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1. Ferenc VARNYÚ, 2. Péter SZUCHY

EPEE WEAPON GUARD MATERIAL TESTING

1-2. Technical Institute, Faculty of Engineering, University of Szeged, Szeged, HUNGARY

Abstract: PBT Hungary Kft. had problems during choosing and shaping of epee weapon guard's material. As they requested we examined three different sort of aluminium alloy that were supplied by an Austrian material trading company only with trading signals. We produced the material constitutions, the tensile test and the hardness on both side of the 1.5 mm thick plates. Based on these data we identified the alloys then we made suggestions for the material choice and shaping procedures.
Keywords: epee weapon guard's material, tensile test, hardness, aluminium alloys

1. INTRODUCTION

PBT Hungary Ltd. produces fencing accessories since 1991 on its plant in Békéscsaba, epee guard too, among of them (Figure 1). The tubby part of the guard is manufactured by deep drawing on a deep drawing machine specially specifically adapted for this goal (Figure 2) followed by other manufacturing steps (that are out of our scope). The function of guard is to protect the hand of the fencer against the opposer's weapon, therefore it has to be light but excessively resistant against dynamic strain. Beside of these the most important features are easy shaping, attractive outfit and advantageous cost.

Figure 1. Epee guard

Figure 2. Deep drawing machine with tools

Now the company uses EN AW-2017A [AlCu4MgSi] aluminum plate, but beside the long standing material they continuously seek after producing new and better quality guard, so it tests regularly different materials and producing technologies. A Viennese trader suggested test two other aluminum plates without giving the material constructions, but he provided some plate for testing. The deep drawing tests were successful only with one of these plates, they could not manufacture the other plate by the used technology, and the material always broke out. The successfully manufactured guard was not strong enough. We were asked to find solution for the problem.

2. MATERIAL TESTS

First of all we identified the two new plates, than we measured their physical features (Vickers hardness, yield stress, tensile strength) that are important for material shaping. We have got only 1-1 piece

110x110x1.5 mm plates for the tests, so we produced 2-2 pieces non-standard size tensile specimens. Hereafter the plates of two kind are signed by Nr.1 and Nr.2, and the former used plate Nr.0.

2.1. Identification of material composition

The alloy composition tests were made by OXFORD X-MET 5000 portable X-ray fluorescence (XRF) analyzer. This instrument is able to recognize a lot of important elements (Fe, Cu, Cr, Zn, Pb, Mn, Ni, Co, Mo, Ta, W etc.) by single shot, and Al, Si, P, S without vacuum or He attachments.

The result of analysis was determined by the reference data base according to the EN 573-3:2013 Chemical composition of aluminum semi-products standard stored in the analyzer. We tested both Nr1. and Nr2. plates (results in Table 1).

Table 1. Material composition analysis results

Measured	Nr1. plate = Al 2024			Nr2. plate = Al 5083		
elements	Conc.	STD	Limit	Conc.	STD	Limit
Cr	0.00%	0.016	0.00-0.10%	0.05%	0.013	0.05-0.25%
Mn	0.63%	0.029	0.30-0.90%	0.45%	0.022	0.40-1.00%
Fe	0.42%	0.024	0.00-0.50%	0.27%	0.013	0.00-0.50%
Ni	0.04%	0.002	0.00-0.05%	0.02%	0.001	0.00-0.05%
Cu	4.63%	0.047	3.80-4.90%	0.06%	0.003	0.00-0.10%
Zn	0.24%	0.009	0.00-0.25%	0.02%	0.002	0.00-0.25%
Pb	0.01%	0.002	0.00-0.05%	0.00%	0.001	0.00-0.05%
Reference:	Aluminum ID/2014			Aluminum ID/5083		
cursive: elements are not mentioned in standard						
More specifications in standard						
Mg			1.2-1.8%			4.0-4.9%
Si			max 0.5%			0.0-0.4%
Ti			max 0.15%			0.05-0.25%

So the Nr1 plate was identified as EN AW-2024 T3 [AlCu4Mg1], the Nr2 plate as AW-5083 H111 [AlMg4.5Mn0.7]. T3 means: naturally aged, with relaxing thermal treatment. H11: cold formed, in soft condition.

For the identified materials the following physical features are available (Table 2) [www.albau.hu/informaciok.htl, downloaded: 09. august 2015.].

Table 2. Published physical features of materials

Nr.	Material	Condition	Tensile strength (MPa)	Yield stress (MPa)	Strain (%A5)	Hardness (HB)
0.	EN AW-2017A	T4	385	245	12	95
1.	EN AW-2024	T3	440	290	13	110
2.	EN AW-5083	H111	280	125	17	70

2.2. Hardness measurment

The hardness measurements were executed by NEMEZIS 9000 universal hardness testing equipment (Figure 3) on both sides of plates. There was a problem with the thickness of the plates, 1.5 mm plate thickness is not enough for correct measurement, so we examined the hardness data as referring information to each other not as absolute hardness values. There were 5-5 measurements executed on each sides.

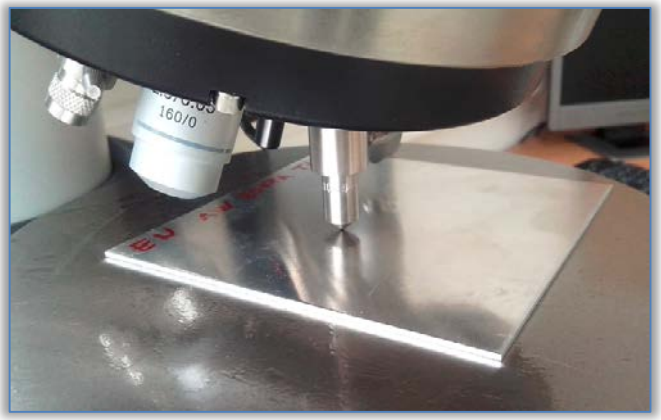

Figure 3. NEMEZIS 9000 hardness measuring equipment

Plate Nr.1 on written side: average: 47.07HV; standard deviation: 5.17 (Figure 4). Plate Nr.1 on non-written side: average: 40.21HV; standard deviation: 1.19 (Figure 5). Plate Nr.2 on written side: average: 18.4 HV; standard deviation: 0.36 (Figure 6). Plate Nr.2. on non-written side: average: 31.76 HV; standard deviation: 0.29 (Figure 7).

Based on the hardness measurements it is obvious that the Nr2. Al5083 plate's both sides are softer then the Nr1. plate, adequately to technical literature (Al2024: 110HB, Al5083: 70HB) [www.albau.hu/informaciok.htl downloaded: 09. August 2015.]

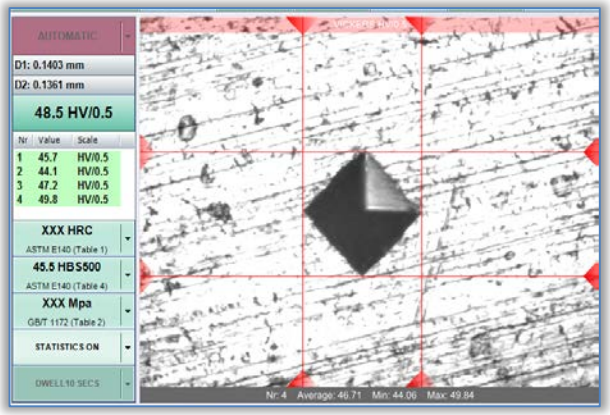

Figure 4. Plate Nr.1. Vickers hardness measurement series on written side

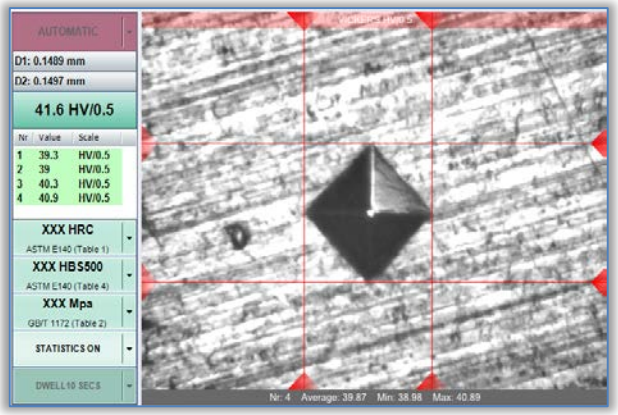

Figure 5. Plate Nr.1. Vickers hardness measurement series on non-written side

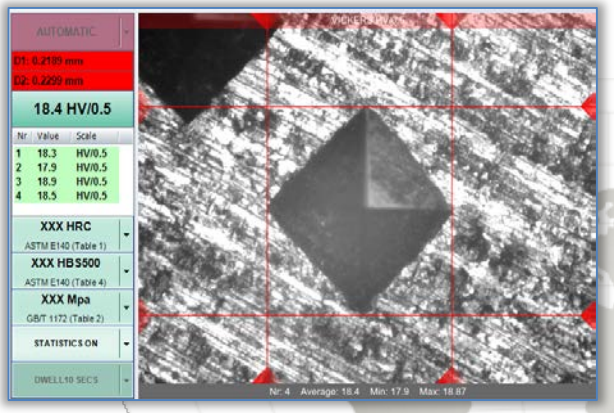

Figure 6. Plate Nr.2. Vickers hardness measurement series on written side

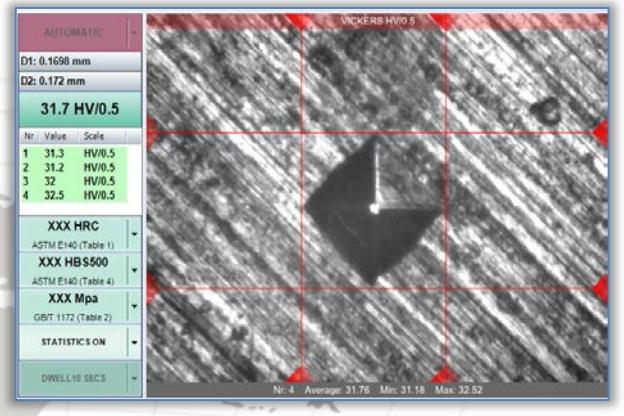

Figure 7. Plate Nr.2. Vickers hardness measurement series on non-written side

2.3. Tensile test

The tensile tests were executed by QUASAR 100 bench. 2-2 tensile test specimens were produced by end milling. The specimen's overall length was 110 mm, reduced section was 50x15x1.5 mm, grip sections were 25 mm wide.

The tensile test diagrams of the plate Nr1. are shown on Figure 8. The measured values approached the literature data: 421.18 N/mm², 422.61 N/mm², published 440 N/mm².

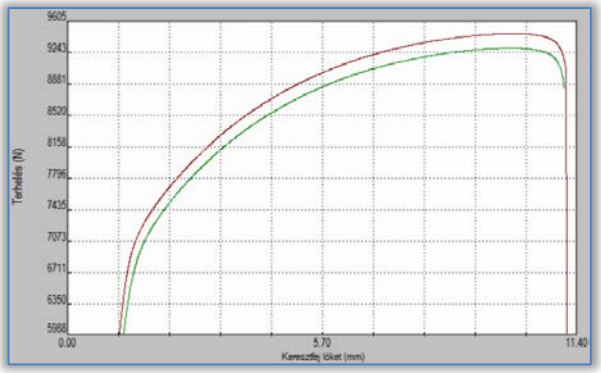

Figure 8. Plate Nr.1 tensile test diagrams (X axis: Elongation, Y axis: Load)

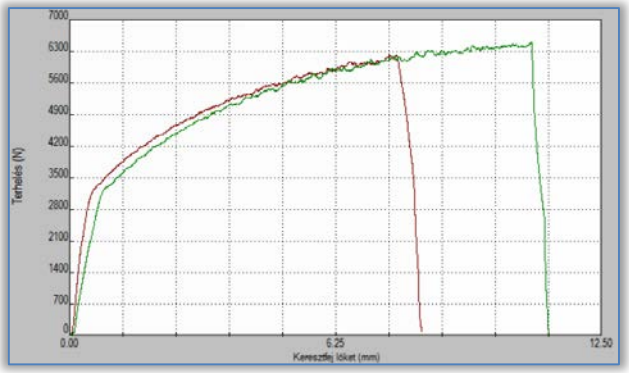

Figure 9. Plate Nr.2 tensile test diagrams (X axis: Elongation, Y axis: Load)

The tensile test diagrams of the plate Nr 2 is shown on Figure 9. The first specimen was tore a little bit later as it was expected (289.87 N/mm²), the 2 specimen's result (277.93 N/mm²) was near to the literature data (280 N/mm²).

3. CONCLUSIONS

Notes for the identified materials from its producer:

1. EN AW-2024 T3 [AlCu4Mg1] is a highly alloyed plate with higher tensile strength, marked out for automobile, airplane, instrument industry. On the field of machine engineering it is the essential

aluminium alloy for wear-resistant, tough parts. Weldable with its own material, after welding it is susceptible for cold-cracking. Due to its high Cu content its surface can be treated but only limited decoration result can be achieved and its corrosion resistance is not the best.

2. EN AW-5083 H111 [AlMg4.5Mn0.7] is a medium alloyed aluminium plate. It has the highest strength as a natural, hot-rolled plate, even so it can be well bent, welded and manufactured. It substitutes well the AlMg5 alloys, as its multiple usage this is the highest quantity aluminium alloy used worldwide. Its machinability easy with both HSS and HM tools. It can be well anodized for surface protection, but its colour and hard anodizing is limited.

The AW-2014 is highly alloyed plate, the AW-5083 is medium alloyed plate. The measured material features indicate the difference as well. For substitution of the presently used EN AW-2017A plate the EN AW-2014A, EN AW-2024 plates were suggested.

For further tests we recommended two other types of aluminium plates:

1. EN AW-6082 T6 [AlSi1MgMn]its strength is higher than medium
2. EN AW-7022 [AlZn5Mg3Cu] and EN AW-7075 [AlZn5.5MgCu] high alloyed aluminium plates.

In this job we were asked by the producer to help choosing material for epee weapon guard. The purchaser advised him two new materials without detailed description. We analysed and recognised the suggested materials and compared them to the used one with their advantages and disadvantages as well.

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