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Title	Structure refinement of Al-coated Mg-Li alloy by multi extrusion-rolling process and its superplastic characteristics [an abstract of dissertation and a summary of dissertation review]
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Citation	北海道大学. 博士(工学) 甲第13390号
Issue Date	2018-12-25
Doc URL	http://hdl.handle.net/2115/72369
Rights(URL)	https://creativecommons.org/licenses/by-nc-sa/4.0/
Type	theses (doctoral - abstract and summary of review)
Additional Information	There are other files related to this item in HUSCAP. Check the above URL.
File Information	Tianlong_Zhang_abstract.pdf (論文内容の要旨)

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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　　博士（工学）　　氏名　張 天龍

学 位 論 文 題 名

Structure refinement of Al-coated Mg-Li alloy by multi extrusion-rolling process and its superplastic characteristics

(押出圧延複合プロセスによる Al 被覆 Mg-Li 合金の組織微細化と超塑性特性)

Mg alloys are potential structural metal materials which can meet the compelling need for weight-reduction and energy-efficiency in industry, because of the lowest density of Mg among all structural metallic materials. Also, Mg alloys possess other attractive properties such as high specific stiffness and good castability. In spite of these advantages, the critical problems that restrict the wide application of Mg alloys are their poor corrosion resistance and low plasticity. However, the conventional coating methods do not work well on Mg alloys because of the high chemical activity of Mg. In this study, the author aims to give a corrosion-resistant Al coating on a Mg alloy by a newly developed hot extrusion method, which is proved to be an effective and efficient coating method for Mg alloys. However, the practicability of this method should depend on the deformability of the as-extruded Al-coated Mg alloy bar, for the need of various shapes in industries. Therefore, to solve the low plasticity problem of Mg alloys is important as well as to solve the poor corrosion resistance problem.In this study the author proposes a new method for grain refinement which leads to dramatic improvement of plasticity of Mg alloys.

A special class of Mg alloys, dual-phase Mg-Li alloys are focused on in this study, for their attractive formability: good plasticity at room temperature and possible superplasticity at high temperatures. Three Mg-Li alloys with different Zn addition were used: Mg-8wt% Li (LZ80), Mg-8wt% Li-2wt% Zn (LZ82) and Mg-8wt% Li-5wt% Zn (LZ85). Pure Al was used as the coating material. All the three kinds of Mg-Li alloys were successfully coated with Al by the hot extrusion method and were then successfully rolled into thin sheets. These Mg-Li alloys exhibited different mechanical properties at room temperature but similar superplastic elongation at high temperatures. At a temperature of 573 K and at a strain rate of 0.001 s^{-1}, these three kinds of Mg-Li exhibited fracture elongations of about 400% without the Al coating. The fracture elongations of Al-coated alloys dropped to over 200%, for pure Al exhibits no superplasticity at high temperatures. Nevertheless, this is a much larger elongation than the original elongation of Al without the base Mg-Li alloy.

A larger superplastic elongation of the base Mg-Li alloy is considered to bring an improvement on the overall elongation of the Al coated alloy. This needs grain refinement of the Mg-Li alloys and large plastic deformation accompanied with dynamic recrystallization is usually an effective method for the grain refinement. Because conventional extrusion and rolling only produce limited deformation, many severe plastic deformation methods have been developed to fabricate ultra-fine structures. However, these methods were not effective in refining the phase structure in the dual-phase Mg-Li alloy. To refine the coarse phases in the dual-phase Mg-Li alloys is the key point of achieving good superplasticity.

For these reasons, a multi extrusion-rolling deformation process was developed in this study to refine the crystal grain and phase structures. In this method, after 4 passes of different kinds of plastic deformation, both grain and phase structures were significantly refined. Especially, the LZ85 alloy exhibited an extremely large fracture elongation of 1400% at 473 K and 0.001 s^{-1}. Moreover, an elongation of more than 600% was observed at 473 K even at high strain rate of 0.01 s^{-1}. Also, at a lower temperature of 423 K, the alloy exhibited a large fracture elongation of 720% at 0.001 s^{-1}. The values of the strain rate sensitivity were approximated to 0.5, which suggests that the superplastic deformation is based on grain boundary sliding. Dislocation glide is identified to be an accommodation mechanism.

Just as the hot extrusion coating method, by using an Al plate in the final extrusion step, a corrosion-resistant Al coating can be easily produced. This is another advantage of the multi extrusion-rolling deformation process. With the multi extrusion-rolling deformation process, the Al-coated LZ85 alloy exhibited a large improvement of superplastic elongation. At 473 K at 0.001 s^{-1}, an about 900% elongation was observed, though cracks appeared on the Al coating. An elongation of about 400% was observed at 473 K at 0.05 s^{-1} without cracks on the coating. Also, at a lower temperature of 423 K, the alloy exhibited a large fracture elongation of about 400% at 0.001 s^{-1} without cracks on the coating.