Developing Superplasticity in A AZ91 Magnesium Alloy Through a Combination of Rolling, ARB and ECAP

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The paper summarises results of experiments aimed at development of structure of modified Mg-Al-Zn alloys at hot deformation. Methods ARB and ECAP were used in the described experiment. It was proved that hardly forming materials could achieve very high plastics properties. After making plastics deformation, the using materials of alloy AZ91 analysed superplastics behaviour, it was certified by obtaining results, when ductility to rupture of alloy AZ91 was 418 %, it is demostrated at conclusion of the article. The experiment proved big influence of previous plastics deformation to ending values of mechanical properties. It was verified that better results are at rolling in more steps compared to rolling in one pass. The low submission temperature at last pass through die ,it causes obtaining higher final properties. It was obtained the material about grain size d ≈ 0.7 µm during using the technology of ECAP. Abreast of it the technology ARB enabled to get material of grain size in interval d ≈ 1-10 µm. The sekond technology brings higher strength properties. Only 3 cycles were sufficient to lower original grain size under limit 10 µm.

Keywords: magnesium alloys, ECAP, microstructure, mechanical properties, superplasticity

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References

[1] MATHIS, K, GUBICZA, J., NAM, V. (2005). Microstructure and mechanical behavior of AZ91 Mg alloy processed by equal channel angular pressing. *Journal of Alloys and Compounds*, Vol. 394, pp. 194–199.

[2] WEI, Y. H., WANG, Q. D., ZHU, Y. P. et al. (2003). Superplasticity and grain boundary sliding in rolled AZ91 magnesium alloy at high strain rates. *Materials Science and Engineering A*, Vol. 360, No. 1, pp. 107-115.

[3] PRADO, M. T., DEL VALLE, J. A., CONTRERAS, J. M. et al. (2004). Microstructural evolution during large strain hot rolling of AM60 Mg alloy. *Scripta Materialia,* Vol. 50, Iss. 5, pp. 661- 667.

[4] AVEDESIAN, M.M., BAKER, H. (1999) ASM Specialty Handbook *Magnesium and Magnesium Alloys*, The Materials Information Society (H, Backer (Ed.)), Materials Park, OH.

[5] MABUCHI, M., IWASAKI, H., YANASE, M., HIGASHI, K. (1997). Low temperature superplasticity in an AZ91 magnesium alloy processed by ECAE. *Scripta Materialia*, Vol. 36, Iss. 6, pp. 681–686.

[6] SOLBERG, J.K., TORKLEP, J. (1991). Superplasticity in magnesium alloy AZ91. *Materials Science and Engineering A.* Vol. 134, No. 25, pp. 1201–1203.

[7] TSUJI, N. (2003) ARB and other new techniques to produce bulk ultrafine grained materials. *Advanced Engineering Materials,* Vol.5, No. 5, pp. 338-344.

[8] GREGER, M., VLČEK, M. (2009). Forged pieces from magnesium alloys. *Mechanika,* Vol. 95, No. 332, pp. 21-23.

[9] LICHÝ,P., BEŇO, J., CAGALA, M. (2013). Inoculant addition effect on thermomechanical and thermophysical properties of Mg-Sr magnesium alloy. *Manufacturing Technology*,Vol. 13, No. 1, pp. 64 – 67.

[10] WATANABE, H., MUKAI, T., ISHIKAWA, K., HIGASHI, K. (2002). High-strain-rate superplasticity in an AZ91 magnesium alloy processed by ingot metallurgy route. *Materials Transactions,* Vol. 43, No. 1, pp. 78-80.

[11] WANG, Q., WEI, Y., Chino Y., Mabuchi, M. (2008). High strain rate superplasticity of rolled AZ91 magnesium alloy. *Rare Metals*, Vol.27, No.1. pp. 46-50.

[12] TROJANOVÁ, Z., TURBA, K., SZÁRAZ, Z. et al. (2012). Superplastic behaviour of an extruded AZ91 alloy. *Acta Physica Polonica , A*, Vol. 122, No. 3, 597-600.

[13] LIN, H. K., HUANG, J. C. (2003). Fabrication of low temperature superplastic AZ91 Mg alloys using simple high-ratio extrusion method. *Key Engineering Materials,* Vol. 233 - 236, pp. 875-880.

[14] AL-ZUBAYDI, A. F., ROBERTO, B., HUANG, Y., LANGDON, T. G. (2013). Structural and hardness inhomogeneities in Mg-Al-Zn alloys processed by high-pressure torsion. *Journal of Materials Science*, Vol. 48, pp. 4661-4670

[15] VOJTĚCH, D., KUBÁSEK, J., VODĚROVÁ, M. (2011). Structural, mechanical and in vitro corrosion characterization of as-cast magnesium based alloys f or temporary biodegradable medical implants. *Manufacturing Technology,* Vol. 12, No. 13, 285 –292.

[16] VESLING, F., RYSPAEV, T. (2007). Effect of heat treatment on the superplasticity of magnesium alloys. *Russian Journal of Non-Ferrous Metals*, Vol. 48, Iss. 1, pp. 57-62.

[17] ŠEDÁ, P., MELZER, S., JAGER, A., LEJČEK, P. (2012). Influence of crystal orientation on texture evolution of magnesium single crystals after ECAP processing. Conference proceedings *21 st International Conference on Metallurgy and Materials METAL 2012*, Tanger, Brno 2012, pp. 368-373.

[18] GREGER, M., KOCICH, R., ČÍŽEK, L. (2007). Superplastic properties of magnesium alloys. *Journal of Achievements in Materials and Manufacturing Engineering,* Vol. 22, Iss. 2, pp. 83-86.

[19] ČÍŽEK, L., GREGER, M., DOBRZANSKI, L. A. et al. (2006) Mechanical properties of magnesium alloy AZ 91 at elevated temperatures. *Journal of Achievements in Materials and Manufacturing Engineering*, Vol. 8, Iss. 1-2, pp. 203-206.

[20] RUSZ S., ČÍŽEK, L. HADASIK, E. et al. (2012). Structure refining of the AZ31 alloy by severe Plastic deformation processing. Conference proceedings *21 st International Conference on Metallurgy and Materials METAL 2012*, Tanger, Brno 2012, pp. 471-476.

[21] GREGER, M., WIDOMSKÁ, M. (2011). Analysis of influence of structure on mechanical properties of AlSiMg aluminium alloy processed by ECAP. *Manufacturing Technology,* Vol. 11, No. 11, 17 – 22.

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