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OTTAWA June 26th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1671.

Metallurgical Examination of T-16 Universal Carrier Track Pins from Somerville Field 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

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Abstract

Thirty T-16 Universal Carrier track pins, representative of those at present on field test at Somerville, Mass., were examined. The pins were of three types: SAE 3115 cased, NE 8620 cased, and NE 8650 homogeneous. The homogeneous pins, having an impact strength approximately five times that of the best cased pin, should give the most satisfactory performance in field test, if previous relationship of laboratory test results and field performance continues to be borne out.

Origin of Material and Object of Investigation:

On May 31st, 1944, thirty T-16 Universal Carrier track pins were submitted by Capt. V. J. Sharkey, for Director, Tanks and M.T., Inspection Board of United Kingdom and Canada, Detroit, Michigan. The pins are samples of those at present on field test at Somerville, Massachusetts. It was requested (Req. 50028, May 29th) that a metallurgical examination be carried out in order to determine the relative merits of the

(Origin of Material and Object of Investigation, cont'd) -

pins.

The pins were received in groups of six, as follows:

Group

1-a. Single V.P. 1943, SAE 3115 headed by Allied Products, heat-treated by Commercial Steel Treaters, Detroit, and sent to Auto Specialties, St. Joseph, Michigan.

1-b. Single V.P. 1944 - MM - SAE 3115, notched on each side of head, cold-headed by Allied Products, heat-treated by Commercial Steel Treaters, Detroit, and forwarded to Ford Motor Company of Canada, Windsor, Ontario.

1-c. Double V.P. 1944, Single M. SAE 3115, cold-headed by Allied Products, Detroit, and heat-treated by Cannon, Wyant and Cannon Foundry Co., Muskegon, Michigan.

1-d. Identification on head "E" 1944, NE 8620. Cold-headed by Russell, Burdsall and Ward, heat-treated by Lindberg Heat Treaters Co. of Chicago, supplied to Auto Specialties Co., St. Joseph, Michigan.

1-e. V.P. - MM on head, 1944 with grinding marks across pin head, NE 8650. Cold-headed by Allied Products Corporation, austempered by Commercial Steel Treaters Co., Detroit, and forwarded to Auto Specialties Co. for assembly into test tracks.

Diameter Measurements:

The diameter measurements shown in Table I are the average of five readings taken over the length of each pin.

TABLE I. - Average Diameter, in Inches.

Pin No.	Group 1-a	Group 1-b	Group 1-c	Group 1-d	Group 1-e
1	0.4336	0.4324	0.4330	0.4350	0.4317
2	0.4337	0.4324	0.4325	0.4348	0.4314
3	0.4345	0.4324	0.4336	0.4345	0.4315
4	0.4344	0.4328	0.4325	0.4346	0.4315
5	0.4333	0.4330	0.4328	0.4340	0.4313
6	0.4335	0.4331	0.4334	0.4345	0.4316
Group average	0.4338	0.4327	0.4329	0.4345	0.4315

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(Continued on next page)

Chemical Analysis:

The chemical analysis was determined for one pin of each group.

TABLE II. - As Found.

Group No.	Carbon	Manganese	Silicon	Nickel	Chromium	Molybdenum
	- Per cent -					
1-a ⊕	0.22	0.51	0.29	1.43	0.34	-
1-b	0.21	0.51	0.26	1.43	0.36	-
1-c	0.18	0.44	0.26	1.27	0.34	-
1-d ⊕⊕	0.20	0.83	0.29	0.60	0.53	0.24
1-e ∅	0.47	0.85	0.26	0.36	0.52	0.22

	⊕ SAE 3115 Recommended Purchasing Specification	⊕⊕ NE 8620 Specification	∅ NE 8650 Specification
	- Per Cent -		
Carbon -	0.13-0.18	0.18-0.23	0.48-0.53
Manganese -	0.40-0.60	0.70-0.90	0.75-1.00
Silicon -	0.20-0.35	0.20-0.35	0.20-0.35
Nickel -	1.10-1.40	0.40-0.70	0.40-0.70
Chromium -	0.25-0.45	0.40-0.60	0.40-0.60
Molybdenum -	---	0.15-0.25	0.15-0.25

Hardness:

Rockwell hardness values of surface and core for each pin are shown in Table III.

Case Depth:

The case depth was measured with a Brinell microscope on transverse specimens etched with 10 per cent nitric acid. Results are shown in Table III.

Bend Test:

Two pins of each type were tested with the standard bend test machine. The deflections at the first audible cracking are recorded in Table III.

Impact Tests:

Two pins of each group were subjected to the standard

(**Impact Tests**, cont'd) -

45-foot-pound-blow impact test. The impact properties were further compared by testing two pins of each group on a drop impact machine using a 50-pound weight. The results of both tests are also shown in Table III.

(Table III appears on Page 5)

Microscopic Examination:

A microscopic examination was made of transverse sections cut from one pin of each group. Figures 1, 3, 5, 7 and 9 are photomicrographs at X500 magnification showing representative core microstructures. Figures 2, 4, 6 and 8 are photomicrographs, at X250, showing case microstructures.

The microstructures at the core of the SAE 3115 pins are as follows: Group 1-a, coarse low-carbon martensite, with some ferrite at grain boundaries (see Figure 1); Group 1-b, low-carbon martensite and ferrite (see Figure 3); and Group 1-c, low-carbon martensite and ferrite.

The microstructure of the case of the SAE 3115 pins consisted of nodular martensite with scattered particles of a white constituent which is white etching martensite or retained austenite (see Figures 2, 4 and 6).

The NE 8620 cased pins (Group 1-d) have a completely low-carbon martensitic core microstructure, while the case is composed of the usual nodular martensite.

The "austempered" NE 8650 homogeneous pins have a martensitic microstructure. The amount of partial decarburization at the surface is slight, being only evident in the microstructure (Figure 10) by small particles of ferrite at the surface.

(Page 5 contains Table III.)
(Text continues on Page 6.)

(Hardness, Case Depth, Bend Test and Impact, cont'd) -

TABLE III.

GROUP	PIN NO.	SURFACE HARDNESS, ROCKWELL 'A'	CORE HARDNESS, ROCKWELL 'C'	CASE DEPTH, INCHES	BEND TEST DEFLECTION, INCHES	IMPACT TESTS: No. of 45 ft-lb. blows ⊕	IMPACT TESTS: Ft-lb. impact, using 50-lb. weight ⊕⊕	REMARKS
			- CASED PINS -					
1-a.	1	79-80	29-31	0.014	0.45			
	2	82-83	28-30	0.019	0.55			
	3	83-84	36-38	0.020		2		Failed.
	4	81-82	38-39	0.020		3		Failed.
	5	82-83	36-38	0.015			60	Broke.
	6	81-82	36-39	0.014			50	Broke.
1-b.	1	81-82	28-30	0.012	0.40			
	2	82-83	30-32	0.014	0.38			
	3	83-84	32-34	0.012		4		Failed.
	4	82-83	32-34	0.013		3		Failed.
	5	82-84	32-33	0.016			50	Passed.
	6	81-82	29-31	0.012			60	Failed.
1-c.	1	78-79	23-25	0.019	0.60			
	2	76-77	21-23	0.012	0.85			
	3	74-75	16-18	0.014		4		Unbroken.
	4	76-77	18-20	0.018		4		Unbroken.
	5	76-77	18-20	0.017			60	Passed.
	6	79-80	23-24	0.018			70	Failed.
1-d.	1	81-82	38-41	0.010	0.38			
	2	82-83	38-39	0.010	0.38			
	3	81-82	41-42	0.009		6		Unbroken.
	4	81-82	44-45	0.013		6		Unbroken
	5	82-83	39-41	0.010			70	Passed.
	6	82-83	42	0.010			80	Failed.
			- HOMOGENEOUS PINS -					
		(Rockwell 'C')						
1-e.	1	40-42	49-50					
	2	36-37	49-50					
	3	38-40	50				400	Unbroken
	4	39-40	48-50				400	Unbroken
	5	43-44	48-51				400	Unbroken.
	6	43-44	48-50				400	Unbroken.

⊕ Tests on standard universal carrier impact test machine, using 45 foot-pounds.

⊕⊕ Tests on impact testing machine used for homogeneous universal carrier pins and Canadian Dry Pin track pins.

DISCUSSION:

Cased Pins.

Surface hardness values of the cased pins, with the exception of those in Group 1-c, are above the 80 Rockwell 'A' minimum required by Specification O.A. 214.

The core hardnesses of approximately one-third of the cased pins lie within the 24-32 Rockwell 'C' range specified by O.A. 214. Those in Group 1-c are notably low, while those in Group 1-d are all above the specified maximum.

The case depths vary between 0.009 and 0.020 inch but values are fairly uniform within each group. It is interesting to note that the depths of case of all pins in Group 1-d, with the exception of one, are below the 0.012-inch minimum specified by O.A. 214.

Bend tests show that for all the cased pins the case has sufficient ductility to pass the required 0.25-inch minimum deflection. The exceptionally high values obtained for pins in Group 1-c are explainable by the low case and core hardnesses.

Drop impact tests of two types have shown the relative impact strengths of the pins to be progressively greater for Groups 1-a, 1-b, 1-c, and 1-d.

Microscopic examination has shown that there was some variation in the heat treatment given pins in each group. All pins had a normal case microstructure, of varying depth. The coarse martensite in the core of pins in Group 1-a suggests that they have been quenched from a temperature well above the upper critical. The grain-boundary ferrite present indicates some slackness in the quench. The mixture of low-carbon martensite and ferrite in the core of pins in Group 1-c shows that they have been quenched from a temperature below

(Discussion, cont'd) -
- Cased Pins, cont'd -

the upper critical of the core. This is quite likely, since Campbell, Wyant and Cannon, the heat-treaters of these pins, use a sliding quench whereby the pins are cooled from the austenizing temperature to a point above the Ar_3 of the case before quenching. This temperature is below the Ar_3 point of the core, and should the pin be left too long at the former temperature prior to quenching, precipitation of ferrite will result in the core.

This investigation has substantiated results obtained in many previous tests on Universal Carrier cased track pins. The resistance to impact is a function of the case depth, core hardness, and surface hardness. Relatively high impact strength may be obtained with high core hardness only when the case depth is low (less than 0.015 inch). Thus, the NE 8620 pins with high core hardness and a thin case had the greatest impact strength of the cased pins.*

Early pin failures due to low impact strength are to be expected in pins of high core hardness and thick case. The behaviour of the cased pins at later mileages, when failure will be due to fatigue, is not so easily predicted. Since it is now generally believed that fatigue failures very often start in the transition zone of case and core, pins of low core hardness, such as Group 1-c, would be more prone to fatigue failure.

Homogeneous Pins.

The NE 8650 homogeneous pins (Group 1-e) have a surface hardness of 36 to 41 Rockwell 'C' and a core hardness of 48 to 51 Rockwell 'C'. It is noteworthy that all pins tested in impact withstood a 400 foot-pound blow. The microstructure of

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* This does not mean that NE 8620 pins will always have high impact strength. As discussed in O.D.M.L. Report of Investigation No. 1631, April 22, 1944, pins otherwise heat-treated may have very poor bend and impact properties.

(Discussion, cont'd) -

- Homogeneous Pins, cont'd -

these pins is martensitic. The heat treatment given them was such that the salt bath temperature was kept below the martensite-forming point. They are not austempered to give a bainite structure, but are merely salt-quenched.

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Generally speaking, the NE 8620 cased pin, as heat-treated for this field test, should be the most satisfactory cased pin. The NE 8650 homogeneous pin has an impact strength of approximately five times that of the best cased pin, and about ten times that of the case; e.g., all cased pins tested in these Laboratories developed cracks in the case after a 45 foot-pound blow. With this impact strength, greater bending properties, and inherently greater resistance to fatigue, the homogeneous pin must be considered to be of higher merit than any cased pin.

CONCLUSIONS:

1. Average pin diameters were:

Group		(Inches)
1-a	-	0.4338
1-b	--	0.4327
1-c	-	0.4329
1-d	-	0.4345
1-e	-	0.4315

These are within the specified pin diameter tolerances.

2. SAE 3115 cased pins have core hardness values of 16 to 39 Rockwell 'C', surface hardness values of 74 to 84 Rockwell 'A', and case depths of 0.012 to 0.021 inch. The C. W. C. cased pin may have been quenched from below the critical of the case, which would explain the low surface hardness obtained.

3. NE 8620 cased pins have core hardness values

(Conclusions, cont'd) -

of 38 to 45 Rockwell 'C', surface hardness values of 81 to 83 Rockwell 'A', and case depth of 0.009 to 0.013 inch.

4. NE 8650 homogeneous pins have surface hardness of 36 to 41 Rockwell 'C' and core hardness of 48 to 51 Rockwell 'C'.

5. Bend test deflection for cased pins varied from 0.38 to 0.85 inch.

6. All cased pins passed the "standard" universal carrier impact test of one 45 foot-pound blow. Under impact test with a 50-pound weight, pins in Group 1-a failed a 50 foot-pound blow, while pins in Groups 1-b, 1-c, 1-d and 1-e withstood blows of 50, 60, 70, and 400 foot-pounds, respectively.

7. The NE 8620 cased pins (as this lot is heat-treated to give high core hardness and low case depth) are considered the most suitable cased pin.

8. The NE 8650 homogeneous pin, with high impact strength and fatigue resistance, should give the most satisfactory performance in field test.

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Figure 1.

X500, etched in 2 per cent nital. CORE MICROSTRUCTURE OF GROUP 1-a.

Figure 2.

X250, etched in 2 per cent nital. CASE MICROSTRUCTURE OF GROUP 1-a.

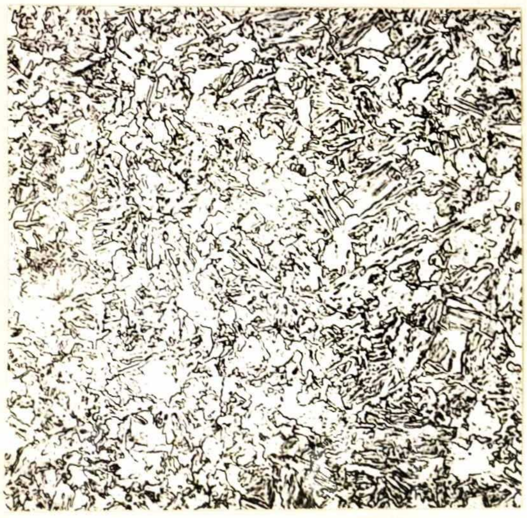
Figure 3.

X500, etched in 2 per cent nital. CORE MICROSTRUCTURE OF GROUP 1-b.

Figure 4.

X250, etched in 2 per cent nital. CASE MICROSTRUCTURE OF GROUP 1-b.

Figure 5.



X500, etched in 2 per cent nital. CORE MICROSTRUCTURE OF GROUP 1-c.

Figure 6.

X250, etched in 2 per cent nital. CASE MICROSTRUCTURE OF GROUP 1-c.

Figure 7.

X500, etched in 2
per cent nital.

CORE MICROSTRUCTURE OF
GROUP 1-d.

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Figure 8.

X250, etched in 2
per cent nital.

CASE MICROSTRUCTURE OF
GROUP 1-d.

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Figure 9.

X500, etched in 2
per cent nital.

CORE MICROSTRUCTURE OF
GROUP 1-e.

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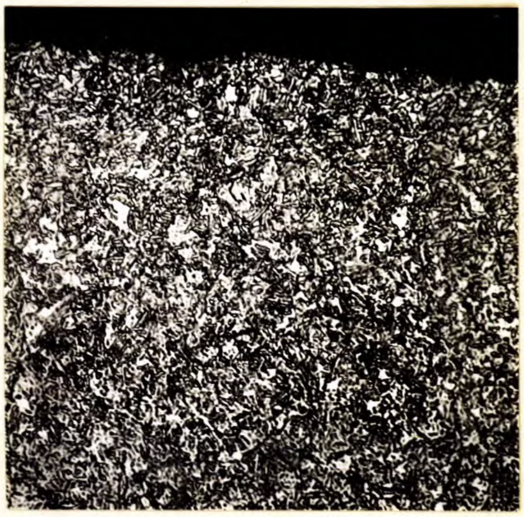
Figure 10.



X250, etched in 2
per cent nital.

MICROSTRUCTURE AT SURFACE
OF GROUP 1-e.

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