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PREPARATION OF SAMPLES OF PRECIPITATION HARDENING ALUMINIUM ALLOYS FOR DIFFERENTIAL SCANNING CALORIMETRY (DSC)

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ABSTRACT
Samples of aluminium alloys for DSC are usually prepared by punching. The present authors have recently shown that, in the case of precipitation hardening alloys, the deformation introduced during punching might interfere with the characterization of microstructure by means of DSC. On the other hand, spark cutting strongly reduces the deformation of disc samples. In this paper further results are presented for alloys of the Al-Cu, Al-Mg-Si and Al-Zn-Mg series. It is shown that the previous conclusions strongly depend on the particular alloy.

INTRODUCTION
Calorimetric techniques have long been applied to microstructural characterization of aluminium alloys (1-10). Beyond the basic scientific interest of these studies, their underlying aim is to use calorimetry as an effective, rapid tool to characterize the different tempers used in heat treatable commercial aluminium alloys (1, 5-9). One of the most serious problems in using an analytical technique as a routine tool is the preparation of samples. In particular, sample preparation might hinder the direct comparison between DSC results from laboratory produced and commercially fabricated alloys.

Although it is widely recognized that deformation may affect phase formation in heat-treatable aluminium alloys (1, 2, 5, 6), punching of samples for DSC is a common practice Recently it has been shown that the shock loading resultant upon punching, introduces substantial plastic deformation into the punched discs, which can interfere with the observation of deformed structures in steels (11), and the characterization of the microstructure in Al-Cu and Al-Mg-Si alloys by means of DSC (10). On the other hand it has been pointed out that a suitable alternative to punching might be spark cutting (10-11). The purpose of this work is to present further results for alloys of the Al-Cu, Al-Mg-Si and Al-Zn-Mg series. The main result of this study is that the previous conclusions, although being a general rule for heat treatable aluminium alloys, strongly depend on the particular alloy.

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MATERIALS AND EXPERIMENTAL PROCEDURES

The material used in this work was supplied by the Extrusion Division of the "Empresa Nacional del Aluminio" in extrusions of different shapes. All alloys had been D.C. cast in billets, preheated and extruded to the final shape. Atomic absorption gave the compositions reported in Table 1. For Al-Mg-Si

Table 1 - Composition in weight percentage of the alloys studied in this work

ALLOYS		Mg	Si	Cu	Zn	Fe	Mn	Cr	Ti	Pb	Bi
Al-Cu	2011	--	0.12	5.41	0.04	0.31	0.02	0.04	0.02	0.35	0.44
	2036	0.49	0.26	2.35	0.006	0.25	0.22	0.006	0.02	--	--
										Mg_2Si	Excess Si
Al-Mg-Si	6063	0.52	0.47	0.001	0.006	0.20	0.001	0.001	0.009	0.82	0.17
	6005	0.51	0.68	0.18	0.003	0.21	0.24	0.16	0.02	0.80	0.38
	6181	0.65	0.95	0.007	0.007	0.35	0.05	0.003	0.025	1.02	0.57
	6261	0.77	0.58	0 34	0.015	0.25	0.29	0.006	0.03	1.22	0.13
										Zr	--
Al-Zn-Mg	7015	1.85	0.14	--	4.92	0.20	0.006	0.11	0.015	0.15	--

alloys the percentage of Mg_2Si and the excess of Si to form that compound are also given. 30x50x1 mm sheet samples were prepared from the extrusions. DSC samples (5 mm diameter x 1 mm discs) were punched from the sheets. Both sheets and DSC samples were solution-heat treated and quenched in water at 25ºC. Whereas sheets were directly quenched, DSC samples were placed inside an aluminium tube with holes, this procedure guarantees a similar quench rate for the two types of samples (10). Samples were then naturally and/or artificially aged. After ageing, more DSC samples were either punched or spark cut from the sheets. The three types of samples will be hereafter referred to as undeformed, punched and spark cut samples. The following heat treatments were given. Al-Mg-Si alloys 1 h at 530ºC, water-quenched, 3 days at 25ºC plus 45 min at 175ºC. Al-Zn-Mg alloys 1 h at 465ºC, water-quenched and 6 h at 100ºC. Al-Cu alloys 15 min at 525ºC, water-quenched, 24 h at 100ºC for AA2011, and 7 days at 25ºC for AA2036. Punching was performed in a press described elsewhere (10), and spark cutting in a commercial equipment.

The DSC measurements were performed in a Perkin Elmer DSC-2C apparatus. High purity aluminium was used as reference. The runs were carried out at heating rates of 5 and 20ºC/min and under dynamic argon atmosphere (1 l/h).

RESULTS AND DISCUSSION

Aging heat treatments were chosen to build up in all the alloys a G.P. zone microstructure (2-10). Therefore the DSC curves will have a similar structure, namely, dissolution of G.P. zones, formation of the coherent or semicoherent phases, dissolution of the latter, followed by formation and dissolution of the incoherent phases (5,6-10). As in this case deformation mainly affects the formation of semicoherent or coherent phases, we shall concentrate the foregoing discussion on this region of the DSC curves. Table 2 reports the peak temperatures for that reaction (whenever two peaks appear, the two corresponding temperatures are given) and Figs. 1 and 2 show two representative examples. It should be remarked that the most important effects are found for the alloys AA2011 and AA-6063 (Fig. 2) previously

Table 2 - DSC peak temperatures (K) for the formation of the coherent phases (see text)

Samples		undeformed		spark cut		punched	
Heating rate (K/min)		20	5	20	5	20	5
Al-Cu	2011	636	-	624	-	596	-
	2036	564,653	-	563,654	-	557,649	-
Al-Mg-Si	6063	581	520,556+	570	514.554+	542	504+
	6005	542,584	513,558	536,576	509,550	533,571*	508,550
	6181	546,589	524,564	534,581	510,555	532 578	508,552*
	6261	536,583	512,557	535,581	510,553	532,571*	508,549*
Al-Zn-Mg	7015	520,554*	497,528			515	492,524*

+ heating rate 2.5 K/min , * weak reaction (shoulder)

studied by the present authors (10). An interesting case is that of AA2036 although not very large shifts in the peak temperatures are found, the two peaks reported in Table 2 are actually a triple peak structure (Fig. 1) which becomes a double peak structure after punching. In these three alloys the beneficial effect of spark cutting is very noticeable. Instead, for the remaining alloys, either the effect of punching is very weak (AA7015 and AA6261), or

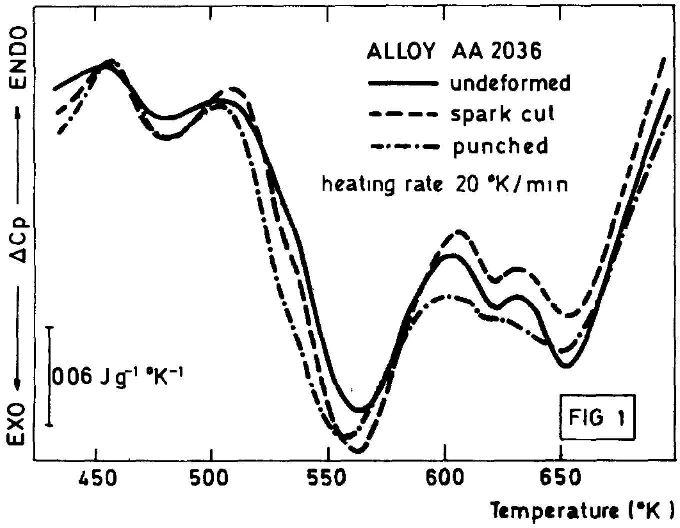

FIG 1

spark cutting does not introduce any improvement (AA6005 and AA6261). The strong differences found within the family of Al-Mg-Si alloys should be ascribed to compositional changes, such as the amount of Mg_2Si, excess of Si and the presence of other elements such as Mn. Finally it should be noticed that, as previously found by other authors (9), Al-Zn-Mg alloys are not very susceptible to punching.

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