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, $\bar{c}$:

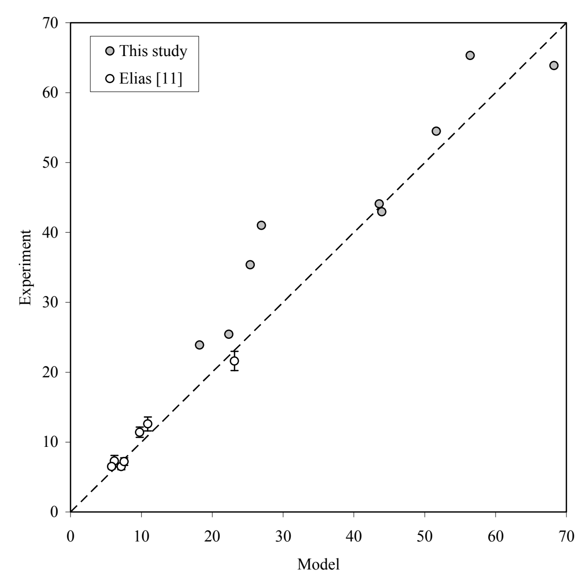
$$n = \frac{4\,A}{\pi}\left(1 - \frac{1}{\bar{c}}\right)\Phi^{\infty} \ , \qquad (1)$$

where A is the fibre aspect ratio and Φ^{∞} is the fractional contact area of a network with infinite coverage as given by,

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

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

[1] W.W. Sampson. *J. Mater. Sci.* **39**(8):2775-2781, 2004.
[2] J. He, W.J. Batchelor and R.E. Johnston, *Appita J.*, **57**(4):292-298, 2004.
[3] T.C. Elias. *Tappi J.* **50**(3):125-, 1967.

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