FILE COPY

OTTAWA November 28th, 1940.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 933.

An Examination of a Broken Steel Stud
from an INDIAN Motorcycle Sidecar.

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

O T T A W A   November 28th, 1940.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 933.

An Examination of a Broken Steel Stud
from an INDIAN Motorcycle Sidecar.

=======

Source of Material and Object of Investigation:

On November 19th, 1940, the office of the D.C.I.A.(G), Department of National Defence, 479 Bank Street, Ottawa, Ontario, sent in a broken steel stud from an INDIAN Motorcycle sidecar. It was noted that a number of these parts had failed in service. An examination of the broken part was requested in order to determine, if possible, the cause of the failure.

Macro-Examination:

The failed steel stud broke at the point A shown in Figure 1. It may be seen that there was a marked change in section at the point of fracture and that the fillet provided to counteract the effect of this sectional change is of very small radius.

Figure 1.

To size.

A view of the fracture at x3 magnification is shown in Figure 2. The photograph makes evident the duplex nature of the fracture, areas at "a" and "b" being smooth with the centre area at "c" being somewhat rougher. The coarseness of the machine tool marks in the neighbourhood of the fracture is also evident.

(See Figure 2 on next page)

(Macro-Examination, cont'd) -

Figure 2.

x3.

Chemical Analysis:

A sample of the steel from the stud was analysed and the following results obtained:

		Per cent
Carbon	-	0.31
Manganese	-	0.79
Silicon	-	0.20
Sulphur	-	0.021
Phosphorus	-	0.012
Nickel	-	1.36
Chromium	-	0.66
Molybdenum	-	0.06

Hardness Tests:

The hardness of the metal was determined by the Brinell method, using a 3,000-kilogram load applied for 30 seconds. Hardnesses were taken at a distance of ½ inch and 1 inch respectively from the fracture. A value of 286 was obtained in each case.

Impact Values:

A standard Izod impact test specimen was machined from the longer section of the broken stud and the following values obtained in the Amsler impact testing machine:

Notch	Impact value, ft. lb.
No. 1	75
No. 2	73

The fracture of the broken impact test specimen was fine-grained.

Microscopic Examination:

A sample of the stud was removed from a section of the stud at the fracture. It was then given a metallographic polish and examined under the microscope.

Figure 3.

x100.
Unetched.

Figure 4.

x100.
Etched in 2 per cent nital.

Figure 3 is a photomicrograph at x100 magnification of the unetched specimen and shows that the steel is fairly clean. The steel was re-examined after etching in a 2 per cent solution of nitric acid in alcohol. Figure 4,

(Continued on next page)

(Microscopic Examination, cont'd) -

a photomicrograph at x100 magnification, shows the structure of the etched material. The greater percentage of the structure consists of dark etching sorbite, the iron-iron carbide constituent. Small white particles of ferrite, the iron constituent, are also present. The steel is faintly banded, the bands running parallel to the stud surface. Figure 5 shows the structure at x1000 magnification.

Figure 5.

x1000.
Etched in 2 per cent nital.

Discussion of Results:

Macro-Examination -

The duplex nature of the fracture shows that the break was produced by the action of alternating stresses. Progressive failure occurred across the smooth areas, the smoothness being produced by wear in service. Impact stresses caused the final failure across the rougher central areas. The deep tool marks and the small fillet radius

(Continued on next page)

(Discussion of Results, cont'd) -

(Macro-examination, cont'd) -

at the change in section are defects in a part subjected to the action of alternating stresses, as they function as stress raisers and as such allow for the institution of fatigue cracks.

Chemical Composition -

The stud steel composition was within the limits specified for S. A. E. Steel 3130. Woldman, on page 215 in his book "Engineering Alloys", states that this steel when oil quenched and drawn to a maximum hardness of 293 is used in automobile parts such as shafts and studs. The type of steel, then, may be regarded as satisfactory. The low sulphur and phosphorus contents show that the steel was properly made.

Hardness and Impact Tests -

The stud hardness is only slightly below the maximum given by Woldman. The notch sensitivity of a material, i.e., the manner in which the fatigue properties of a steel are affected by stress raisers such as surface imperfections, is directly proportional to its hardness, as the softer material deforms plastically and by so doing lowers the stress concentration. It is considered that the stud steel is sufficiently hard to be sensitive to the effect of the rough machining marks and the sharp filleting present at the point of fracture.

The steel has excellent impact properties. The fine-grained fracture of the impact test specimen shows that failure cannot be attributed to the use of a coarse-grained steel. An International Nickel Company property chart for

(Discussion of Results, cont'd) -

(Hardness and impact tests, cont'd)—

S. A. E. 3130 steel oil-quenched from 1500 - 1500° F. shows that a drawing at 900° F. produces hardness and impact properties similar to those of the stud steel. The following physical properties also would be expected:

Ultimate stress, p.s.i.	Yield point, p.s.i.	Elongation in 2 inches per cent	Reduction in area, per cent	Fatigue strength in reversal flexture, p.s.i.
146,000	115,000	17.0	58.0	73,000

Microscopic Examination -

The cleanness of the steel indicates that it was carefully made. The slight banding of the structure and the presence of small particles of ferrite in the sorbite definitely show that the steel was quenched from under its upper critical temperature, for if the steel had been quenched from around 1500° F. it would have had a uniform sorbite structure. The presence of ferrite in the steel may affect the resistance of the stud to the action of alternating stresses, as fatigue cracks may be initiated at these low-strength ferrite areas. It is considered more likely, however, that the crack started in the harder, more notch-sensitive material.

Summary and Conclusions:

An examination of the fracture showed that failure had been caused by the action of alternating stresses, that

(Summary and Conclusions, cont'd) -

the part was roughly machined, and that there was only a small radius fillet at the change of section where the fracture occurred. The steel was found to be of satisfactory composition, and hardness and impact tests indicated that it had satisfactory physical properties. Microscopic examination showed that the steel was clean and made up of sorbite in which there were small bits of ferrite. The presence of ferrite indicates a quench from too low a temperature.

The ferrite in the structure is a minor defect which quenching from a proper temperature will remove. Rough machining and sharp filleting are considered to be defects, as the steel is sufficiently hard to be notch-sensitive. If it is not possible to avoid this condition it would be better to draw the steel at a higher temperature, as the softer article so produced, while lower in fatigue strength, is less notch-sensitive. However, a finer finishing and more generous filleting are recommended. Should this not remedy the trouble an increase in the cross-section is recommended. If this is unpractical, the fatigue strength of the part could be increased by drawing at a little lower temperature. The hard material so produced would be more notch-sensitive, however; consequently the part would require more careful machining and filleting. Such finishing may not be possible in production and in this event the only alternative is to

(Continued on next page)

(Summary and Conclusions, cont'd) -

make the part from a higher alloy and consequently a higher fatigue strength steel.

oooooooo
oooo
oo

NBB:PES.