FACTORS AFFECTING THE FIBRE STRENGTH DISTRIBUTION DURING THE FATIGUE LIFE OF TiMMCs

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INTRODUCTION

As one aim of the reinforcing fibres is to improve the fatigue and tensile properties of the composite with respect to the monolithic material, the S/N behaviour of TiMMCs has been studied to determine how the strength of the reinforcing fibres affects the fatigue life of the composite and also how fibre strength degradation due to fatigue and/or exposure to an aggressive environment can influence the fatigue life.

Fibre strength distributions have been evaluated by means of a single fibre test. The effects of the etching solution used to remove the matrix have been carefully examined. Weibull weakest link theory has been subsequently used to analyse the results of single fibre tests.

As a starting point, the strength distribution for the fibres extracted from the as-received composite has shown that the processing route of the composite does not produce an important reduction of strength with respect to the virgin fibres (Figure 1).

To evaluate the extent of fatigue degradation, strength distributions for fibres extracted from specimens fatigued at different values of peak applied stress have been compared with the fibres extracted from the as-received composite. The test methodology has shown the occurrence of fibre strength degradation only in the case of composite characterised by global fatigue damage. Localised or global fatigue damage has been confirmed by the distribution of matrix secondary cracks and also by the interpretation of acoustic emission data representing the evolution of fibre damage during the life of the composite. The mechanisms causing fibre strength degradation will be discussed based on SEM observation of the etched fibres before and after single fibre testing.

The extent of fibre strength degradation in an aggressive environment has been studied by carrying out high temperature fatigue tests in air and in vacuum. In this context, virgin fibres have been exposed to high temperatures for different lengths of time to evaluate degradation mechanisms.

In general, this study has shown that strength degradation mainly affects the fibres bridging the main crack or secondary cracks of the matrix. This result has been also confirmed when studying the S/N behaviour of composites characterised by an irregular geometrical distribution of fibres, but characterised in the as-received condition by the same fibre strength distribution as the composites having a regular array of fibres. The irregular fibre geometry has been taken into account to explain the poorer fatigue life and the much lower run-out stress of these composites. Considering run-out conditions, secondary matrix cracks appear more widely spaced and in accordance the extent of fatigue strength degradation is less important when compared to composites with a more regular array of fibres fatigued near to their run-out stress (Figure 2).

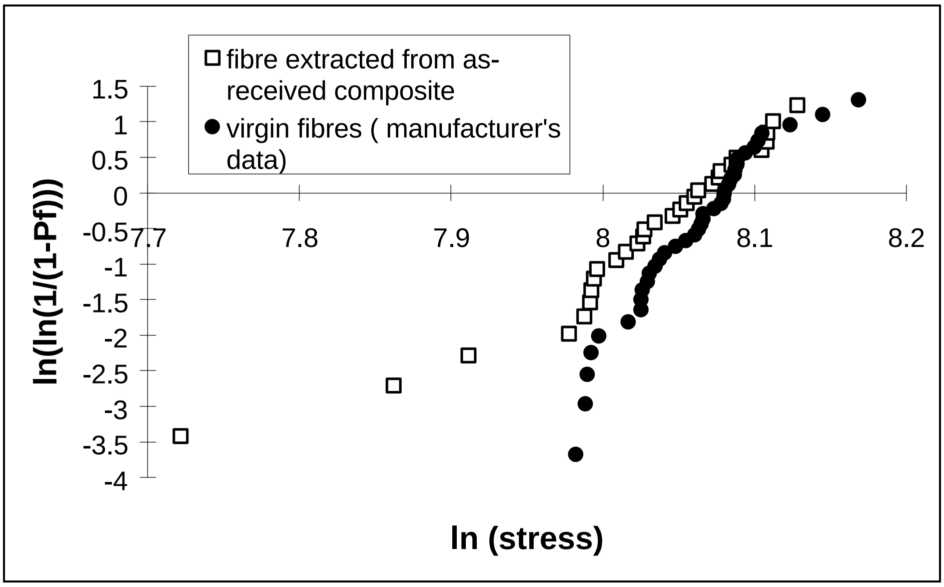

Figure 1. Comparison of fibre strength distributions between virgin fibres and fibres extracted from the as received composite

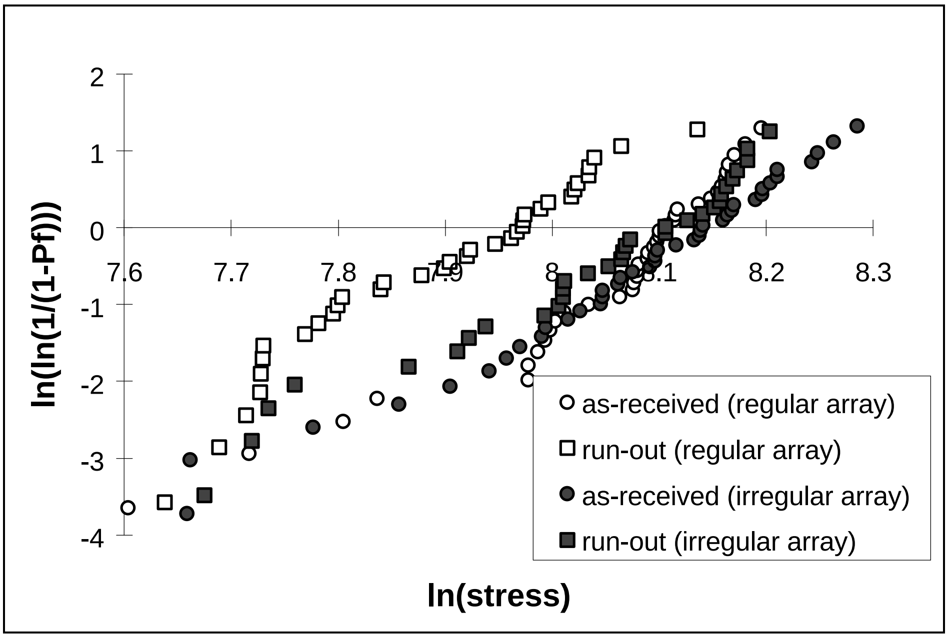

Figure 2. Effect of fibre strength degradation depending on the regular or irregular geometric distribution of fibres in the composite