Cavity Distribution in a Multi-strained AA5083 Product

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Abstract

Cavitation in superplastically formed aluminum alloy 5083 (AA5083) material has been found to be dependent on factors such as tensile strain, stress, strain rate and temperature. In this work, the cavity size distribution in a multi-strained item produced through biaxial superplastic forming process is presented using Image Pro Plus analysis of the metallographs. It was generally found that there is an increase in the average number of cavity per unit area from the less-strained to the more strained regions of the product. Also, there is a significant textural homogeneity across the material as indicated in the inverse pole figures obtained through x-ray pole figure scan.

*Keywords: B*iaxial superplastic forming, Strained regions, Cavities, Texture

1 INTRODUCTION

At the International Conference on Superplasticity (ICSAM – 91) in Osaka, Japan, superplasticity was defined as the ability of polycrystalline materials to exhibit very high elongation prior to failure in a generally isotropic manner. Superplasticity has also been defined as the ability of certain materials to undergo extreme elongation at the proper temperature and strain rate [6].

Superplastically formed materials have been found to develop reasonable amount of cavitation after their deformation. The size and distribution of cavitation have also been found to depend on strain, stress, strain rate and temperature conditions during deformation. Cavitation behaviour of superplastic materials has been less examined when deformed biaxially [1]. In this work, the cavitation behaviour of AA5083 formed by a biaxial superplastic forming process to form a multi-strained product is presented. Also, the results from an x-ray diffractometer scan on the different strained parts are given in the form of inverse pole figures.

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Experimental Methodology

A sheet of AA5083 with chemical composition of Al-4.6%Mg-0.7%Mn-0.15%Cr was deformed to form into a die using a gas-blowing superplastically forming machine after being heated up to about 500^{0}C. Figure 1 shows the multi-strained item after its formation from a sheet 30cm x 30cm x 0.2cm dimensions of the alloy. A small piece of the AA5083 material under investigation was cut from each of the seven (7) regions (also referred to as samples 1 to 7) as indicated in Figure 1. The strained regions are marked 2, 3, 4, 5, 6 and 7, while '1' is unstrained. Each piece was then mounted using epoxy resin, ground, polished and observed under an optical microscope at a magnification of 100. The grinding was done on SiC backed papers with grit sizes of 800, 1200 and 2400. Thereafter, the polishing was carried out on MD-Mol© (3µ) using DP-Red© with the final polishing performed on MD-Chem (0.04 µ) with OP-AN©. All the grinding and polishing products were obtained from Struers©. Two of the images obtained are given in Figures 2 and 3 for strained levels 1 & 7 respectively. Fifteen (15) different areas of each of the samples were examined on the microscope and analyzed to obtain a good statistical result. The analysis of the microscopic images was carried out using an Image ProPlus© software to quantify the cavity area distribution on the specimens. Results obtained are graphically presented

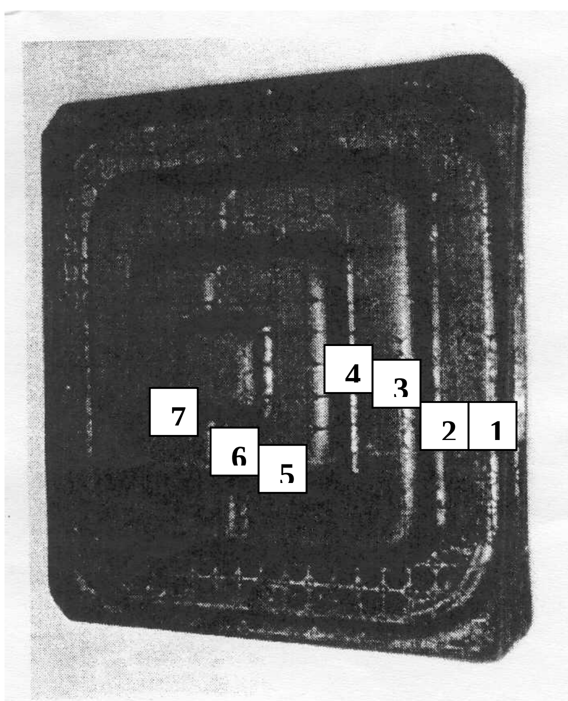

Figure 1: AA5083 tray with multi-strained regions 1 -7 superplastically produced by a gas blown method.

in Figures 4 and 5. In addition, the strain and thickness distribution from levels 1 to 7 is presented in Table 1 and Figure 5. Phillips© x-ray diffractometer was later used to take the pole figure scan of the samples in order to assess their crystal orientation distribution using the inverse pole figure.

Results and Discussion

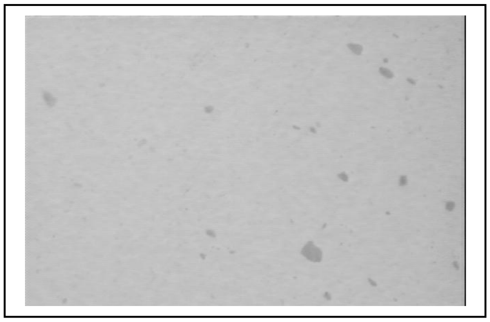

Figure 2: Strained level 1.

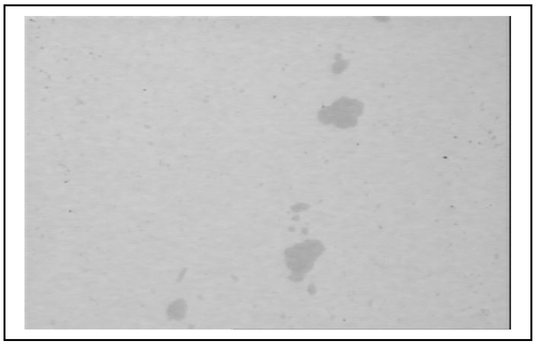

Figure 3: Strained level 7.

Figures 2 and 3 are typical microstructures of samples 1 and 7 respectively which show cavities as dark gray areas. Analyses of the sizes of the cavities in terms of their average areas are graphically shown in Figures 4 and 5. Figure 4 represent cavities with areas between 2.01 µm^2 and 8.00 µm^2, while Fig. 5 is for those cavities greater or equal to 8.01 µm^2 in area.

While there is a regular behavior with respect to the variation of the cavity area with the strained levels for areas between 2.01 µm^2 and 8.0 µm^2, an irregular observation was noticed for those cavities of areas greater than 8.0 µm^2. This might have been due to the mechanisms involved in the migration and merging of cavities at higher strain levels (3). Usually, at higher strains, smaller cavities merge to form bigger cavities.

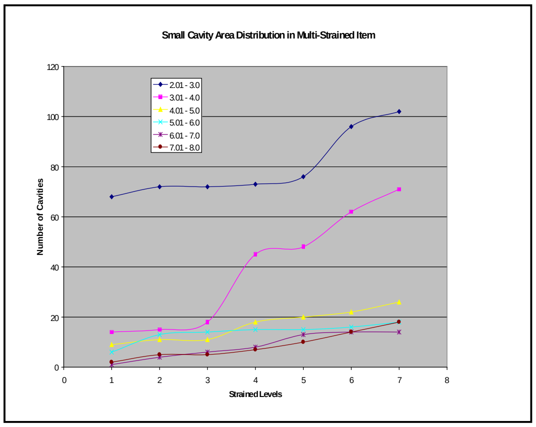

Figure 4: The Small Cavity Area Distribution .

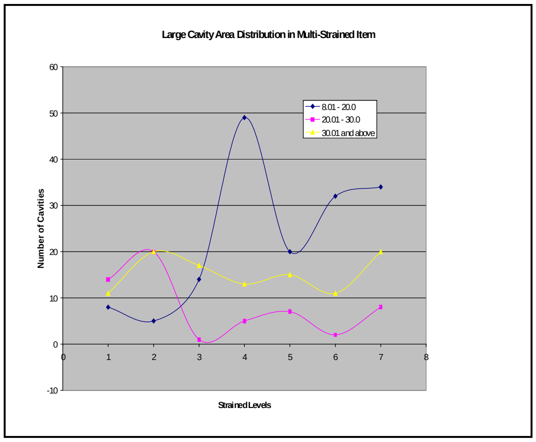

Figure 5: The Large Cavity Area Distribution

Variation of the thickness and strain across the levels are presented in Figure 6. As expected, there is an increase in strains from levels 1 to 7. Finally, x-ray diffractometry analysis of samples 1 to 7 produced the 2 theta peaks shown in Figure 7. The inverse pole figures of some of the samples are presented in Figures 8 and 9 and they show textural homogeneity across the samples.

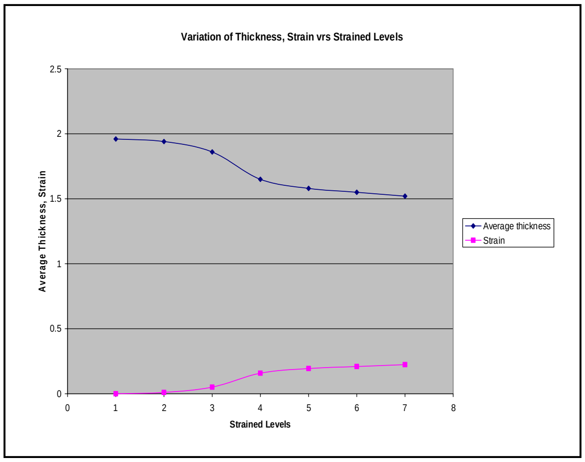

Figure 6: The variation of thickness and strain.

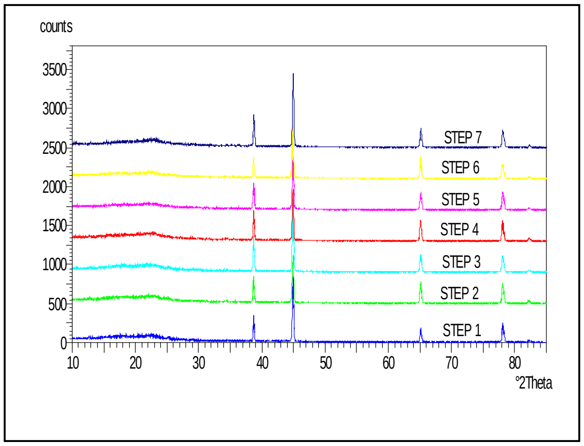

Figure 7: The 2θ peaks from 2θ scan.

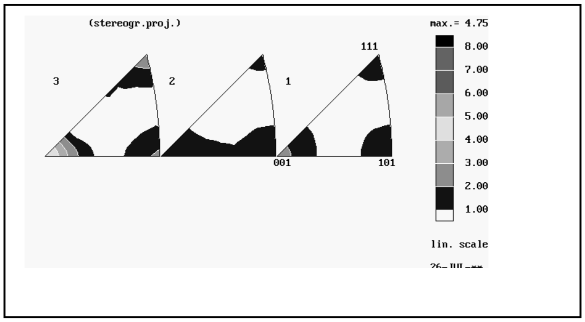

Figure 8: Inverse Pole Figure for Sample 1.

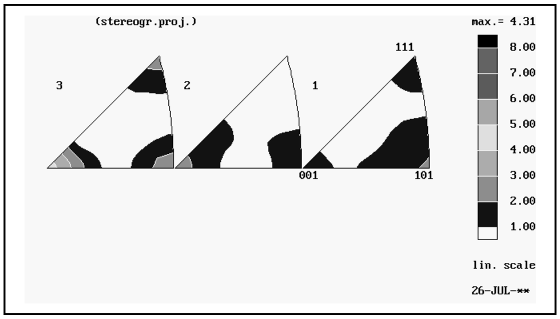

Figure 9: Inverse Pole Figure for Sample 7.

CONCLUSION

The cavitation distribution in the multi-strained AA5083 item was found to follow an irregular order from regions 1 to 7. However, an increase in strain was reported from the lowest to the highest regions. Finally, a textural homogeneity occurred through the test piece.

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