from 1800 F, Followed by Normalizing from 1700 F with Draw at 1300 F X1000

