LPD Lab Services

Metallurgical Examination of Jigsaw Blades for Cutting Aluminium alloy

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Danie Els

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LPD Lab Services Limited
Suite 1, D Building
Glenfield Business Park
Philips Road
Blackburn
Lancashire, BB1 5RZ
United Kingdom
www.lpdlabservices.co.uk
enquiries@lpdlabservices.co.uk
Tel 01254-676074
Fax 01254-278845

Contact Name – Client Company Name
Address
Postcode

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1 Introduction

LPD Lab Services received three jigsaw blades for metallurgical examination from a boat manufacturer. The client claimed to have cut 4 mm thick aluminium alloy plate and that the blades were destroyed after cutting a short distance. It took three blades to cut 200 mm where one blade used to cut many sheets without any problem.

This report discusses the results of optical microscopy, hardness testing and chemical analysis performed on the jigsaw blades. Retrospectively, the client was requested to supply a sample of the new aluminium alloy sheet that could not be cut, as well as a sample of the previous aluminium alloy sheet that presented no problem in cutting. Hardness tests were performed on the aluminium alloy sheet samples. The purpose of this work was to understand why the blades could not cut the new aluminium alloy sheet, but had no difficulty in cutting the previous aluminium alloy sheets.

2 Sample Preparation/Method Details

Visual and magnified optical examinations were performed on the blades. This facilitates the study of macro features that can help to identify the nature of the failure and any factors that could have contributed to the failure.

A section was taken from across the middle of one of the blades. The cross-section was encapsulated in phenolic resin, metallographically polished and then etched in a 3% nitric acid aqueous solution. Examination of the microstructure was done at magnifications up to 500x using a Zeiss Axioskop-40 microscope.

Vickers hardness measurements were performed on the jigsaw blade and aluminium alloy sheet materials. A Vickers-Armstrong B59153 hardness tester using a 30 kg load was used for the blade material, and a Buehler Micromet II hardness tester using a 100 g load was used for the aluminium alloy samples. Testing was performed according to BS EN ISO 6507.

A sample of one of the jigsaw blades was chemically cleaned, acid digested and then analysed by means of inductively coupled plasma optical emission analysis (ICP-OES) to determine the chemical composition. The carbon and sulphur content were determined by combustion.

The optical examination, the metallographic assessment and hardness tests were performed on the 4th of November 2024, and the chemical analyses were performed on the 6th of November 2024.

3 Results and Comments

3.1 Visual Examination

The jigsaw blades received for examination are shown in Figure 1, and a closer view of the affected areas on the blades are shown in Figure 2. The middle third of the teeth on each blade was encased in a layer of smeared aluminium alloy adhering to the teeth.

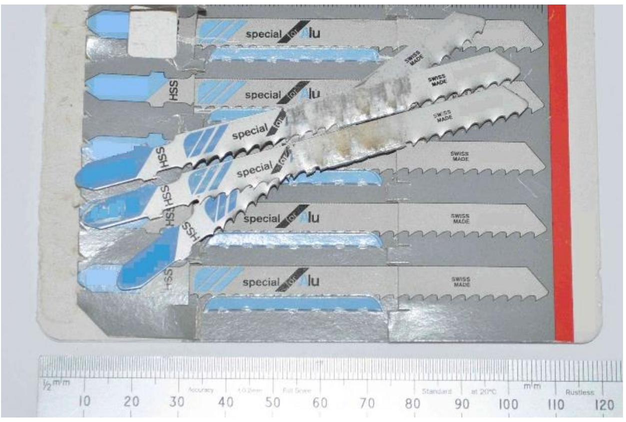

Figure 1. The received jigsaw blades.

Figure 2. The affected areas of the jigsaw blades.

3.2 Optical Microscopy

Magnified optical examination of the affected areas on the blades confirmed that the teeth were encased in deformed aluminium alloy, as shown in Figure 3 and at higher magnification in Figure 4. This clogging of the teeth would have made it impossible for the blades to cut.

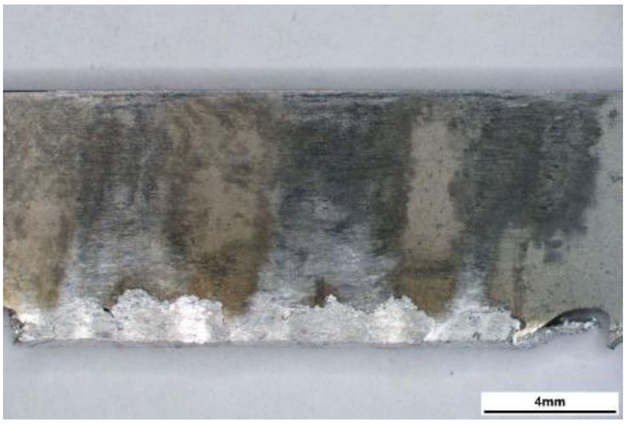

Figure 3. A lower magnification of the affected area on a blade.

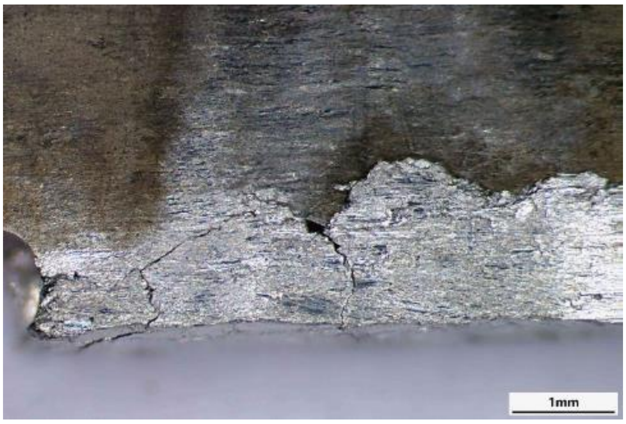

Figure 4. A higher magnification of the affected area on a blade.

An attempt to push the aluminium alloy off the blade, using a needle point file, proved to be successful, with some force, as shown in Figure 5. The aluminium alloy appeared to have cold welded onto the sides of the teeth. Figure 6 shows three of the released aluminium alloy fragments lined up to mimic the pattern of the teeth from which they were liberated.

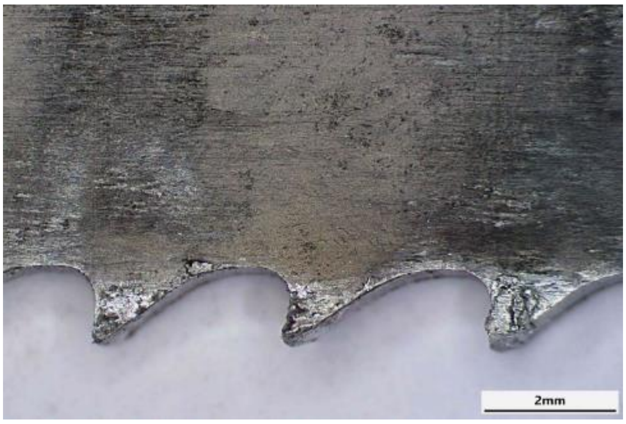

Figure 5. The teeth from which most of the aluminium alloy was removed.

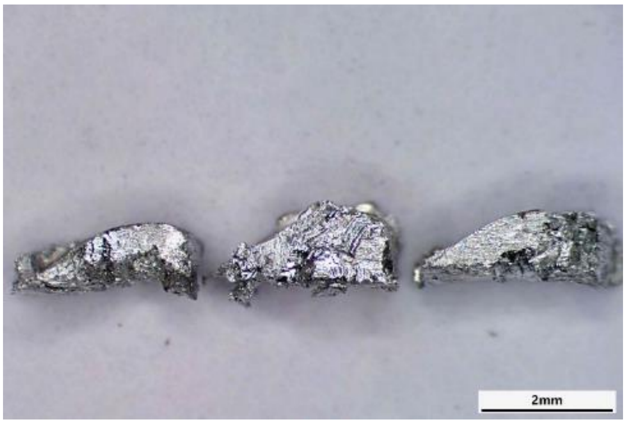

Figure 6. Some bits of aluminium alloy removed from the teeth.

The aluminium alloy did not cut very well. Instead, it adhered to the blade and clogged up the gaps between the teeth, thereby making it impossible for the blade to cut. Removal of the aluminium alloy from the teeth revealed that the teeth were not damaged and were, indeed, still sharp.

3.3 Metallographic Examination

Examination of a metallographically prepared section from one of the blades revealed very fine grains of tempered martensite with randomly dispersed primary carbides, typical of high speed tool steel. No irregularities were observed. A photomicrograph is shown in Figure 7.

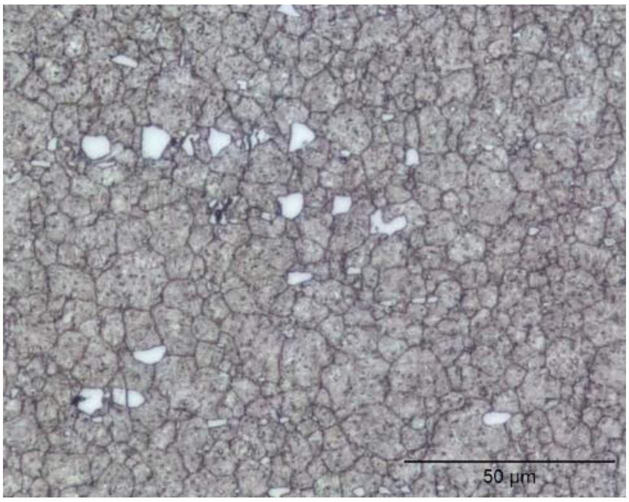

Figure 7. High magnification photomicrograph of the jigsaw blade's microstructure.

3.4 Chemical Compositional Analysis

Table 1 presents the chemical analysis results. The chemical composition of the blade material was typical of high speed tool steel and it matched the compositional requirements for EN ISO 4957 material HS3-3-2.

Table 1. Chemical analysis results (wt%).

Element	**Blade Material**	**EN ISO 4957:1999 Steel HS3-3-2**
Carbon	0.98	0.95-1.03
Silicon	0.39	0.45 maximum
Manganese	0.35	-
Phosphorous	0.02	-
Sulphur	0.02	-
Chromium	3.94	3.80-4.50
Molybdenum	2.70	2.50-2.90
Vanadium	2.32	2.20-2.25
Tungsten	2.80	2.70-3.00
Cobalt	0.96	-

3.5 Hardness Testing

Table 2 presents the hardness test results. The hardness of the blade material was the same as that prescribed by EN ISO 4957:1999, 746 HV[1] (62 HRC). The new aluminium alloy sheet was significantly softer that the usual aluminium alloy sheet. This significantly low hardness of the new aluminium alloy sheet was the reason for it not cutting as easily as the harder aluminium alloy previously used by the client.

Table 2. Results of the hardness tests in Vickers.

Test	**Results (HV)**		
	Blade	**Typical Sheet**	**New Sheet**
1	743	40.4	28.8
2	746	40.7	28.4
3	744	40.0	28.5
Average	744	40.4	28.6

[1] Converted using Table 2 of ASTM A370.

4 Conclusions

From the test results it was discovered that the jigsaw blades were not at fault, and that the blades were, when removing the adhering aluminium alloy, still intact.

The cause of the difficulty to cut the plate was the softness of the new aluminium alloy plate which required a different approach, compared to the usual harder aluminium alloy, for hassle free cutting.

5 Recommended Next Steps

Firstly, it would be prudent to ensure that the procured aluminium alloy sheet, which was softer than usual, was in fact the correct material.

Secondly, when cutting soft aluminium alloy, there are two additional steps to be taken in order to facilitate the cutting process:

- Use a lubricant, like WD-40 or 3-in-1 oil, to help prevent the aluminium alloy from adhering to the blade and to reduce friction.
- Try to cut at a faster speed (i.e. the rate going forward) to reduce the heat created by friction between the blade and the aluminium alloy plate (caused by the oscillating motion of the blade).

Primary Author: Danie Els MSc MIMMM
Function: Senior Metallurgist

Signature: ________________
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End of report