IMPROVEMENT OF TI-6AL-4V FRACTURE TOUGHNESS BY HEAT TREATMENT

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INTRODUCTION

It is well known that the fracture toughness behaviour of Ti alloys depends strongly on microstructural parameters. The aim of the present work is to investigate the effect of three different heat treatments on mechanical properties of 20 mm. diameter mill annealed bars. The treatments studied were recrystallization anneal below the beta transus (RR) and beta anneal followed by air cooling (BA) or water quenching (WQ).

EXPERIMENTAL PROCEDURE

Tensile properties were determined using standard round specimens machined from the heat treated bars. Fracture toughness tests were performed on an instrumented impact machine over a temperature range of -196 to 20ºC using full size fatigue precraked Charpy V notched specimens. The dynamic fracture toughness was calculated utilizing the equivalent energy method as described by Rack (1).

RESULTS AND DISCUSSION

The results of the tensile and fracture toughness for the different heat treatments are summarized in table 1. It is shown to be in agreement with previous papers of Jaffee(2) and Seagle et.al. (3) that the beta phase heat treatments, that produce acicular microstructures, decrease the ductility of the alloy. In the samples where this treatment was followed by air cooling, this lower ductility was compensated for by a considerable increase in toughness. However, when it was followed by water quenching, the

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measured values were even lower than the results obtained in the original mill annealed bars. Recrystallization anneal leads to a small increase in both ductility and toughness compared to the mill annealed samples.
These results contradict the general belief that acicular microstructures lead to an improvent in toughness (2,3) Rogers (4).

However, it is in agreement with the observations of Gysler and Luetjering (5) who showed that a refinement in plate dimensions reduced the resistance to crack propagation because of less pronounced crack path deviations than those detected in the fine microstructures. The scanning electron microspy observations were consistent with the results obtained in the mechanical tests. In the air cooled specimens fracture propagates along the boundaries of individual plates linked by ductile dimples while the WQ samples fracture surfaces exhibit steps, each of them formed by a colony of small size martensite plates. The RR treatment showed ductile dimples in the whole fracture surface. The action of different fracture mechanisms leads to differences in crack growth path deviations and could justify the changes in toughness.

ACKNOWLEDGEMENT

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TABLE 1

Effect of Heat Treatment on Mechanical Properties.

Heat Treatment	y.s. (M Pa)	U.T.S. (M Pa)	Elong. %	R.A. %	Ka (M Pa $m^{\frac{1}{2}}$) 20ºC	-196ºC
Mill ann.	1024	1113	12.7	45.2	47	24
B.A.	1058	1117	8.5	12.2	96	38
W.Q.	1072	1148	8.3	11.0	38	23
R.R.	869	967	14.5	46.3	56	27