8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

GROWTH OF SURFACE FLAWS ON GLASS FIBRES DURING HIGH TEMPERATURE EXPOSURE

***S. Feih[1,2], Z. Mathys[3] and A.P. Mouritz[4]**

[1]RMIT, GPO Box 2476V, Melbourne, Victoria, 3001, Australia
s.feih@crc-acs.com.au

[2]CRC-ACS, 506 Lorimer Street, Fishermans Bend, Victoria, 3207, Australia

[3]DSTO, 506 Lorimer Street, Fishermans Bend, Victoria, 3207, Australia
zenka.mathys@dsto.defence.gov.au

[4] RMIT, GPO Box 2476V, Melbourne, Victoria, 3001, Australia
adrian.mouritz@rmit.edu.au

Key Words: *Glass fibres, fire, fracture mirrors*

ABSTRACT

Strength reduction of glass fibres after high temperature exposure is an important issue when considering recycling of glass fibre composites. During recycling, the resin matrix might be burned off at temperatures around 500ºC for times of up to 2 hours [1]. Although glass fibres appear unaffected on visual inspection, the heat treatment can significantly decrease the fibre strength and remains one of the major issues preventing the use of recycled glass fibres. Up to now, the reason for this strength decrease was unknown, although various factors have been reported in the literature [1].

Recent fire research by Feih et al [2,3] has further explored the strength decrease of glass fibres as a function of time and temperature. Exposure of glass fibres to elevated temperature results in significant strength reduction for temperatures as low as 350ºC. As shown in this current work, this strength loss is caused by an increase of the size of surface flaws.

The strength loss of glass fibres is measured by fibre bundle testing and found to be time and temperature dependent, as shown in Figure 1 for E-glass. A difference in chemical composition of the fibres did not influence the strength degradation characteristics as established by comparing Advantex® glass fibres with standard E-glass fibres, which have a different chemical composition. However, the higher glass softening point of the Advantex® fibres is reflected in superior high temperature performance. The measured strength decrease is currently modelled based on a phenomenological model with four fitted parameters [3]. A better understanding of the underlying mechanisms is given in the present work.

For E-glass fibres, the strength reduction observed in the fibre bundle test was compared to the strength decrease as determined from single fibre testing. The latter test also shows significant strength reduction (see Figure 2), but the effect is less severe when compared to the bundle test (50% versus 75% for 30mins at 450ºC). This is attributed to the fact that the single fibre test eliminates friction effects, which can considerably affect the results of the fibre bundle test. Furthermore, both tests show that the fibre modulus remains unaffected by heat treatment.

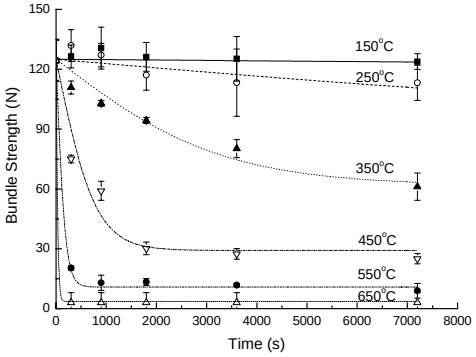

Figure 1: Fibre bundle strength as a function of time and temperature

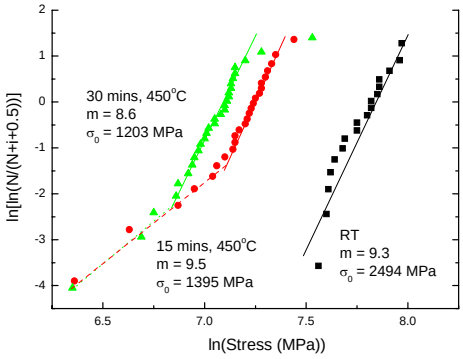

Figure 2: Weibull plot of single fibre test results

Fracture mirror sizes on the glass fibres after single fibre tensile testing were investigated and related to the fibre strength (see Figure 3). Based on fracture mirror measurements (size indicated by dashed white line), the glass strength reduction was found to be controlled by the growth of surface flaws during heat treatment. Figure 4 relates the reciprocal square root of the fracture mirror depth to the failure stress and shows a linear relationship. From linear fracture mechanics, the size of surface flaws was found to grow from an average depth of 100nm (as received) to an average depth of 450nm after heat treatment at 450ºC for 30mins.

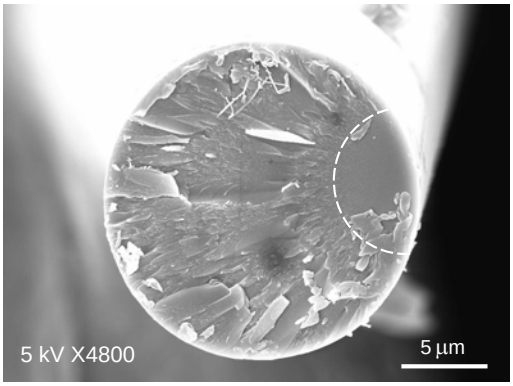

Figure 3: Fracture surface with surface flaw fracture mirror

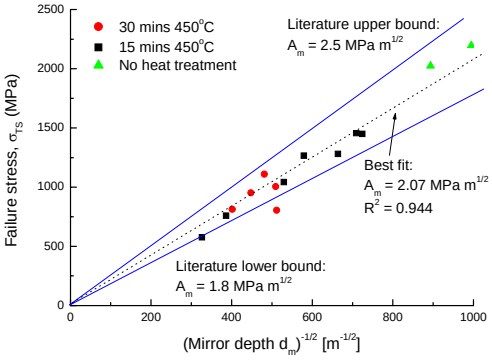

Figure 4: Fracture stress correlation with fracture mirror size

It is postulated that the growth of the flaw occurs due to the attack of atmospheric moisture during high temperature exposure. Additional tests will be undertaken to evaluate the strength reduction of glass fibres after heat exposure in vacuum and in inert atmosphere to test this hypothesis.

REFERENCES

[1] S.J. Pickering, R.M. Kelly, J.R. Kennerly, C.D. Rudd, N.J. Fernwick, *Journal of Composites Science and Technology*, Vol. **60,** pp. 509-523, **(**2000).

[2] S. Feih, Z. Mathys, A.G. Gibson and A.P. Mouritz, *Journal of Composites Science and Technology*, Vol. **67**, pp. 551-564, (2007).

[3] S. Feih, Z. Mathys, A.G. Gibson and A.P. Mouritz, *Journal of Composite Materials*, Vol. **41**, pp. 2387-2410, **(**2007).