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Factors influencing MOW deinking: Laboratory scale studies

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Abstract

The deinking of MOW is examined at laboratorial scale. The effect of deinking aids, pre-washing and mixing are studied. The operating conditions during pulp treatment affect the pulp and paper properties, interfering with the mechanism of ink removal and modifying the ink particle characteristics. Pre-washing the pulp facilitates the deinking process. Cellulolytic enzymes and deinking chemicals are comparable in terms of ink removal ability.

Keywords: Paper pulps; Non-impact inks; Deinking; Enzymes; Image analysis; MOW

1. Introduction

The use of recycled fibres for paper manufacture is highly desirable. However, the production of a good quality paper requires an adequate modification of the secondary fibre properties and the removal of a large amount of contaminants, namely stickies, sizing and coating agents, mineral fillers and inks. The selection of equipments and recycling techniques is a difficult task that greatly depends on the type of furnish available for production, thus leading to new research in the recycling field. One of the factors that should be considered is the ink formulation [1], which rends the deinking process particularly difficult, due to the constant modification of its chemical composition.

Generally, the industrial process for removing wastepaper contaminants involves re-pulping, screening, cleaning, washing and flotation [2,3]. Attempting to reflect the industrial process, the laboratory deinking trials frequently include four sequential stages, namely sample preparation, pre-washing, pulp treatment and fibre/ink particles separation. Each stage contributes to the overall effectiveness of deinking. Two goals are envisaged: (i) the detachment of the ink particles from the fibre surface; (ii) the removal or separation of the ink particles.

In order to favour deinking, chemical products have been used for a long time [1]. More recently, enzymes appeared as an alternative deinking aid [4]. Enzymatic deinking is advantageous for industrial usage because it is efficient, quick and has a low environmental impact [2–7]. However, due to the high heterogeneity of the paper provisions, the behaviour of a particular paper sample during recycling remains to large extent unpredictable. More data are required, to help understanding the action mechanism and the development of an economic and effective process.

In the present work, mixed office wastepaper (MOW) deinking is studied at laboratory scale; the effect of pH, deinking aids, pre-washing and mixing on the deinking process is examined. The office grades are generally more difficult to deink because, during printing, the thermoplastic synthetic polymers present in the laser and photocopy toners fuse at high temperature and adhere strongly to the fibres surface [8–10]. The high-quality fibres content in this paper, however, justifies its re-utilisation.

2. Methods and materials

The office wastepaper samples were treated according to the general protocol presented in Fig. 1. The experimental plan was organized in order to analyse: (i) the effect of the deinking aids (chemical products and/or enzymes) on pulp

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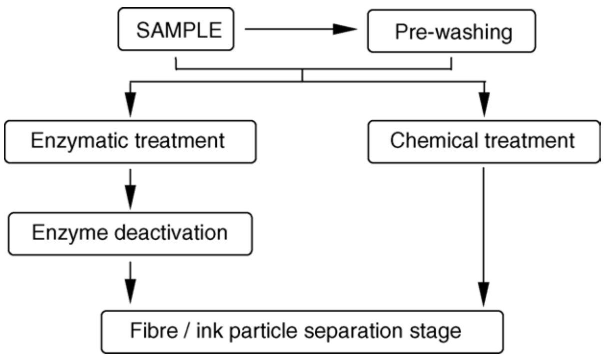

Fig. 1. General deinking sequence.

Table 1
Enzyme characterisation and dosages applied to the pulps

Enzyme	FPase		CMCase	Xylanase
	FPU (ml)[a]	FPU (g)[b]	U (ml)[a]	U (ml)[a]
Celluclast 1.5L	57	0.5	26.0	680
Buzyme 2523	3	0.1	5.3	33

[a] Enzymatic activity in the cocktails as provided by the suppliers.
[b] Enzyme dosage used in the pulp treatments expressed per gram of oven-dry (o.d.) pulp.

deinkability; (ii) the contribution of a pre-washing stage; (iii) the effect of attrition, caused by mixing the pulp, on the fragmentation and detachment of the printed ink films.

2.1. Enzymes

Two commercial enzymatic preparations were selected to perform this study: Celluclast 1.5L and Buzyme 2523. The first has been referred as an effective deinking aid [6,7,11]; the second was found to be efficient, in a preliminary set of assays [12], on the deinking of several paper pulps, namely a chemical pulp (MOW, 84% of ink removed), a mechanical pulp (51%) and a photocopy printed pulp (92%). The relevant hydrolytic activities of these preparations are presented in Table 1. The endoglucanase, cellulase and xylanase activities were measured using the carboxymethylcellulase (CMCase), filter paper (FPase) and xylan oat spelt assays, respectively, as described in Wood and Bhat [13] and Bailey et al. [14]. Reducing sugars were measured by the dinitrosalicylic acid method (DNS), using glucose as standard [15].

2.2. Paper pulp

The pulp used in this work was kindly supplied by the paper company *Renova*, S.A. (Torres Novas, Portugal). It was obtained by disintegrating mixed office wastepaper (MOW) on the Renova mill, and provided as high consistency pulp slurry. In order to evaluate the pre-washing stage contribution to deinking, a preliminary washing step (as described in Section 2.5) was conducted immediately after the sample preparation: a "washed" mixed office wastepaper was obtained (WMOW).

2.3. Enzymatic deinking

The pulp (25 g on oven-dry basis) was suspended in distilled water and disintegrated for 10 min in a 250 ml plastic container using a *Heidolph* overhead stirrer (model RZR-1) and a propeller especially designed for this work (Fig. 2). Then, the enzyme was added to the mixer according to the values shown in Table 1. The enzymatic preparations were previously diluted (in 10% of the total reaction volume), in order to achieve a better dispersion. According to the conditions defined in a previous work, the deinking reaction was allowed for 30 min at 11% consistency, pH 7.0 and 50 °C, with continuous slow mixing [16,17]. To inactivate the enzyme, the pulp suspension was boiled for 10 min. The cellulose degradation was quantified using the DNS method. To avoid redeposition, the released ink was immediately separated from the fibres, as described ahead. The fibres were finally recovered for testing.

In order to test the effect of the mechanical action on enzymatic deinking some treatments occurred in the absence of mixing, after disintegrating the pulp for 1 min; to evaluate the benefit of using surfactants during enzymatic deinking, Celluclast 1.5L was supplemented with a commercial surfactant (Rhecol OCP—Allied Colloids) in other assays.

Control assays with denatured enzyme were made in parallel. Each experimental condition (enzymatic assay or control) was assayed twice and a good reproducibility was found. The

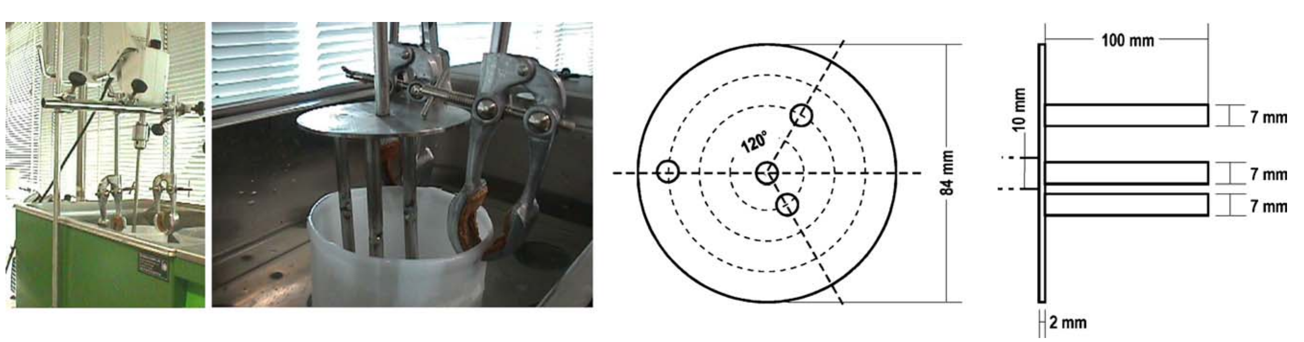

Fig. 2. Enzymatic/chemical treatment of pulp slurries at UM laboratory facilities (from the left to the right) pulp treatment device, propeller detail, propeller design.