THE MATERIAL CHARACTERISTIC AND THE DEFORMATION DEVELOPMENT BY MAGNESIUM PLATES IN THE AREA OF ITS CRITICAL STATE

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Abstract

The Magnesium alloys play significant role in the weight lowering of the means of transport. The principal difference between forming the magnesium alloys and steel is temperature used by magnesium. Although some forming operations of magnesium alloys can be done at room temperature, elevated temperatures are used in most applications. Because of the hexagonal close-packed crystal structure, the cold forming of magnesium alloys is restricted to mild deformation and generous bend radius. The magnesium plate is due to its lack of slipping systems hardly cold formable when the slip realizes itself only in basal planes. However, the slip takes place in pyramidal planes from 225°C as well. Formed magnesium alloys can be used as either BIW parts or the dashboard carrier in the automotive industry. AZ31 alloy is commonly used for such purposes. When considering the use of magnesium plates in BIW structure, a material characteristic verification were needed, which the stress-strain tensile test in temperature camera and strengthening curves. Such results serve to further design of pressing tool construction.

Keywords: Magnesium alloys, hexagonal close-packed, slip planes, crystallographic texture, Hot forming

1. INTRODUCTION

Contemporary bodywork of a motorcar generally consists of steel sheets of different qualities, including sheets for skin panels or maximally strong sheets. It is very popular nowadays to use aluminium sheets mostly for outer parts. Apart from these materials magnesium sheets used for both surface and structural components could play in the future an important role in the further reduction of the weight of the bodywork. Magnesium and its alloys crystallize in hexagonal close-packed structure (HCP). Magnesium density near room temperature 20°C [1] is 1.738 g/cm^3 which is 4.5 times lower compared to steel and 1.5 times lower compared to aluminium. Young´s modulus for magnesium is E_{Mg}=4,2*104 MPa [1]. Young´s modulus for magnesium is considerably lower than for steel (E_{steel}=2,1*105 MPa). It is therefore necessary to take this into consideration when forming components and proportionally increase the thickness of the stamped parts. The Fig. 1 represents the comparison of the mechanical properties of different material types.

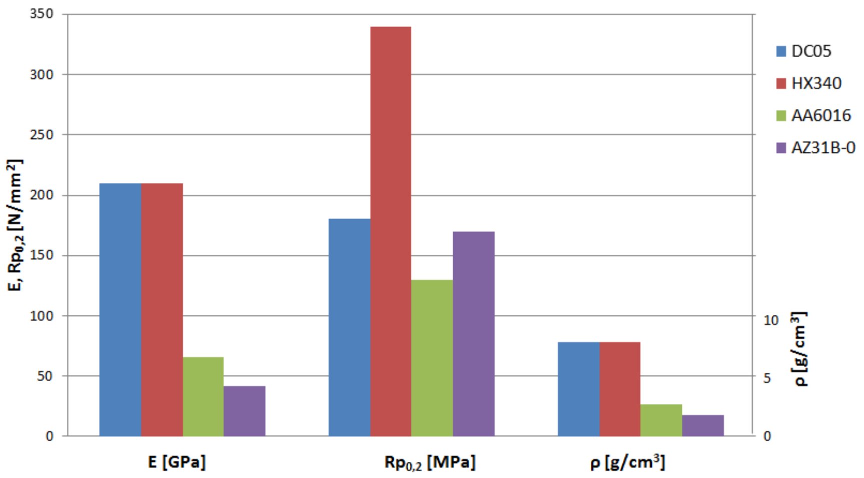


Fig. 1 Young´s modulus, elastic strength and specific weight for steel (DC05, HX340), aluminium (AA6016) and magnesium (AZ31B-0) plates [1]

1.1. Production of magnesium sheets

The rolling of different character is used to produce magnesium sheet products. The sheet is made of slabs in several steps of hot rolling and interstage amnealing. Thanks to the change in thickness and heat processing the original primary texture (grain size 70 – 800 μm) is reshaped into a mild, even secondary texture (grain size 7 - 15 μm). Only plates are produces in this process. The above described process is, however, extremely costly due to multiple interstage amnealing. To face this expensive aspect the continuous process of rolling from meltage has been used to produce the magnesium sheets. The principle of the production line constructed by Magnesium Flachprodukte GmbH, Freiberg in Germany see fig. 3. [2] is given as an example.

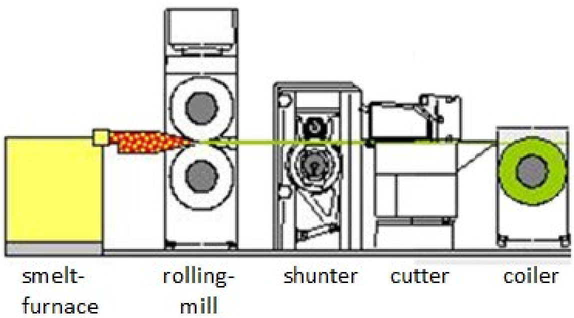


Fig. 3 Rolling process melt metal [2]

The substantial difference between those two processes is the fact that when the process of the rolling of the meltage alloy is used you can directly get a broad strip of a roll , rolled at high temperatures with the definite size in the x/cross section. The advantages of the production of the strips directly from meltage alloy are [3]:

- fast congealing,
- reduction of segregation,
- possibility of continuous production proces,
- reduced layout of the production line,
- energy saving.

1.2. Stamping tools

The sheets from magnesium alloys as well as other alloys with hexagonal crystal lattice are much better processes at higher temperatures due to the existence of additional slip planes. Thanks to this fact plastic deformation is reached more easily. This process is also typical of practice. The production equipment used to produce the pressings from magnesium sheets is identical with the production from other steel materials. The requirements for tools and the process of pressing itself differ due to the production at higher temperatures. Pressing with solid punch (**Fig.2**) and pressing into liquid (**Fig.3**) belong among the most frequent methods. Moulded sheet is the most frequently pre-heated by induction heating. [3]

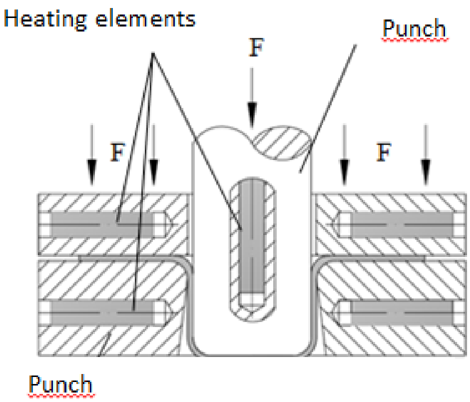


Fig.2 Solid punch and with heating elements [2]

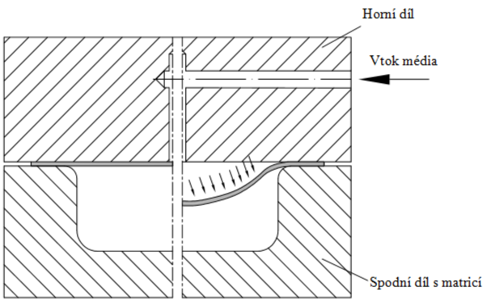


Fig.3 Pressing into liquid [2]

2. EXPERIMENTAL PART

Mechanical properties tests were carried out at temperatures 20 °C, 100 °C, 230 °C, 280 °C. The samples were taken in the direction of 0°, 45° and 90°. Stress-strain tensile test was carried out at Tira Test 2300 device in temperature camera, where the required warming up of the sample was reached. The warming up samples reached the required temperatures. The results can be seen in **Fig. 4** and in **Table 1**.

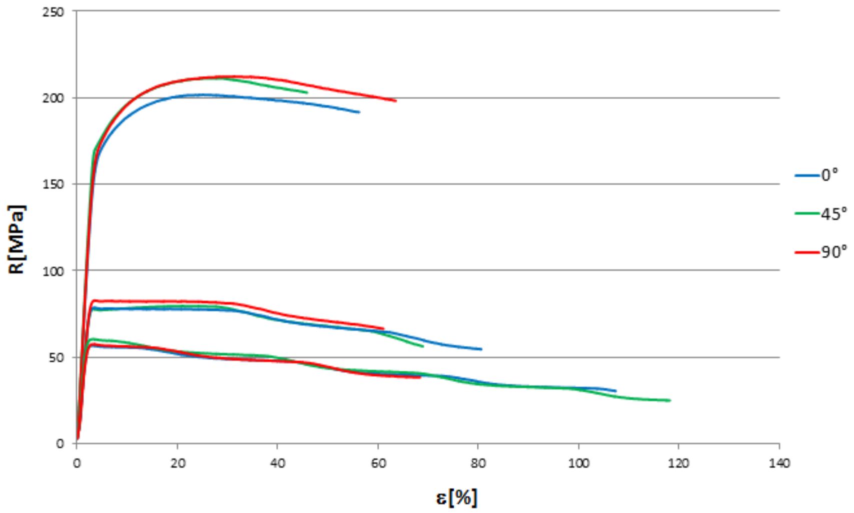


Fig. 4 Mechanical properties in dependence on temperature and direction of rolling

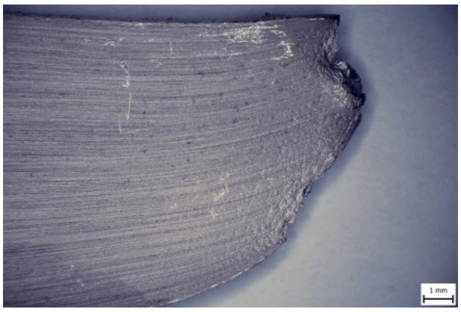
Table 1 Mechanical properties of alloy AZ31, temperatures 100°C, 230°C, 280°C, direction of rolling 0°

T [°C]	R_m [MPa]	R_e [MPa]	A_{80} [%]
20	263	179,5	19,78
100	203	142	54,19
230	83	78	68,92
280	58	55	107,37

3. FRACTURE SURFACES

The samples were subjected to macroscopic analysis using Steromikroskop SZH10 device. The direction of rolling is obvious from the samples. There was a distinct neck on the samples at temperatures 230°C and 280°C.

100 °C



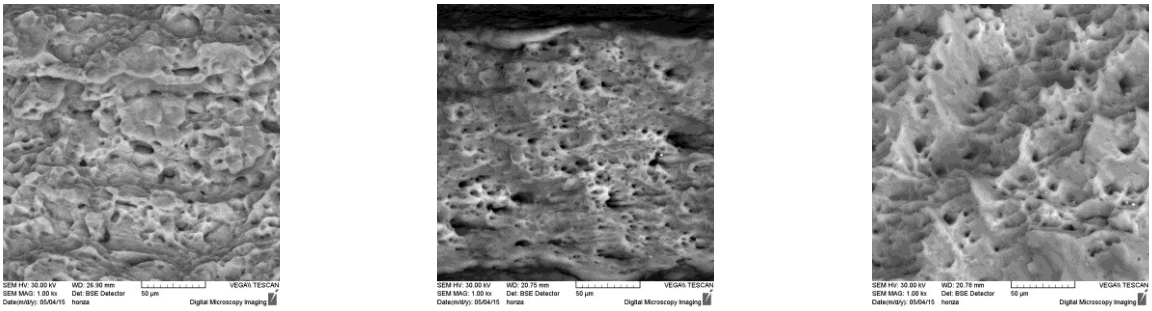
230 °C

280 °C

Fig. 5 The picture are taken from Steromikroskop SZH10

4. FRACTURE SURFACES EXAMINED BY THE SCANNING ELECTRON MICROSCOPE

The scanning electron microscope TESCAN VEGA2 XMU with backscattered electrons was used for examination. There was always a malleable fracture with pitting morphology on samples torn at temperatures 230°C and 280°C. On the other hand it is more about quasi-brittle fracture on samples torn at temperature 100 °C.



100°C 230°C 280°C

Fig. 8 The picture are taken from electron microscope TESCAN VEGA2 XMU s backscattered electrons, magnification 1000x

CONCLUSION

It was proved during the particular tests that the magnesium sheet AZ31 is more malleable at higher temperatures. At the same time based on the tests it is obvious that rolling has significant influence on the mechanical properties and the process of plastic working itself. Carrying out the tensile test at temperatures 230°C and 280° there were some optical changes on the sample surfaces. These changes should influence the audit of the surface parts of the bodywork. Examining REM by backscattered electrons there is an apparent change from quasi-brittle fracture to plastic fracture, which is connected to the increase in temperature. The material was fine-grained and homogeneously structured without any impurities.

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