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Microstructure and Properties of AlFe-Alloys (AA 1050 – AA 8021) for Packaging

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Abstract

The microstructure and the strengthening behaviour of Al-Fe-alloys (AA 1050-8021) is influenced by the alloy composition and the process parameter intermediate annealing. The element Fe has a very pronounced and positive effect on strength and elongation behaviour. With increasing Fe both mechanical values, tensile strength and elongation, increase in the O-temper condition and the resulting grain size is very fine and uniform. In addition to the Fe-content the process parameter, intermediate annealing, is important for the recovery behaviour, while through this process route thermal stability of the tensile strength is reduced.

By controlling all these procedures it is possible to produce a high strength foil with good formability and a very fine grain structure.

1. Introduction

Important aspects of foil material are their softening and recrystallisation behaviour. Fe and Si are the main elements in AlFeSi-alloys and their presence is known to exert an important influence on thermal softening properties, grain size, texture or formability [1-3]. The material processing combination of rolling and thermal treatment is also regarded as an important aspect. [4,5].

In this investigation several AA-alloys with their typical Fe-content up to AA 8021 are studied. In addition, the intermediate and the final annealing treatments were regarded.

2. Experimental

Several AA-alloys (figure 1) with their typical Fe-content were investigated with regard to their influence on the microstructure. The material was produced according to industrial practice (Figure 2).

At final thickness the strength was determined in the as-rolled condition and after annealing by tensile tests. The microstructure was studied by light and electronic microscope. The grain structure was checked in surface section. Information about the dissolved Fe- content was obtained by measuring the electrical resistivity at 4.2 K. The content of Fe in solid solution was calculated from the resistivity using the factor 3.20 µohmcm/ wt.% Fe.

No.	alloy	Si typical range	Fe typical range
1	**AA 1050**	0.08 - 0.15	**0.20 - 0.35**
2	**AA 1200**	"	**0.45 - 0.65**
3	**AA 8079**	"	**0.80 - 1.10**
4	**AA 8021**	"	**1.20- 1.40**

Figure 1: Composition of alloys in wt.%

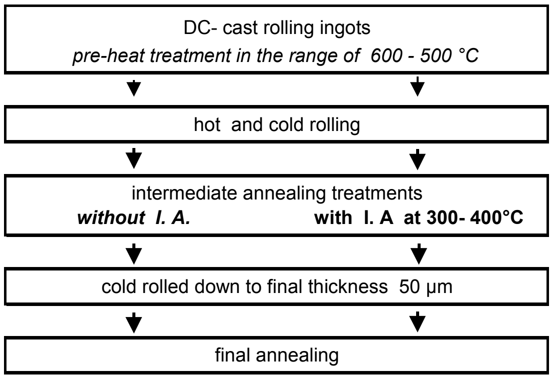


Figure 2: Experimental procedures

3. Results

3.1 Microstructure

The influence of the alloy composition on the constituent particles was investigated by image analysis of light microscope sections. The number of particles increase with the Fe-content, while on the other hand the area of the particles is not very strongly affected by the alloy composition / Fe-content (figure 3a)

The fine dispersoids in the material were observed by transmission electron microscope. The resulting TEM-photos were measured by image analysis.

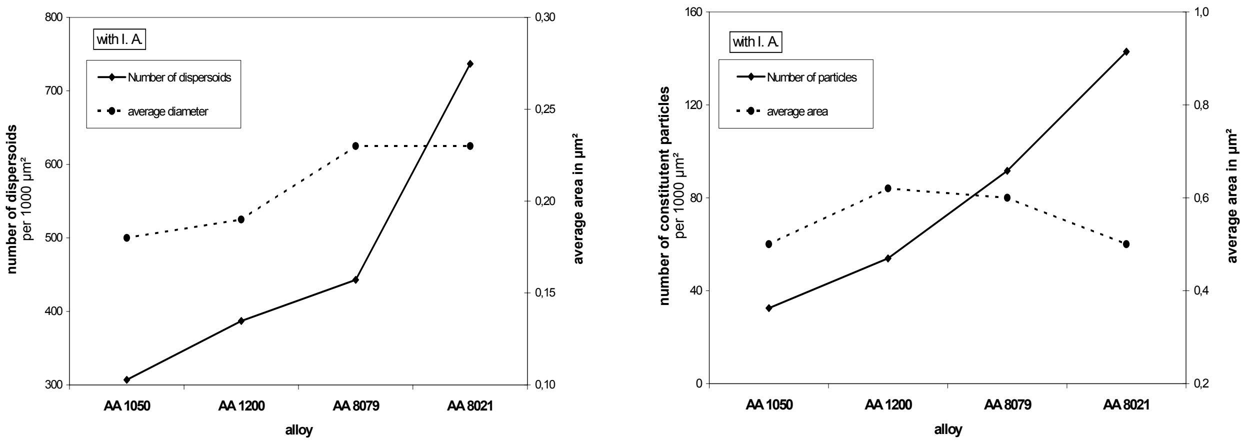


Figure 3: Influence of alloy composition / Fe-content on constituent particles and dispersoids.

The dispersoids show the same trend in relation to the alloy composition as does the constituent particles. With higher Fe-content the number of dispersoids increase, but the phase size (=average diameter) is not really affected.

3.2 Fe in Solid Solution

Information about the Fe- content in solid solution in the as-rolled condition and after annealing (350°C/1h) was obtained by measuring the electrical resistivity at 4.2 K. The content of Fe in solid solution was calculated from the resistivity.

The figure 4 a show the calculated values for the as-rolled condition and after annealing (350°C)

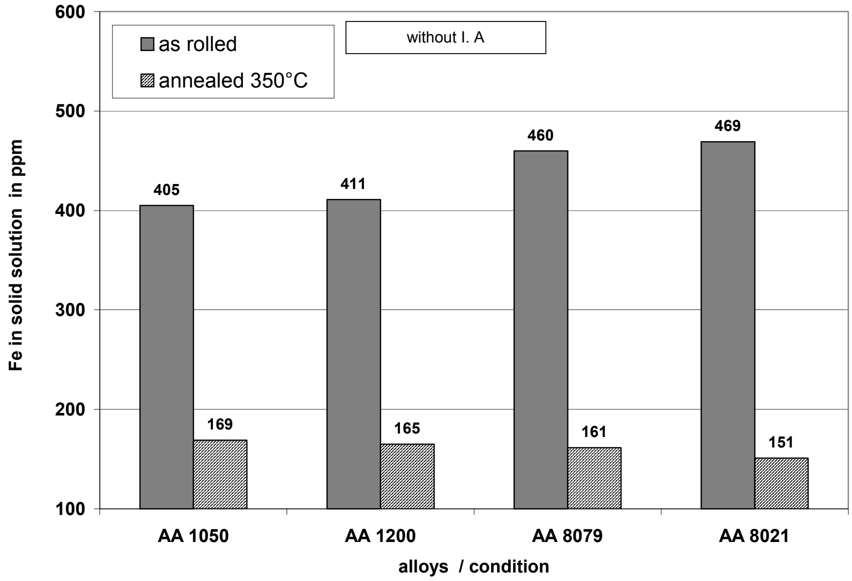


Figure 4: Influence of alloy composition and annealing on Fe-content in solid solution.

In the as-rolled condition a slight increase of the values is visible with higher Fe-content / alloy-composition. For the annealed condition the trend is contrary to the behaviour of the as-rolled condition. In this case a slight decrease of the Fe-content can be observed.

So as a result the decomposition of Fe during annealing is increased in the alloys AA 8079 and AA 8021.

3.3 Influence of Alloy Composition on Thermal Stability

The influence of the alloy composition (process without I.A.) on the thermal stability (softening behaviour) is shown in figure 5.

The starting point in the as rolled condition differed as result of the alloy and the values are related to the iron content: with high Fe-contents (AA 8079+8021) the strength is increased, while on the other hand at lower iron content lower strength values are achieved. The beginning of recrystalli-sation (=drop in the curve) started in the temperature range of 200 - 260°C. The start temperature is influenced by the alloy composition. With high Fe-content (AA 8079+8021), the start of recrystallisation began in the temperature range of 200-220°C. The alloys with lower Fe-content (AA 1050+1200) show a better thermal stability and therefore the start temperature is higher. In the case of alloy AA 1050, the drop in the softening curve is observed for temperature > 260°C.

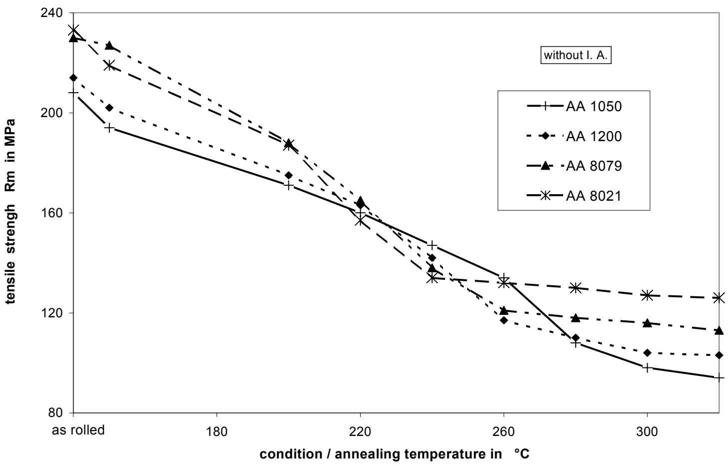


Figure 6: Strength at final thickness 0.050 mm in the as rolled condition and after annealing (1h)

3.4 Influence of Intermediate Annealing Treatment

The influence of intermediate annealing on strength and elongation behaviour is shown for the alloy AA 1050 in the figure 7.

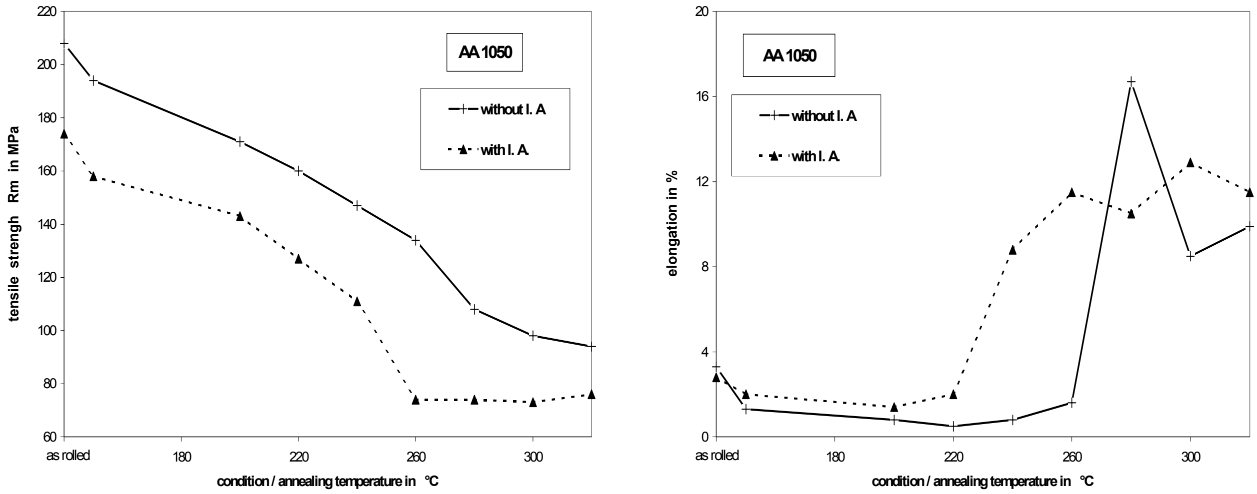


Figure 7: Influence of intermediate annealing on strength and elongation at final thickness.

The process route “with I.A.“reduces the strength in the as-rolled condition and also the thermal stability of the foil material is weaker than for the production “without I.A.“ The thermal stability is also visible in the elongation behaviour. The elongation increased at lower temperature for the material with I.A. than for the foil without I.A.

3.5 Strength and Elongation in the O-temper Condition

The influence of the alloy composition / iron content (process with I.A.) on strength and elongation in the O-temper condition is shown in figure 8.

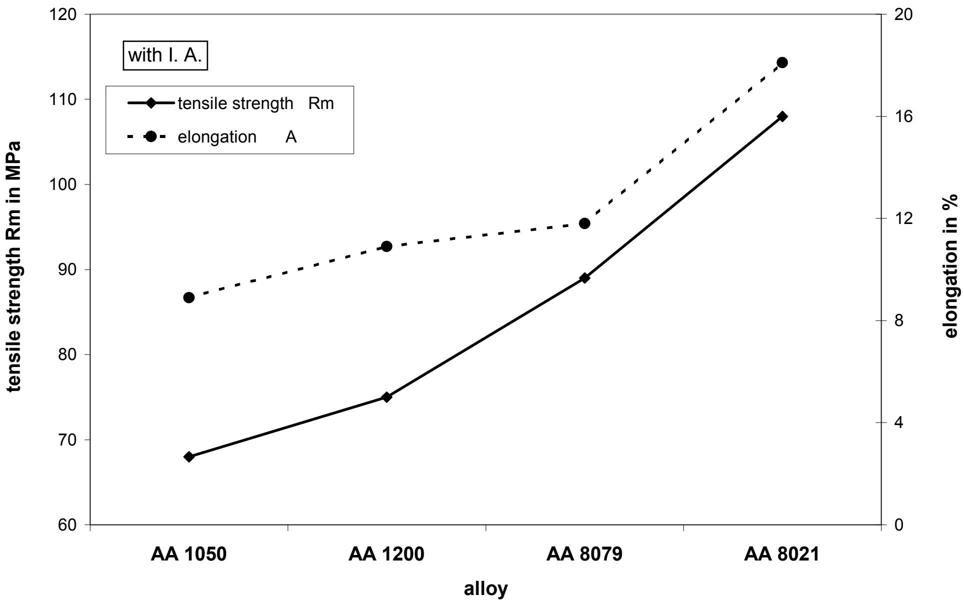
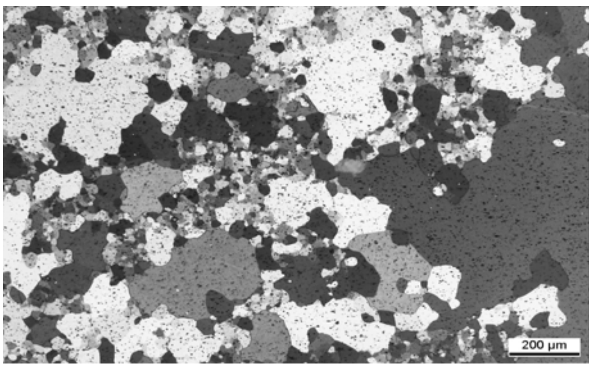


Figure 8: Influence of alloy composition on strength and elongation in the O-temper condition.

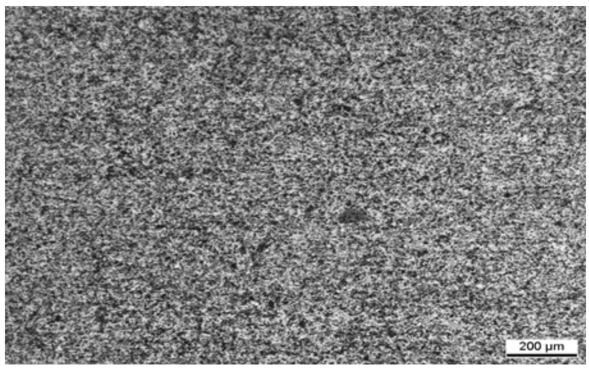
The tensile strength increased from the alloy AA 1050 to AA 8021 and also the elongation is related to the iron content; so that in the case of a high Fe-content high strength and high elongation values are achieved.

3.6 Influence of Fe-content on the grain structure in the O-temper condition

The resulting grain structure in the O-temper condition is given for two alloys in figure 9. The AA 8021-alloy show a very fine and uniform grain structure, while the AA 1050-foil show a much coarser and non-uniform grain size. So the grain structure is well related to the strength and elongation values as presented already.



a) AA 1050



b) AA 8021

Figure 9: Grain structure in the O-temper condition for the two alloys AA 1050 and 8021.

4. Discussion and Conclusions

The alloy composition / Fe-content has a very pronounced effect on the microstructure and a positive effect on strength and elongation behaviour. With increasing Fe-content both mechanical values, tensile strength and elongation, increase in the O-temper condition and the resulting grain size is very fine and uniform. It can be concluded that strength and elongation is primarily influenced by grain size. [6] .

The process parameter, intermediate annealing, is important for the recovery behaviour. Using the production route with intermediate annealing treatment the thermal stability of the tensile strength is reduced. The parameters, alloy composition and intermediate annealing, seems to have an influence on the Fe-content in solid solution and the decomposition of iron during final annealing. The decomposition of iron is decreased and so the interaction of precipitation and recovery is lesser than in the case of low Fe-content and / or production without intermediate annealing. [7,8]

The number of particles (constituent and dispersoids) is related to the resulting final properties.

By controlling all these procedures it is possible to produce a high strength foil with good formability and a very fine grain structure.

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