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STATUS OF SURFACE AND MICROSTRUCTURES IN PRODUCTS MADE OF EXTRUDED ALLUMINIUM

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ABSTRACT
This paper gives research results about commercial examination of aluminum alloy-based products according to industrial standards. Results of metallographic tests of extruded aluminum microstructure shown in this paper indice that irregular deformation of material leads to microstructure variations through certain zones of the product. That influences mechanical properties, and it can even be the main cause of indications obtained by penetrants.
Keywords: aluminum, microstructure, surface

1. INTRODUCTION
Table 1 shows requirements which semi-product must fulfill to get the final product with proper plasticity and properties required by quality assurance standards.

Table 1. Maximum deflection in [mm] for various supporting layouts

N°	Required conditions	Influences and defects
1	Plasticity, Mechanical properties	**The type of production**: sources of raw materials, furnace systems, melting system **Chemical structure of the alloy**: contents of alloys and imperfections **Structure**: cast blocks, rolled, forged or drawn products
2	Semi-product quality, Especially surface quality	**Defects during metal production**: porosity, lunker remnants, rough dendrite structure, coarse-grained structure **Defects during plastic processing**: scabs, stains, scratches, distortion wedges, orange surface **Defects during heating and annealing**: intercrystal corrosion
3	Shape and tolerances	Imperfect profiles, unequal wall thickness, tolerance errors
4	Uniform structure and quality	Brittle precipitation over grain boundaries, surface roughness, material change

Figure 1 shows defects on metallic semi-product surface, which can have negative influence onto final product quality. Defects such as shallow cracks are allowable, and can be removed by grinding. Scabs and stains on the surface of stamped and rolled products can appear because of rough surface of castings. Rough surface occurs due to swamping of melted metal, overflowing or roughness of mold walls. Scales and patches, which appear on surfaces of rolled products periodically, are caused by defects on rolling cylinders.

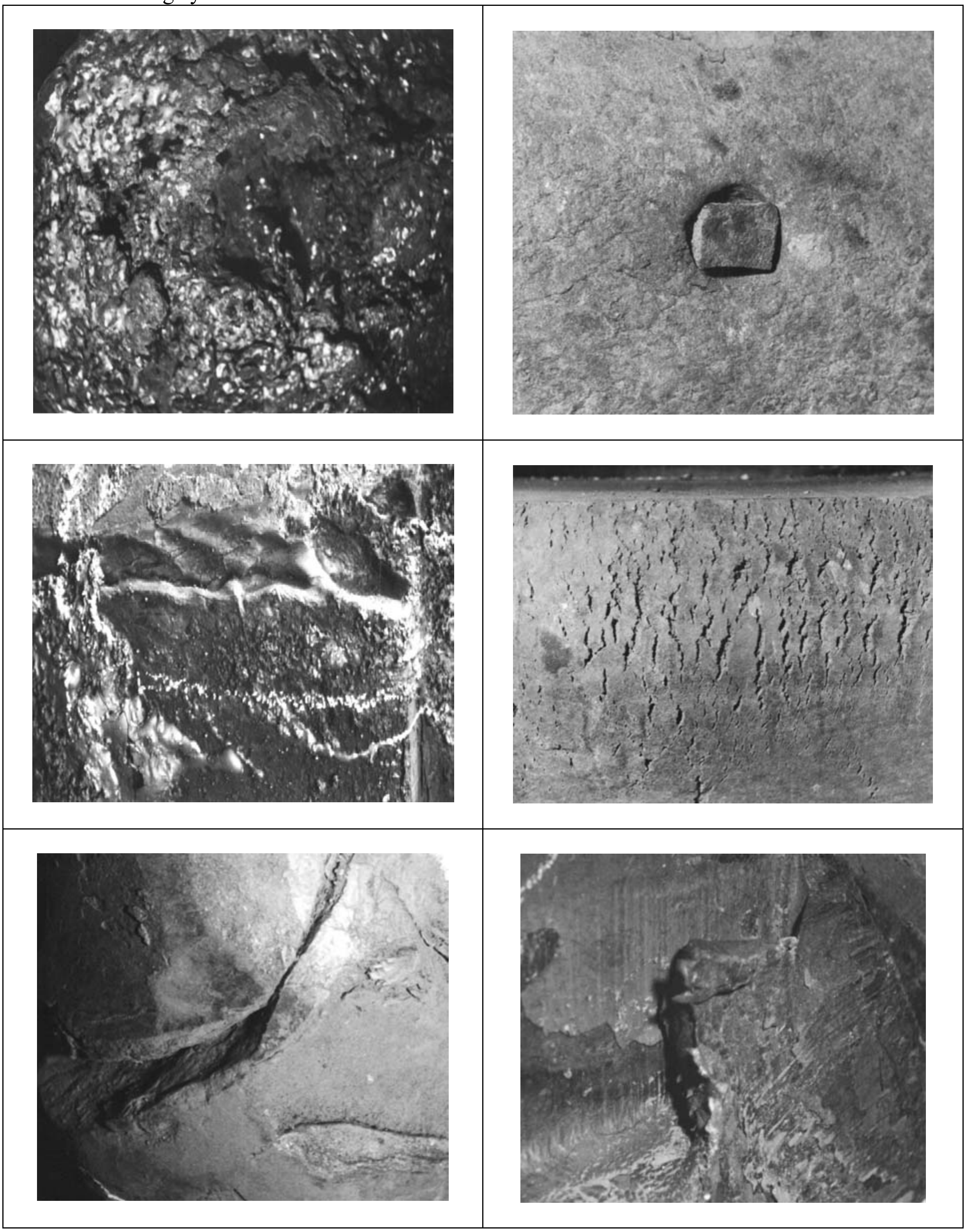
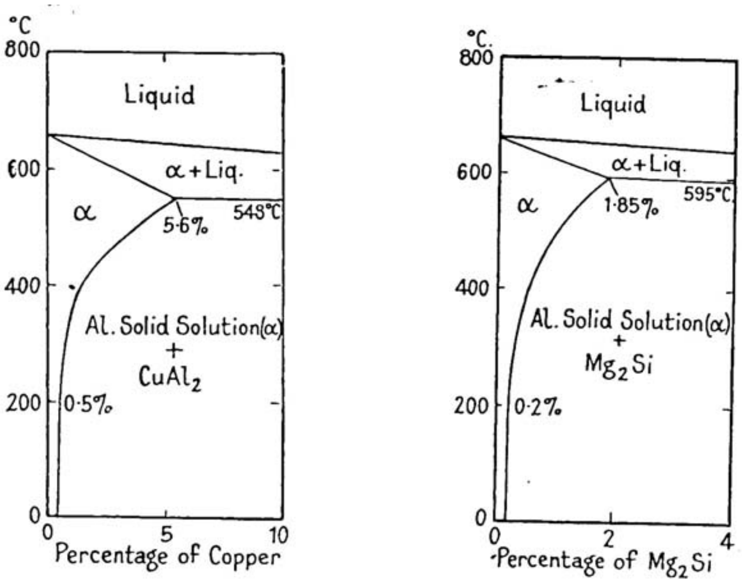


Figure 1. Surface defects on metallic semi-products.

Alloys for squeezing contain brittle, eutectic or peritectic crystals (Fig. 2.a), crushed and distributed in the basis of multiple alloyed solid solution (Fig. 2.b). The Alloy is in pressed state and it did not solidify.



a) b)

Figure 2. Phase diagrams of Al-Cu (fig. a) and Al-Mg (fig. b) alloys.

In most cases, even experienced tester can not use etching method to identify various types of crystals due to complexity of effects during crystallization which occur in multi-component alloys, and because of the fact that triple and multi-component alluminials act similarly during etching.

2. MATERIALS, METHODS AND RESULTS

Tests shown in this research are performed on extruded thin-walled products made of aluminum alloy, produced of rod-shaped material according to commercial procedure and industrial standards. Following tests were performed: dimensional control, surface test by penetrants, mechanical tests – hardness and tensile strength, along with metalographic tests.

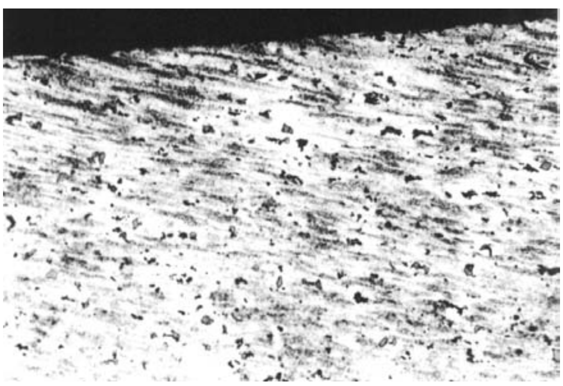
Results of dimensional control show different values on particular measurement locations on the single product. The largest deviation of wall thickness is 0.015 mm, and minimum deviation is 0.095 mm.

The penetrate test (Tiede – Pen AP-1) showed linear axial indications varying length at most products. These indications are 3 to 100 mm in length. More detailed microscopic investigations were performed in order to explain the cause for these indications.

Hardness test results showed acceptable results, opposed to unacceptable tensile strength test results.

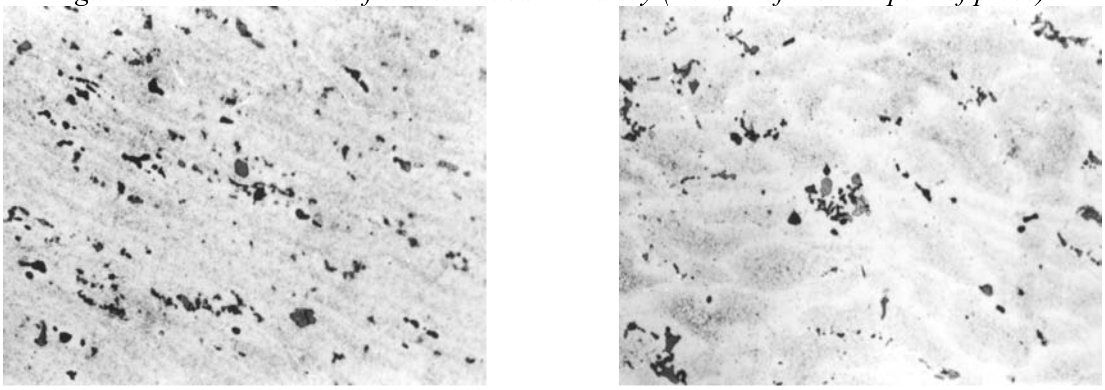
Microscopic investigations over the inner surface of thin-walled specimens indices horizontal, parallel, shallow cracks. Pitting appeared on both sides of the product (internal and external surface) maximum 3 μm deep on external surface, and approximately 20 to 30 μm deep on internal surface of the product.

Results of metallographic tests are shown in figures 3 and 4.



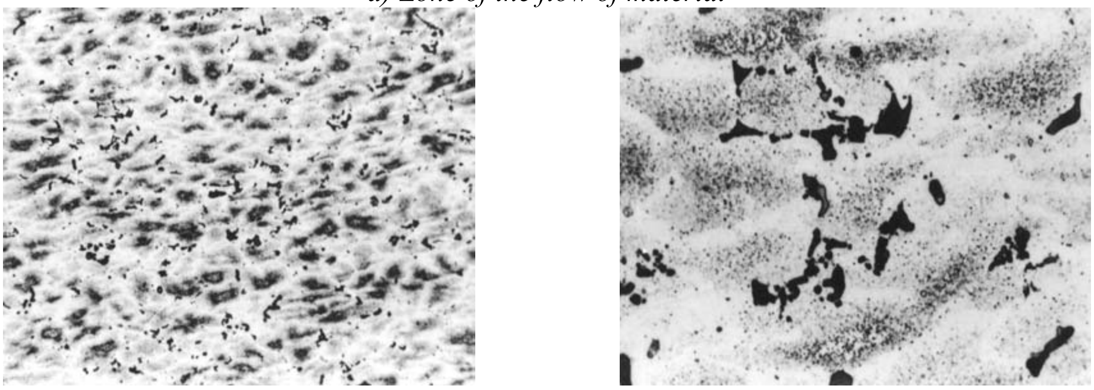
x 125

Figure 3. Microstructure of one extruded Al – alloy (Border of the thin part of piece).



x 325 *x 625*

a) Zone of the flow of material



x 125 *x 625*

b) Flawless zone of material

Figure 4. Microstructure of one extruded Al – alloy.

Microstructure of all products contains precipitated particles of Zn, Mg and Cu over the grain boundary in multiple alloyed solid solution based on aluminum. Allocation of precipitated particles shows the flow of metal during processing (Fig.3, 4). Larger microscopic investigations do not show optically significant difference in microstructure continuity in grains with intensive material flow opposed to microstructure of grain with less deformation.

3. CONCLUSION

According to results obtained in this research, it can be said that there were irregular distribution of deformation in the material during processing of tested aluminum alloy. This lead to variations in microstructure over particular zones of the product with different level of deformation, which influenced also mechanical properties, such as tensile strength, which is below allowable limit. These differences in structure can be result of varying stress distribution inside the specimen, which is caused by frictional forces between the surface of the die and extruded material. Besides differences in microstructure, it is usually said that irregular deformation most commonly causes indications obtained by penetrate tests and small cracks noticed in stereo-microscopic investigations.

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