Institute for Process and Particle Engineering

Graz University of Technology

Fractionation of Wood Fibres and Fines in the Froth Layer of a Flotation Cell

Jakob D. Redlinger-Pohn, and Stefan Radl

Graz University of Technology,
Institute of Process und Particle Engineering, Graz, Austria

Introduction

Flotation is used in the paper and pulp industry to remove unwanted hydrophobic particles [1] from wood fibre pulp. However, also fibres and organic fines, which are hydrophilic, are removed in the process. Mechanical entrapment of fibres and fines by ascending bubbles was identified to cause this loss of fibres [2].

Collapsing bubbles in the froth lead to a vertical backflow of water from the froth top to the suspension (Fig. 1, left panel). The backflow of water is termed water drainage. The rate of collapsing bubbles depends on the froth stability, which, amongst other factors, depends on the bubble size. In experimental studies it was found, that fibres and fines were removed by the draining water from the froth at different rates (Fig.1 right panel, top) [3-6]. Literature suggests that draining water (i) causes an increase in fibre consistency in the froth, and (ii) washes fibres and fines from the froth.

While there are studies on the influence of flotation settings on the fractionation performance, these settings were not investigated independently on each other. Here we investigate the effects of the (i) bubble size, (ii) pulp consistency, and (iii) froth height independent on each other.

Material and Methods

A 2D flotation cell (dimensions 900x250x80 mm) with 12 L filling volume was used for the study (Fig. 1, left panel). Gas bubbles (Fig. 1, right panel) were supplied either by (i) needle sparger ($x_{3,mean}$ 3.57 mm) or (ii) frit sparger ($x_{3,mean}$ 1.1 mm). Mechanical pulped fibres (MP) were supplied by Norske Skog and chemical pulped fibres (CP) were supplied by Sappi Gratkorn. Tall oil (Zellstoff Pöls) was identified in a pre-study to produce stable froth for all types of pulp and hence was used as frother in this study. Concentration based on the mass of dry fibres was 700 mg/g for MP and 450 mg/g for CP.

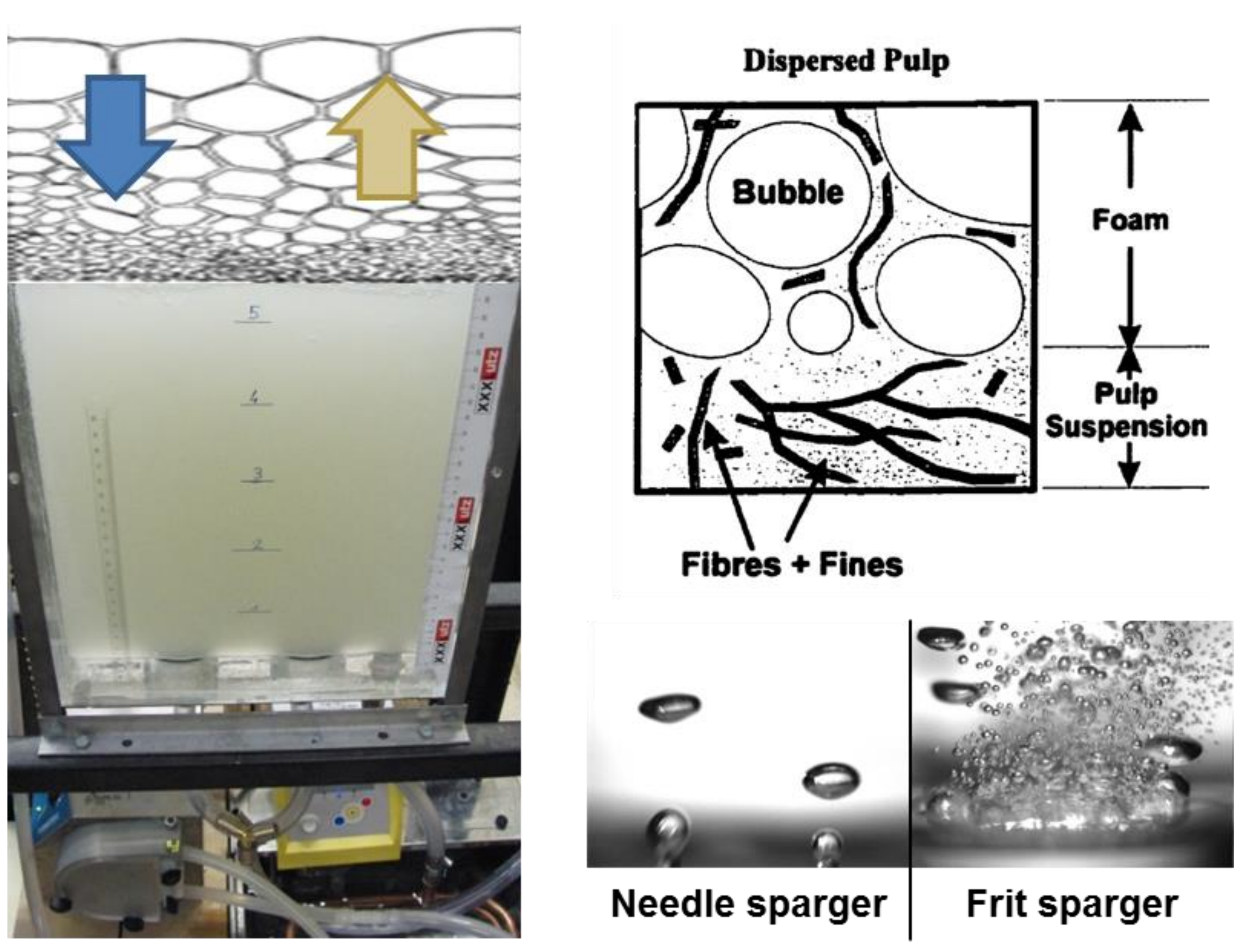

Fig. 1: Left panel: Flotation cell filled with fibre/fines pulp. Schematics of the froth present the flow of drainage water (blue arrow) and froth growth (brown arrow). Right panel, bottom: presents bubbles resulting from the needle sparger and frit sparger. Right panel, top: presents the schematics of fibre and fines separation reported by Ajersch [2].

Flotation froth was collected over time and the amount of fibres and fines in the froth and pulp was measured (i) gravimetrically, and (ii) optically using the L&W Fibre Tester+ (Lorentzen+Wettre, Sweden).

Results were the relative fines content (fraction < 75 µm) w_{fines} in the froth and pulp suspension and the grade efficiency T(x) of the fractionation process.

$$w_{fines} = m_{fines} / (m_{fines} + m_{fibres}) \qquad (1)$$

$$T(x) = \frac{m_{foam}}{m_{pulp}} \frac{q_{3,foam}(x)}{q_{3,pulp}(x)} \qquad (2)$$

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Results

Flotation Performance and Froth Stability

The froth was found less stable in experiments with MP compared to experiments with CP. It is hypothesised , that (i) larger amount of fines in MP ending up as particles between the bubbles in the froth phase, and (ii) higher fibrillation of MP fibres decrease the stability in the froth.
In general, it was found, that the amount of removed froth increased with (i) decreasing froth height, and (ii) increasing froth stability.

Reduction of Fines Content

In Fig. 2 first result "MP / frit - no froth" presents a test case where froth was removed close to the pulp/froth interface and hence at small froth height. No change in the amount of fines was found. For similar settings but increased froth height, "MP / frit - 0.1% con." a reduction of fines of 19% was found. It can be concluded that fractionation of fines occurs in the froth and not at the interface. Increasing the initial pulp consistency from 0.1% to 0.3% yielded better removal of fines. At 0.3% flocks of fibres, which are poor in fines [2] are removed in the froth. A larger amount of fibres yields a smaller relative fines content. CP processed at similar conditions as MP yielded larger removal of fines (75% CP, 19% MP). This might be addressed to smaller initial amount of fines in CP and/or differences in the fibres resulting from differences in the pulping process.

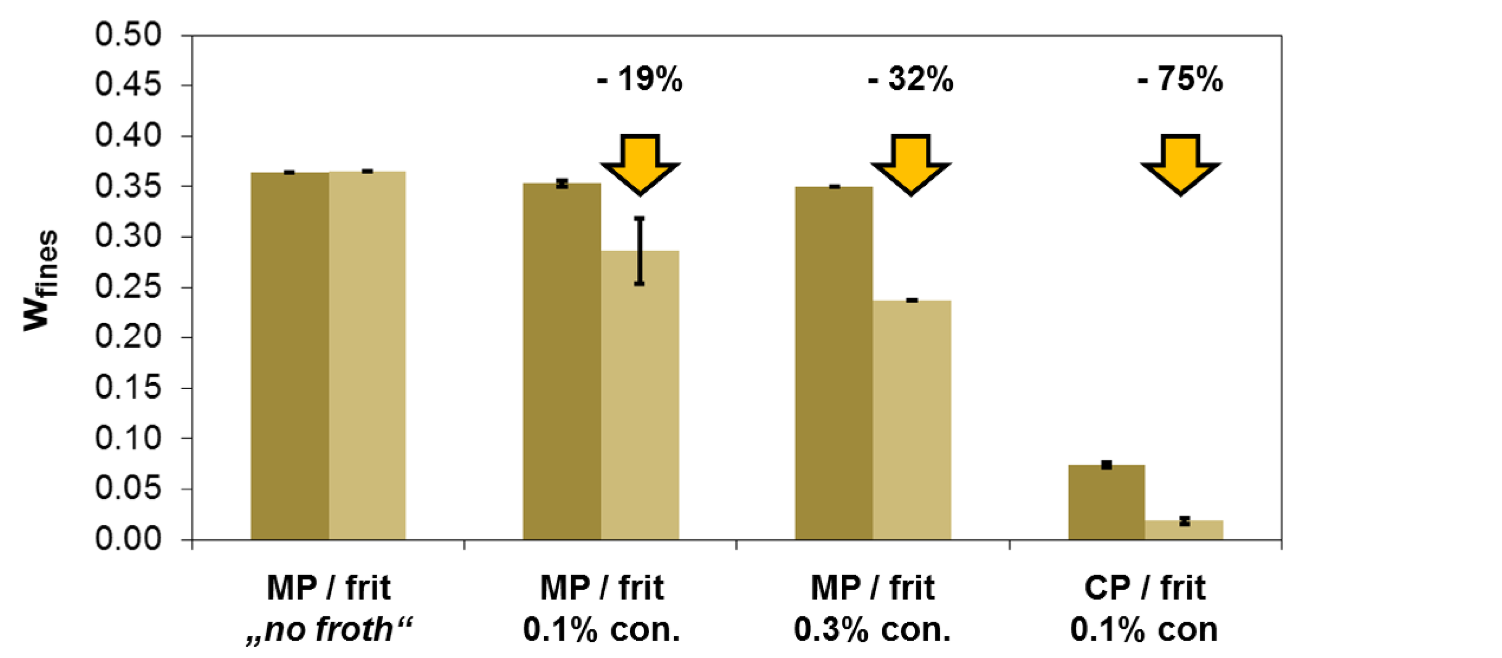

Fig. 2,: Relative fines (particles < 75 µm) content of the pulp (left bars) and froth (right bars). Reduction in the fines content is stated above as percentage based on the amount of fines in the pulp.

Grade Efficiency T(x)

Grade efficiency curves for MP and CP (Fig. 3) present the removal of larger fibre by the froth. Comparing T(x) for the largest and smallest fraction, it was found that best fractionation results were achieved for CP and large bubbles configuration. However, from the absolute value of T(x) it can be seen that only small amount of fibres was recovered in the froth. For both MP and CP small bubbles configuration yielded good fractionation of fibres from fines at high total recovery of fibres (ca. 70% of large fibres for CP, and ca. 40% of large fibres for MP).

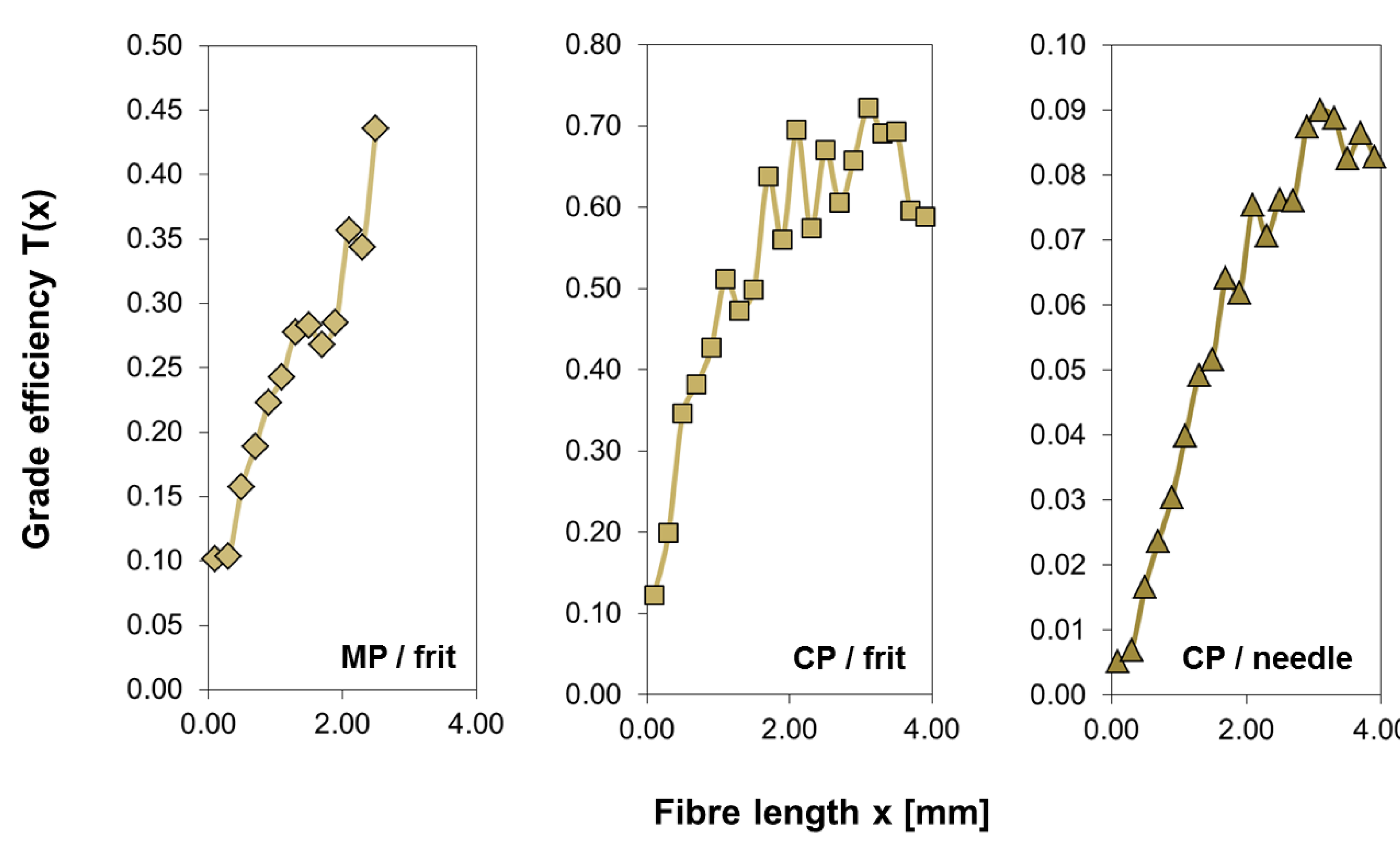

Fig. 3: Grade efficiency T(x) presenting the recovery per fibre size in the froth. Cases from left to right are: mechanical pulp / small bubbles, chemical pulp / small bubbles, chemical pulp / large bubbles.

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