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AN IMPROVED METHOD FOR IDENTIFICATION OF THE INTERFACIAL SHEAR STRENGTH BY TENSILE TESTS OF SHORT-FIBER COMPOSITES

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ABSTRACT

Compatibility of the fibers and matrix is of great importance to achieve good mechanical properties of composite. The interfacial shear strength (IFSS) is often used to characterize this compatibility by a number of direct methods on micro-scale level [1] (e.g. fiber pull-out, microbond, single fiber fragmentation). Although these methods have been validated on the laboratory scale, they are rather problematical to employ and thus not widely used by industry. More convenient, easier and faster are indirect methods, one of which, proposed by Bowyer and Bader [2, 3], seems to be an industry-friendly solution [4]. This technique uses tensile stress-strain response of short fiber composites. The current paper presents modified Bowyer and Bader technique for estimation of the IFSS by employing more realistic representation of stress transfer between fibers and matrix. The method is applied to the short-flax-fiber/starch composites to evaluate the dependence of IFSS on fiber and plasticizer content. Nine flax/starch composites with variable content of plasticizer and fibers were studied; detailed information about production, morphological analysis, and testing is given in [5].

The rule of mixtures [2, 3] relates the stress σ_c and strain ε in short-fiber composite as

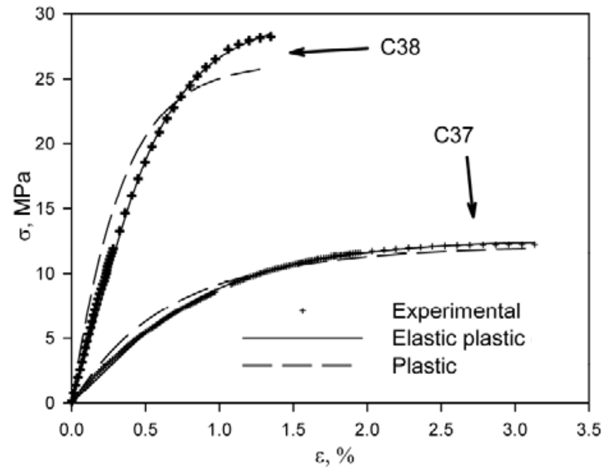
$$\sigma_c = \eta_o \eta_l v_f E_f \varepsilon + (1 - v_f)\sigma_m \tag{1}$$

where E_f and v_f denote the Young's modulus and volume fraction of fibers, η_o and η_l are fiber orientation and length efficiency factors, and $\sigma_m = \sigma_m(\varepsilon)$ is the stress acting in the matrix. The η_l is obtained either by assuming an elastic-perfectly plastic Eq. 2 or rigid-perfectly plastic Eq. 3 stress transfer in composite by interfacial shear

$$\eta_l(l) = \begin{cases} 1 - \dfrac{\tanh \beta l/2}{\beta l/2} & l \le l_{el} \\ 1 - \left(1 - \dfrac{2\tau_i l_p}{E_f \varepsilon r_f}\right)\dfrac{\tanh \beta(l/2 - l_p)}{\beta l/2} - \dfrac{2l_p}{l}\left(1 - \dfrac{\tau_i l_p}{E_f \varepsilon r_f}\right) & l > l_{el} \end{cases} \tag{2}$$

$$\eta_l = \frac{\Gamma\left(1 + \dfrac{1}{\alpha}, \left(\dfrac{l_c}{l_W}\right)^{\alpha}\right) + \dfrac{l_W}{\alpha\, l_c}\left[\Gamma\left(\dfrac{2}{\alpha}\right) - \Gamma\left(\dfrac{2}{\alpha}, \left(\dfrac{l_c}{l_W}\right)^{\alpha}\right)\right] - \dfrac{l_c}{l_W}\exp\left[-\left(\dfrac{l_c}{l_W}\right)^{\alpha}\right]}{\Gamma\left(1 + \dfrac{1}{\alpha}\right)} \tag{3}$$

where τ_i is IFSS, l - fiber length, β - shear lag parameter, l_p - length of the interfacial yielding region, l_e - fiber length at the onset of interfacial yielding, r_f - fiber radius, l_W and α are the parameters of Weibull distribution for fiber length, l_c is the critical fiber length, Γ is gamma function. Detailed account of assumptions and derivations of equations is given in [6]. The η_o can be evaluated from a composite modulus using the respective rule-of-mixtures expression, and thus the only unknown parameter is IFSS, which is obtained by fitting Eq. (1) to the stress-curve of a composite (see Figure 1). The IFSS was found to depend on fiber loading in the composites and to decrease with increasing content of plasticizer (see Figure 1).



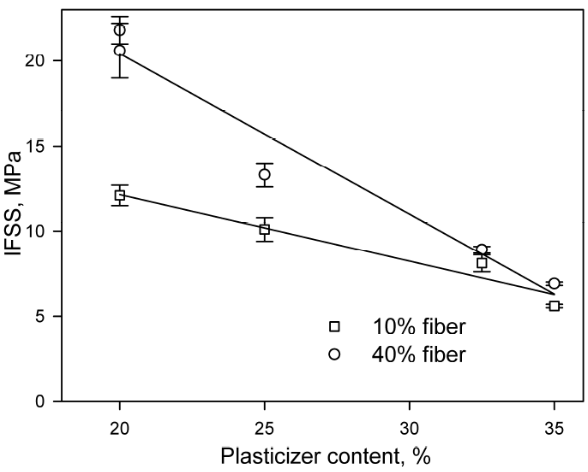


Figure 1. Typical stress-strain curves of composites with 35 wt% plasticizer and different fiber content (left) with approximation (solid lines for elastic-perfectly plastic stress transfer model, dashed lines for rigid-perfectly plastic) and variation of the apparent IFSS with plasticizer content in the matrix (right).

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