Effect of hot deformation parameters on the recrystallized grain size inaluminum alloys

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ABSTRACT

This study is focused on the high temperature deformation mechanism of the three aluminum alloys, A6061、A606 and A6082, in different heating temperatures and strain rate by utilizing thermal processing simulator Gleeble-3500. The experimental procedure was taken as follows: First, the true stress-true strain curve as obtained from the experiment in various conditions was formatted through flow stress formula as built by multiple regression analysis. Then, substituted the related coefficients as obtained from the multiple regression analysis into the formula of simulating grain size. Finally, utilizing OM (optical microscope) and SEM (Scanning electron microscope) in observing the alteration of micro-structure and grain size in measuring during aluminum alloys in thermal compression deformation process; in the mean time, comparing it with the simulated value. When the flow stress data were obtained from the test result at reduction of 66% of three aluminum alloys, A6061、A6066 and A6082, after high temperature compression tests and multiple regression analysis, it is able to obtain flow stress formula in the appropriate range of 1s-1≧ ε ?≧0.001s-1，580 °C≧T≧400°C. According to the result of analysis, it indicates the flow stress of the material decreases along with the temperature rises; increases as strain rate increases. Via the observation of micro-structure, as the material structure changes and generate DDRX (discontinuous dynamic recrystallization) and RDRX (rotational continuous dynamic recrystallization) after thermal compression test; where, one is primarily the dislocation density in increasing from which the necklace structure, the DDRX, was precipitated from the original grain boundary; the other is mainly the dislocation stack and dislocation climb where the smaller grain, the RDRX, was precipitated from inside the original grain. In comparison of the actual value with that of the simulated one, RDRX grain sizes decrease along with temperature lowers and strain rate increases, and the simulated value came closer to the actual value. Reversely, it increases along with temperature rises and strain rate decreases; the simulated value and the grater the difference between the actual quality.

Keywords : Aluminum alloys、High temperature deformation、Flow stress、Dynamic recrystallization、Grain size

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REFERENCES

1.ASM Metals Handbook, Metallography Structures and Phase Diagrams, 8th Ed, Vol.8, 1973, pp.397. 2.M.H Jacobs, Phase Diagrams, European Aluminum Association, Training in Aluminum Application Technologies, Lecture 1203, 1999. 3.J.R. Davis & Associates, Aluminum and Aluminum Allays, 1993, pp.569-570. 4.陳到達議，熱分析，渤海堂文化事業有限公司，1992，pp.251-352。 5.Robert E, Reed-Hill, Reza Abbaschian, Physical Metallurgy Principles, 3rd Ed, 1994, pp.181-186. 6.F.J. Humphreys, Recrystallization and Recovery, Material Science and Technology, Vol.15, 1991, pp.368-376. 7.R.D. Doherty, D.A. Hughes, J.F. Humphreys, Current Issus in Recrystallization: A Review, Materials Science and Engineering, vol.238, 1997, pp.219-274. 8.M.E. Kassner, S.R. Barrabes, New Developments in Geometric Dynamic Recrystallization, Materials Science and Engineering, vol. 410-411, 2005, pp.152-155. 9.A. Gholinia, F.J. Humphreys, P.B. Prangnell, Production of Ultra-Fine Grain Microstructures in Al-Mg Alloys by Conventional Rolling, Acta Materialia, vol. 50 , 2002, pp.4461-4476. 10.S. Gourdet, F. Montheillet, An Experimental Study of the Recrystallization Mechanism During Hot Deformation of Aluminum, Materials Science and Engineering, vol. 283, 2000, pp.274-288. 11.H Chi, A.J. Mclaren, C.M. Sellars, R. Shahani, R. Bolingbroke, Constitutive Equations for High Temperature Flow Stress of Aluminum Alloys, Material Science and Engineering, vol.13, 1997, pp.210-216. 12.易幼平，楊積慧，蘭永誠，7050鋁合金熱壓縮變形的流變應力本構方程，材料工程，2007，第四期，pp.22-26。 13.Huizhong Li, Zhou li, Min Aong, Xiaopeng Liang, Feifei Guo, Hot Deformation Behavior and Microstructural Evolution of Ag- Containing 2549 Aluminum Alloy, Material and Design, vol.31, 2010, pp.2171-2176. 14.C.M. Sellars, G.J Davies, Hot Working and Forming Processes, The Meals Society, 1980, pp.3-15. 15.C.M. Sellars, E.H. Chia, H.J. McQueen, Microstructural Control in Aluminum Alloys, The Metallurgical Society of AIME, 1986, pp.179-196. 16.C.M. Sellars, Modelling Microstructural Development During Hot Rolling, Materials Science and Technology, 1990, Vol. 6, pp.1072- 1081. 17.C.M. Sellars, A.M. Irisarri, E.S. Puchi, Recrystallization Characteristics of Aluminum - 1% Magnesium Under Hot Working Conditions, Microstructural Control in Aluminum Alloys: Deformation, Recovery and Recrystallization, Metallurgical Society of AIME, 1986, pp.179-196. 18.V.L Niranjani, K.C. Hari Kumar, V. Subramanya Sarma, Development of High Strength Al-Mg-Si AA6061 Alloy Through Cold Rolling and Ageing, Materials Science and Engineering , Vol.515, 2009, pp.169-174. 19.付欣，7050鋁合金高溫變形行為實驗研究，碩士論文，中南大學，2008。 20.B. Zhang, T.N. Baker, Effect of the Heat Treatment on the Hot Deformation Behaviour of AA6082 Alloy, Journal of Materials Processing Technology, vol.153-154 , 2004, pp.881-885. 21.I. Sabirov, M.R. Barnett, Y. Estrinb, and P.D. Hodgsona, The Effect of Strain Rate on the Deformation Mechanisms and the Strain Rate Sensitivity of an Ultra-Fine-Grained Al Alloy, Scripta Materialia , vol.61, 2009, pp.181-184. 22.ASM Metals Handbook, Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, 10th Ed, Vol.2, 1990, pp.62-64. 23.ASM Metals Handbook, Heat Treating, 10th Ed, Vol.4, 1991, pp.871. 24.M. Cabibbo, E. Evangelista, M. Vedani, Influence of Severe Plastic Deformations on Secondary Phase Precipition in A6082 Al-Mg-Si alloy, Metallurgical and Materials Transactions , vol.36A, 2005, pp.1353-1364. 25.G. Mrowka-Nowotnik, Influence of Chemical Composition Variation and Heat Treatment on Microstructure and Mechanical Properties of 6xxx Alloys, Archives of Materials Science and Engineering, Vol.6, 2010, pp.98-107. 26.R. Kaibyshev, O. Sitdikov, A. Goloborodko, T. Sakai, Grain Refinement in As-Cast 7475 Aluminum Alloy Under Hot Deformation, Materials Science and Engineering A344, 2003, pp.348-356.