Measurement and modelling of the extent of fibre contact in paper

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Abstract

Recent theoretical developments suggest that for networks of sufficiently high mean coverage, the fractional contact area (FCA), i.e. the structural analogue of RBA, is a function of inter-fibre porosity only [1]. Whereas direct measurements of RBA are rather difficult to obtain, an experimental procedure for directly counting the number of contacts per fibre has recently been developed [2]. The work that we will present here brings together these developments. The theory presented in [2] is simplified to yield an expression for the expected number of contacts per fibre in a network with mean coverage, $\bar{c}$:

$$ n = \frac{4A}{\pi} \left( 1 - \frac{1}{\bar{c}} \right) \Phi^\infty, $$

where $A$ is the fibre aspect ratio and $\Phi^\infty$ is the fractional contact area of a network with infinite coverage as given by,

$$ \Phi^\infty = \frac{2\varepsilon}{\log(1/\varepsilon)} \sum_{c=1}^{\infty} \frac{(c-1)\log(1/\varepsilon)^c}{c\varepsilon!} + \varepsilon(1-\varepsilon)^2 \sum_{c=1}^{\infty} \frac{\log(1/\varepsilon)^c}{c\varepsilon!}, $$

such that it is a function of porosity only. It follows that the expected number of contacts per fibre is a function of porosity and fibre aspect ratio only. We will proceed to show that this means that the mean free-fibre length and pore size depend upon porosity and fibre width only.

We have used experimental data for the number of contacts per fibre presented in [2] along with literature data [3] to test Equation (2) via Equation (1). Very good agreement, as shown in the figure, was found between theory and experiment when the accessible porosity was used. This was defined by us as the sheet porosity excluding pore space within, and directly next to fibres, that is inaccessible to bonding.

References


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