11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Design of the die shape for indirect extrusion of Mg alloy with Al coating

Toko Tokunaga*[1], Maciej Pietrzyk[2], Kiyotaka Matsuura[3] and Munekazu Ohno[4]

[*1] Research Fellow of Japan Society for the Promotion of Science, PhD student, Graduate School of Engineering Hokkaido University, N-13, W-8, Sapporo, 0608628, Japan
and AGH University of Science and Technology, Krakow, 30-059, Poland
ue145460@frontier.hokudai.ac.jp
[2] AGH University of Science and Technology, Krakow, 30-059, Poland, mpietrz@agh.edu.pl
[3] Faculty of Engineering, Hokkaido University, N-13, W-8, Sapporo, 0608628, Japan,
matsuura@eng.hokudai.ac.jp
[4] Faculty of Engineering, Hokkaido University, N-13, W-8, Sapporo, 0608628, Japan,
mohno@eng.hokudai.ac.jp

Key Words: *Mg alloy, Al coating, FE modelling, indirect extrusion.*

Due to their high strength-to-weight ratio and good recyclability, Mg alloys have attracted much attention in the aerospace, automotive and telecommunication equipment industries. However, the use of the Mg alloys has been limited due to their extremely poor corrosion resistance. In order to solve this problem, much effort has been devoted to the development of the technique for Al coating on Mg alloys. A new coating process of Mg alloys by indirect extrusion was devised and the feasibility of this process was investigated [1]. Figure 1 depicts a schematic illustration of the equipment for the hot extrusion. The objective of the present work is to optimize the extrusion parameters for this process by means of numerical simulations of metal flow using finite element code. We performed compression test as a plastometric tests in a temperature range of 250-350 ^{o}C and a strain rate range of 0.01-1 s^{-1}. The specimens with dimensions of ϕ 8×10 mm were used. We determined rheological properties of the Mg alloy on the basis of the test results using inverse analysis [2]. From the analysis we applied the following flow stress model proposed by Gavrus et al. [3]: $\sigma_p = \sqrt{3}\left[WA\varepsilon^{B}exp\left(\frac{-D}{T}\right) + (1-W)Eexp\left(\frac{F}{T}\right)\right]\left(\sqrt{3}\dot{\varepsilon}\right)^{C}$ where σ_p: flow stress, $W = exp(-G\varepsilon)$, ε: strain, R: gas constant, T: temperature in K, $\dot{\varepsilon}$: strain rate, A to G: coefficients. These coefficients were determined by using the inverse analysis and are shown in Table 1. Figure 2 exhibits the comparison between the measured and calculated forces. Optimization problem was formulated with the homogeneity of coating layer thickness, which was used as a goal function. Shape of the die was set as a variable. Results of simulations were compared with the experimental data of [1]. The best process parameters were proposed.

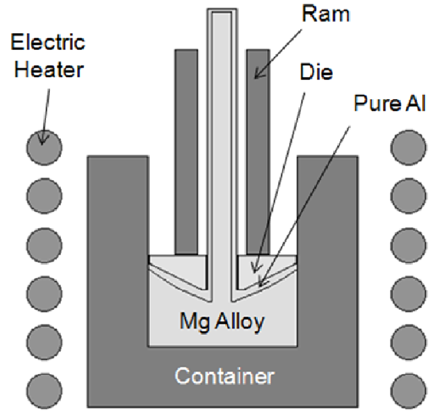

Fig. 1 Schematic drawing of the equipment and samples for hot extrusion.

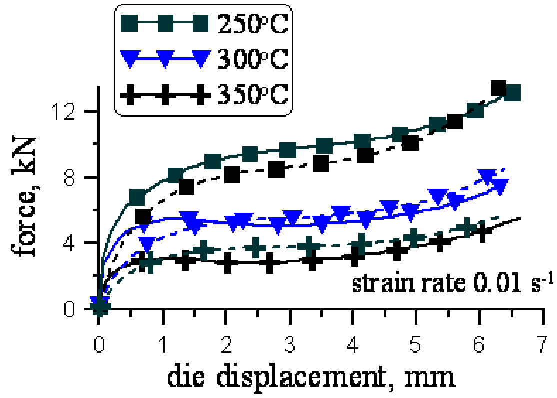

Fig. 2 Comparison between measured (solid lines) and calculated (dotted lines) forces at a strain rate of 0.01 s^{-1}.

Table 1 Coefficients in the equation for the AZ80 alloy obtained from the inverse analysis.

A	*B*	*C*	*D*	*E*	*F*	*G*
5.923	2313.4	0.538	0.1592	0.444	2820.7	5.304

REFERENCES

[1] T. Tokunaga, K. Matsuura, M. Ohno, Aluminum Coating on Magnesium-Based Alloy by Hot Extrusion and Its Characteristics. *Mater. Trans.,* Vol. **53**, pp. 1034-1041, 2012.

[2] D. Szeliga, J. Gawąd, M. Pietrzyk, Inverse analysis for identification of rheological and friction models in metal forming, *Comput. Methods in Appl. Mech. Eng.*, Vol. **195**, pp. 6778–6798, 2006.

[3] A. Gavrus, E. Massoni, J. L. Chenot, An inverse analysis using a finite element model for identification of rheological parameters, *J. Mater. Process. Technol.*, 60, 1996, 447-454.