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OTTAWA July 25th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1688.

Examination of Six Universal Carrier Cased Pins Which Failed Impact Test.

(Copy No. 10.)

Bureau of Mines
Division of Metallic Minerals
-
Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch
O T T A W A July 25th, 1944.

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Abstract.

Six Universal Carrier pins which failed the standard inspection impact test were examined to determine the cause of failure. All pins were of large grain size, which condition would lower the impact strength. The improper heat treatment of four of the pins would further aggravate this condition.

Origin of Material and Object of Investigation:

On July 4th, 1944, fragments of six (6) Universal Carrier cased pins were submitted by Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario. The requisition order and pins were identified as follows:

Requisition No. 830, Report No. 9, Section A, Test 27:

A.E.D.B. Lot No.

1100,	Canadian Acme.	- Broken on impact.
1101,	do	- do
1102,	do	- Variations in surface hardness.
1103,	Allied Products	- Broken on impact.
1104,	do	- do
1105,	do	- do

It was requested that the structure and properties of the pins be examined to determine the cause of failure.

Chemical Analysis:

Drillings for chemical analy sis were taken from the core of each pin. Results of these analyses are shown in Table I.

TABLE I.

	A.E.D.B. Lot No.						Recommended SAE 3115 Purchasing Specification
	1100	1101	1102	1103	1104	1105	
	- P	e r	c	e	n t	-	
Carbon	0.16	0.16	0.19	0.20	0.16	0.21	0.13-0.18
Manganese	0.47	0.46	0.47	0.51	0.46	0.51	0.40-0.60
Silicon	0.28	0.28	0.28	0.28	0.28	0.26	0.20-0.35
Phosphorus	0.011	0.011	0.013	0.007	0.007	0.004	0.040 max.
Sulphur	0.022	0.022	0.022	0.027	0.024	0.020	0.050 max.
Nickel	1.55	1.57	1.59	1.32	1.25	1.27	1.10-1.40
Chromium	0.26	0.27	0.26	0.37	0.34	0.29	0.25-0.45

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Hardness:

Rockwell hardness values for case and core are shown in Table II.

TABLE II.

A.E.D.B.	Surface Hardness, Rockwell "A"		Core Hardness, Rockwell "C"	
Lot No.	As Found	Specified	As Found	Specified
1100	81-82	80 max.	24-26	24-32
1101	81-82	" "	17-18	" "
1102	70-80	" "	80-81 (Rock-well "B")	" "
1103	82-83	" "	30-33	24-32
1104	82-83	" "	29-30	" "
1105	80-82	" "	30-32	" "

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Case Depth:

Transverse specimens of each pin were deeply etched with 2 per cent nital and the case depths were measured with a Brinell microscope. The results are shown in Table III.

(Continued on next page)

(Case Depth, cont'd) -

TABLE III.

A.E.D.B. Lot No.	Case Depth (inches) As Found	Specified
1100	0.018	0.012-0.020
1101	0.012	"
1102	0.012	"
1103	0.018	"
1104	0.016	"
1105	0.016	"

Grain Size:

Pieces of each pin were broken on the Izod impact machine and the grain size of each fracture obtained was estimated by comparison with standard Shepherd bars (see Table IV). The McQuaid-Ehn size was also determined. The specimens were etched with Murakami's reagent for microscopic examination, to outline the grain boundaries more definitely (see Figure 1).

TABLE IV.

A.E.D.B. Lot No.	Fracture Grain Size	McQuaid-Ehn Grain Size
1100	4	3 and 7
1101	4½	4
1102	4½	3 and 7
1103	3½	3
1104	3½	3
1105	7	3 and 7

Microscopic Examination:

Transverse sections of all pins, examined microscopically, showed considerable variation in microstructure.

Pins Nos. 1100 and 1105 had homogeneous martensitic core and case microstructures which are typical for suitably heat-treated SAE 3115 pins (see Figures 2 and 3, photomicrographs at 500 and 200 diameters respectively).

Pin No. 1101 had a core microstructure composed of some martensite and a large proportion of ferrite, as shown in Figure 4 (a photomicrograph at X500). The case microstructure was martensitic, similar to the example already shown in

(Microscopic Examination, cont'd) -

Figure 2.

The microstructure of both case and core of Pin No. 1102 was heterogeneous. The core contained ferrite and fine pearlite (see Figure 5, a photomicrograph at X500). At the extreme surface of the case, the microstructure (see Figure 6, at X500) consists of cementite and martensite. Backing this microstructure is an area of varying amounts of martensite, pearlite and troostite.

Pins Nos. 1103 and 1104 had a normal case microstructure, typical of that shown in Figure 3. The core microstructure was uniformly martensitic but of unusual coarseness (see Figure 7, a photomicrograph at X500).

Discussion:

The chemical composition of each pin is close to the SAE 3115 recommended purchasing specification.

Hardness values and microscopic examination substantiate each other in indicating that Pins 1101 and 1102 have not been properly heat-treated. The core hardness of 17 to 18 Rockwell "C" and the large proportion of ferrite in the core of Pin No. 1102 indicate that it was quenched from a temperature below the critical. Pin No. 1102, on the other hand, appears to have had a slow cooling rate; possibly it has not been quenched at all. The presence of fine pearlite and ferrite in the core is in agreement with a hardness value of 80 to 81 Rockwell "B". In the case, precipitated carbides and a heterogeneous structure of pearlite and martensite explain the variation in surface hardness. As a result of this heat treatment, both pins would have relatively low impact strength. Pins Nos. 1100, 1103, 1104 and 1105, with a uniform martensitic microstructure of case and core, appear to have been properly heat-treated. However, the coarse core structure of 1103 and

(Discussion, cont'd) -

1104 indicate that the quenching temperature was high.

The main cause for low impact strength appears to be large grain size. As shown in Table IV, the grain size, both McQuaid-Ehn and in the heat-treated pin, is 3 to 4 for Nos. 1101, 1103, 1104 and a mixed grain size of 3 and 7 for Nos. 1100, 1102 and 1105. The specification requires that the bar stock have a fine grain size, of 6 to 8 McQuaid-Ehn.

CONCLUSIONS:

1. The chemical analysis of each of the pins is close to the recommended purchasing requirements for SAE 3115 steel.

2. All pins but Lots Nos. 1101 and 1102 meet the hardness specification for both case and core.

3. All pins are within the case depth requirements of 0.012-0.020 inch.

4. The pins are of coarse grain size. This is the most probable cause for failure to meet the 45 foot-pound impact test.

5. Pin No. 1101 has been quenched from below the upper critical of the core, since a large proportion of massive ferrite is present in the microstructure.

6. Pin No. 1102 has a heterogeneous case and core structure. The free carbide envelopes in the case and the pearlite in the core are indicative of a slow cooling rate. It is quite possible that this pin has not been quenched.

7. Pins Nos. 1103 and 1104 have an unusually coarse martensite core structure. This suggests that the pins were quenched from a high temperature.

8. Pins Nos. 1100 and 1105 have been properly heat treated.

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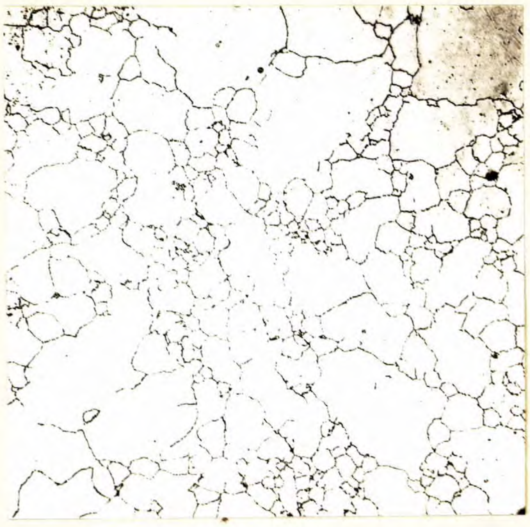
Figure 1.



X100, etched in
Murakami's reagent.

MCQUAID-EHN GRAIN SIZE,
PIN NO. 1100.

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Figure 2.

X500, etched in
2 per cent nital.

CORE STRUCTURE, PIN NO. 1100.

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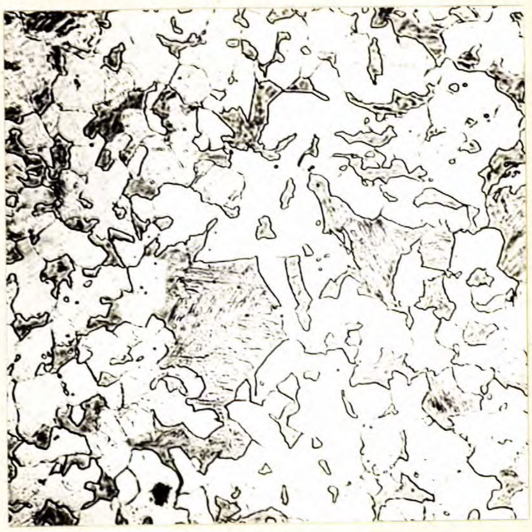
Figure 3.

X250, etched in
2 per cent nital.

CASE STRUCTURE, PIN NO. 1100.

-

Figure 4.



X500, etched in
2 per cent nital.

CORE STRUCTURE, PIN NO. 1101.

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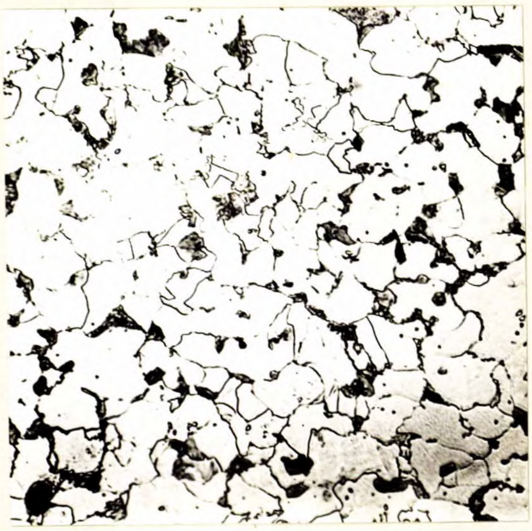
Figure 5.



X500, etched in
2 per cent nital.

CORE STRUCTURE, PIN NO. 1102.

Figure 6.

X250, etched in
2 per cent nital.

CASE STRUCTURE OF PIN NO. 1102,
SHOWING CEMENTITE AT SURFACE.

Figure 7.

X500, etched in
2 per cent nital.

CORE STRUCTURE OF PIN NO. 1103.

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