Institute of Light Metals (ILM) Joint Usage/Research Grant Report in FY 2024

2025/06/11

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| Principal investigator | Affiliation | Universiti Kebangsaan Malaysia, Malaysia |
| Job title | Assistant Professor |
| Name | Intan Fadhlina Mohamed |
| Collaborated researchers of ILM | Affiliation | MRC, Kumamoto University |
| Job title | Professors |
| Name | Zenji Horita |
| Title of the joint research | Precision Control of High-Pressure Sliding Parameter for Magnesium Alloys |
| Joint research Program※check the box | □　Program for Joint Usage / Research Centers (JURC)■　Program for International JURC□　Program for providing samples and materials□　Program for using ILM facilities for sample analysis and characterization | □ Focused themes■ Transportation□ Biomaterials□ Bridge/building materials□ Kink strengthening□　Independent research theme |
| Name of joint usage apparatus | SEM, EBSD, Optical microscope, Hardness tester, Tensile testing machine  |
| Total amount of grant 300 000JPY | Travel expense（ 300,000 JPY） | Consumable Fee（ JPY） |
| **Research Results**　※Please describe the following three items briefly.【The major results】 This study employed severe plastic deformation (SPD) techniques—high-pressure sliding (HPS) and incremental feeding high-pressure sliding (IF-HPS)—to achieve significant grain refinement in magnesium alloys AZ61 and AZ91 over enlarged sheet areas. Various sliding parameters (X3 R5, X5 R3, X7.5 R2, and X15 R1) were used, with a total sliding distance of 15 mm applied to all samples. Superplasticity tests were conducted at 250 °C, 300 °C, and 350 °C with strain rates of 5.5 × 10⁻⁴ s⁻¹, 4 × 10⁻³ s⁻¹, 2 × 10⁻⁴ s⁻¹, and 1 × 10⁻⁴ s⁻¹. In AZ61, the HPS process produced homogeneous hardness across the sample and refined the microstructure to an average grain size of 1.7 μm; the highest elongation (~500%) was achieved at 300 °C and a strain rate of 5.5 × 10⁻⁴ s⁻¹. IF-HPS processed AZ61 samples also showed superplasticity, with elongations exceeding ~300% under optimal conditions and an acceptable grain size of 14 μm at the gauge section. For AZ91, maximum elongation reached ~700% with HPS processing at 250 °C and 5.5 × 10⁻⁴ s⁻¹, and IF-HPS samples under various sliding distances demonstrated elongations ranging from ~220% to ~440%. The optimal condition for IF-HPS was determined to be X3 R5 (3 mm sliding with 5 reciprocations), which minimized crack initiation due to shorter sliding distances and more reciprocation cycles. The IF-HPS method proved effective in producing uniform tensile properties across the sheet and is a promising approach for extending the SPD-processed area without increasing machine capacity while maintaining enhanced mechanical properties.【Future Prospects】 The successful application of the IF-HPS process to Mg alloys AZ61 and AZ91 demonstrates its potential for broader implementation in lightweight structural materials. As a future prospect, it is suggested that the IF-HPS technique be extended to other magnesium alloys such as AZ31, ZK60, and rare-earth-containing Mg alloys to further explore the process versatility and performance. Initial trials should involve conventional HPS processing to evaluate the capability for grain refinement, followed by systematic IF-HPS under varying sliding parameters to determine optimal processing conditions. The assessment of microstructural evolution and mechanical response, particularly superplasticity, will be essential, with emphasis on achieving ultrafine or equiaxed grain structures. Further research should also focus on understanding the deformation mechanisms, scalability of the process, and long-term stability of the enhanced properties for industrial applications in automotive, aerospace, and biomedical fields.【Concrete results】<Publications>(1) A.M. Aziz, I.F. Mohamed, Z. Horita, M.Z. Omar, Z. Sajuri, N.K. Othman, J. Syarif, Mohamed Abdelgawad Gebril, Farhad Ostovan, Seungwon Lee, Kenji Matsuda, Manabu Yumoto, Yoichi Takizawa, Ammar Abdulkareem Hashim Al-Ameri, Journal of Materials Science 59 (14), 5754-5770. “Strengthening of A5052 aluminum alloy by high-pressure sliding process”.(2) T. Komatsu, T. Masuda, Y. Tang, I. F. Mohamed, M. Yumoto, Y. Takizawa and Z. Horita, Materials Transactions, Vol. 64, No. 2 (2023) 436-442. “Production of Ultrafine-Grained Aluminum Alloys in Upsized Sheets Using Process of Incremental Feeding High-Pressure Sliding (IF-HPS)”<International Conference>(1) I.F. Mohamed, Z. Horita. A.M. Aziz PRICM11: The 11th Pacific Rim International Conference on Advanced Materials and Processing(2) T. Komatsu, T. Masuda, Y. Tang, I. F. Mohamed, M. Yumoto, Y. Takizawa and Z. Horita,The 18th International Conference on Aluminium Alloys (ICAA18) Toyama, Japan, Sept. 5-8, 2022.(3) T. Masuda, Y. Tang, I. F. Mohamed and Z. Horita Korea-Japan Joint Seminar Scientific research and technology application for Mg-based alloys and other light metals in South Korea and Japan, Kumamoto, Japan, October 5, 2022. |
| **Notes**・Please use the form and submit to ILM office (mrc@kumamoto-u.ac.jp) by Friday, April 28, 2023.・The joint research report will be published in the ILM joint research report (annual report) and will be available on our website. Therefore, please prepare the contents for public release accordingly.・Please add pages, if needed. |