113材料工程系大學部實習成果觀摩競賽

專業主題

Optimization of Properties of Al-Mg-Si Aluminum Alloys for Space Applications

內容摘要

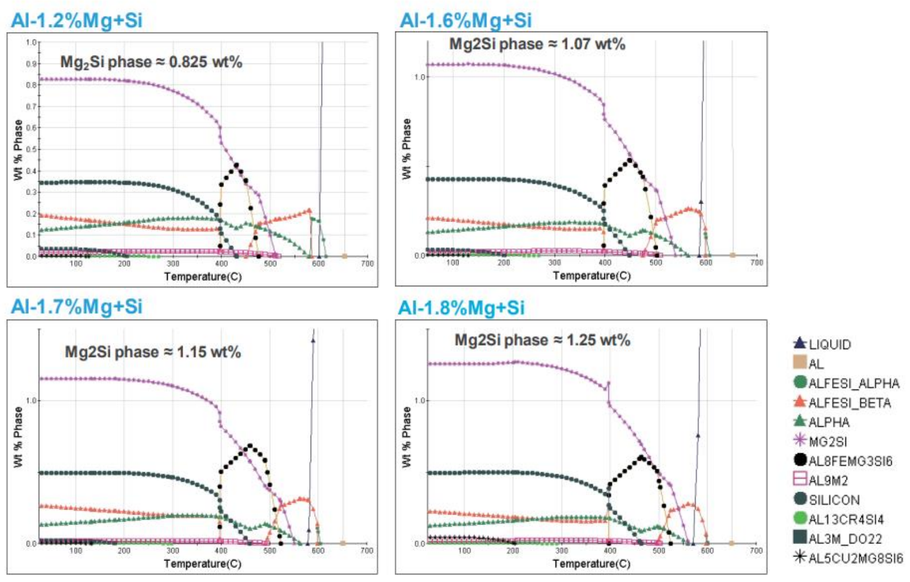
In order to meet the needs of the aerospace industry, some of the materials for aerospace structural components need to be lightweight, high strength, and compatible properties which are suitable for space. Therefore, this study focuses on the components of Al-Mg-Si alloy. Using JMatPro@ to simulate the effect of alloy elements content on the properties, and the selection of heat treatment conditions. In terms of alloy composition adjustment, increasing the content of Mg and Si strengthening elements in the alloys increases the mechanical strength of the materials. The upper limit of the composition is evaluated to determine the Al-Mg-Si alloy suitability. In terms of heat treatment conditions, multi-stage homogenization and T6 heat treatment conditions are optimized to further enhance the mechanical properties of Al-Mg-Si alloys.

In this study, the yield strength (YS) of the Al-1.8%Mg+Si alloy with 1.0 after three-stage homogenization and T6 heat treatment (550˚C, 4h + 175˚C, 8h) can reach more than 330 MPa. The alloy can be used for the procurement of aerospace structural components in the future.

實習成果

JMatPro®

Using JMatPro® for material simulation to predict the ratio of each phase and forming temperature. As a reference for formulating heat treatment parameters.



- By increasing Mg and Si wt.%, the proportion of Mg-Si strengthening phase is increased, which can improve the material strength.
- The Mg-Si phase forms at approximately 550˚C.
- The β-AlFeSi phase is not easily eliminated by heat treatment.

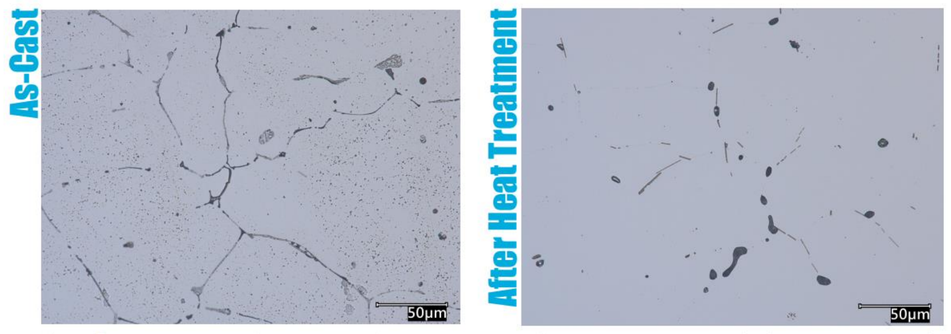
HEAT TREATMENT

Homogenization Treatment	Solution Treatment	Artificial Aging
450°C, 2h + 530°C, 2h + 575°C, 2h	550°C, 4h	175°C, 8h

Melting Temperature	Reaction	Melting Temperature	Reaction
555˚C	Al+Mg_2Si+Si → Liquid	**587˚C**	Al+β-AlFeSi+Si → Liquid
576˚C	Al+β-AlFeSi+Mg_2Si → Liquid+α_h-AlFeSi	**612˚C**	Al+Mg_2Si → Liquid
577˚C	Al+Si → Liquid	**630˚C**	Al+α_h-AlFeSi → Liquid+Al_3Fe

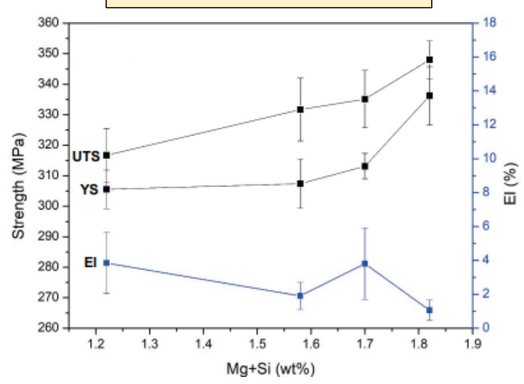
- Three-stage homogenization process avoids eutectic melting and eliminates coarse precipitates.
- Increase the solid solution temperature to dissolve Mg-Si into α-Al.
- Artificial aging causes Mg-Si to form nano-precipitate that improve the strength of the alloy.

MICROSTRUCTURE



- As-Cast contains continuous and coarse precipitates on the grain boundaries.
- Precipitates on grain boundaries are effectively eliminated through three-stage homogenization heat treatment.
- Mg-Si compound forms nanoprecipitates in α-Al after T6 heat treatment.

MECHANICAL PROPERTIES



- With increasing Mg and Si wt.%, the material strength gradually increases.
- The yield strength of Al-1.8%Mg+Si reaches 336MPa after heat treatment.

CONCLUSIONS

- Through JMatPro® material simulation, when the Mg+Si wt.% increases, the proportion of Mg-Si strengthening precipitates increases, so that the strength of alloy increases. We can formulate the three-stage homogenization heat treatment temperature.
- Through three-stage homogenization heat treatment (450˚C, 2h + 530˚C, 2h + 575˚C, 2h), the coarse precipitates on the grain boundaries are effectively eliminated and the material strength can be improved.
- Al-1.8%Mg+Si alloy undergoes three-stage homogenization and T6 heat treatment, the yield strength (YS) can be reached to 336 MPa.

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