# SEPARATION OF FIBRE FINES AND INORGANIC FINES IN RECOVERED PAPER SUSPENSIONS

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## ABSTRACT

Recovered paper is the most important resource for the European paper industry. The utilization rate of recovered paper reached 2007 about 68 % in Germany. Recovered paper is a mixture of fibres, fibres fines, inorganic fines, chemical and extraneous materials. Since the last years the content of inorganic fines was increasing. In 2008 the inorganic content has already exceeded 19 % in sorted mixed papers and boards (recovered paper grade 1.02) [1]. For producing high quality paper the paper mills, which use recovered paper, have to remove undesirable materials. These undesirable materials are on the one hand stickies, plastics, metal and inorganic fines on the other hand, because inorganic fines reduce the strength properties of paper. The removing of inorganic fines means today a high loss of fibre fines, because a selective removal of inorganic fines is not possible with the state of technology. Screeners, hydro cyclones, washers and flotation cells separate always a mixture of fibre fines and inorganic fines. To solve this separation task a sedimentation process was developed.

## KEYWORDS

Fine Particle, Paper Industry, Recovered Paper, Sedimentation, Separation

## 1. Introduction

Recovered paper is today the most important fibre resource for producing new paper. Recovered paper has many advantages over chemical and mechanical pulp like lower energy consumption in stock preparation and lower purchase cost. But recovered paper has also disadvantages like higher concentration of undesirable material. For removing the undesirable components the paper mills have to practice a large effort. The stock preparation in all mills must use many separation and cleaning techniques, to guarantee a good pulp quality.

But not all materials were undesirably from the very first of using recovered paper. Inorganic fines got problematical only for the last years. Due to the stronger use of inorganic particles in paper production, caused by optical properties and lower cost, and because of the closed recycling chain the concentration of inorganic fines in the recovered paper increases. Today, an inorganic fines level is reached which causes problems in producing high quality new paper from recovered paper. Producers of packaging paper have to contend against losses in strength properties, because

strength properties of paper and board decrease with increasing filler content. Producers of graphic paper have to fight against variations in pulp quality to guarantee constant conditions for the paper machine. And producers of hygienic paper have to accept increasing losses for removing nearly all inorganic particles, because inorganic particles decrease the softness of paper. Therefore, one aim of the paper industry is the selective removal of fillers during the paper production process.

The paper industry use flotation cells, washers, screens and hydro cyclones for separation. All these techniques can reduce the content of inorganic fines in the pulp, but not selectively. Always a large amount of fibre fines are removed with the fillers by using established technologies. The rejects of these techniques contain an organic content between 45 % and 65 % [2]. So a removal of inorganic fines by common technique leads to large losses of useful fibre fines and to problems in disposal. Therefore, another separation technique with better separation ratio is necessary to remove inorganic fines more selectively.

This paper deals with a new separation technique to remove inorganic particles. The new technique consists of two separation steps and is based on screening and sedimentation.

## 2. Research target

Target of the project was the development of a new selective separation technique to remove inorganic particles from recovered paper suspensions. The new technique should have a better separation efficiency and a better yield as the common technique.

The new separation process should consist of two steps. In the first step the fibres of the suspension are removed by screening. After the screening step the fines suspension are separated with a new device in an organic and an inorganic fraction. The new device is based on sedimentation because previous trials have shown that organic fines can be separated from inorganic particles by sedimentation.

## 3. Experiments

The separation behaviour of native fines suspensions were investigated in first trials. Native fines mean fibre fines and inorganic fines which have not passed the paper production process. These trials were done in a new built wedge-shaped counter-flow sedimentation cell. The separation results showed that a counter-flow sedimentation process has a very good separation efficiency.

Representing the reality two paper grades were produced to turn out fines of recovered paper. One paper grade was an uncoated paper and the other was a coated paper. The uncoated paper was produced of chemical pulp with $CaCO_3$ as filler and some chemical additives. The coated paper had as base paper the uncoated paper and was coated twice. The first coating layer contained only $CaCO_3$ as pigment and the second contained 50 % $CaCO_3$ and 50 % clay. Of these two paper grades the fines suspensions were produced for further investigations.

One paper grade was pulped in a LC pulper at a consistency of 4 %. After pulping the suspension was screened by a 150 µm hole screen to remove the fibres. The suspension which passed the hole screen was the fines suspension for particle examinations and separation trials. The fines suspension of the uncoated paper had on average a fibre fines content of 45 % and an inorganic particle content of 55 % and the suspension of the coated paper had a fibre fines content of 25 % and an inorganic particle content of 75 %. In the continuing course of this article the fines suspensions of the uncoated paper and the coated paper are called coated paper and uncoated paper.

The particle examinations were done with a manometer centrifuge and sedimentation scales. The separation trials were performed first batch wise in the wedge-shaped counter-flow sedimentation cell and later continuous in a conical counter-flow sedimentation cell. The separation effect was estimated by incineration of the inlet suspension and all produced fractions. Because of the high content of $CaCO_3$ all samples were incinerated at 525 °C like specified in ISO-1762 [3]. As benchmark of the separation effect flotation trials were done in a flotation cell on the laboratory scale, the PTS flotation cell. As flotation chemicals the standard recipe of the INGEDE Method 11 [4] was used, which is an established method in the paper industry.

## 4. Results and discussion

All examinations in both counter-flow sedimentation cells showed that the fibre fines form flocks which settle faster than inorganic particles. As the native fines well as the fines produced of the two paper grades displayed this character. The fibre fines orientate themselves and agglomerate to flocks. But, the flocks are growing just to a limited size. As more fibre fines are in the suspension as more flocks form but not of larger size. This phenomenon that fibres orientate themselves and agglomerate during the sedimentation discovered Kumar and Ramaro [5] as well as Herzhaft and Guazelli [6]. The orientation and agglomeration of fibre fines in recovered paper suspensions describes Feist et al. [7].

Because the fibre fines flocks reach a much higher settling velocity than the inorganic particles the fibre fines can be separated from the inorganic particles by using sedimentation. But requirement for separation is that the fibre fines are not bound with the inorganic particles. This requirement is not achieved in recovered paper suspensions. Retention agents and binders adhere the fibres and fibre fines with the fillers and pigments. This adhesion is not destroyed sufficiently during the pulping process. So the fibre fines are loaded with inorganic particles. Thereby almost all fibre fines and inorganic particles show the same settling velocity in recovered paper suspensions and cannot be separated of each other. This situation is described by Feist et al. [8] in the particle examinations of the uncoated and the coated paper. Without a pretreatment the separation of the fibre fines from the inorganic particles is not possible.

To enable the separation of the fibre fines from the inorganic particles, the coated and the uncoated paper were thermo-mechanical treated in a kneading device, a Beken-Kneader, before the separation process. Feist et al. [8] also investigated the effect of the kneading in the manometer centrifuge. The thermo-mechanical pretreatment caused a slowing down of the average sedimentation velocity but also a widening of the sedimentation velocity distribution. This is a clear indication that agglomerates were destroyed. The separation results in the wedge-shaped sedimenta-

tion cell showed that separation success was extremely improved by the thermo-mechanical pretreatment as you can see in **Figure 1**. The agglomerates between fibre fines and inorganic particles were destroyed by the kneading process. After this thermo-mechanical pretreatment the separation between fibre fines and inorganic particles is possible.

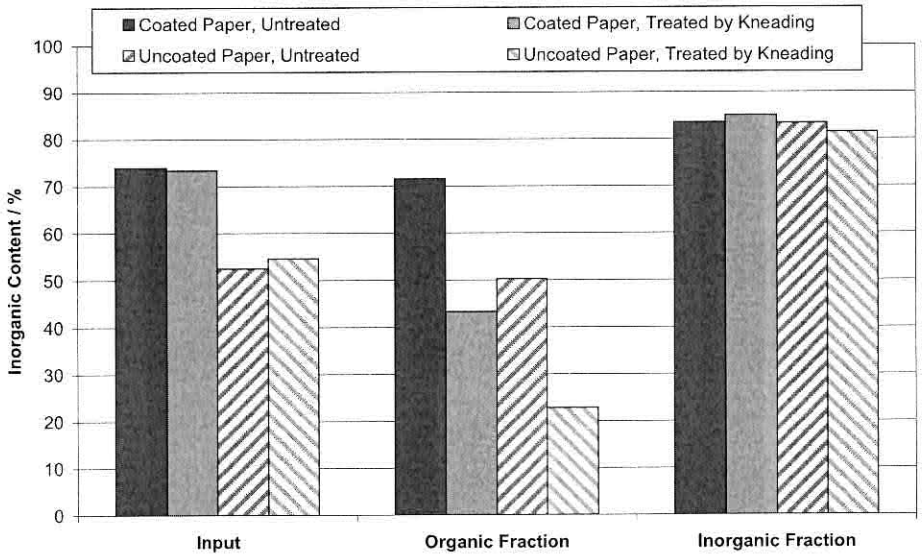


**Figure 1:** Inorganic content of the coated paper and uncoated paper before and after separation in the wedge-shape sedimentation cell with and without thermo-mechanical treatment in the Beken-Kneader

The pretreatment is the requirement for fines of recovered paper to separated fibre fines from inorganic particles. The election and the adjustment of the right process parameters decide the separation success in the separation process. In the counter-flow sedimentation cell the most important parameters are fluid flow ratio and the concentration of fibre fines.

The wrong flow rate, which means to low or to high, in the sedimentation cell degrades the separation effect as **Figure 2** shows. Is the flow rate to high, more and more fibre fines get in the inorganic fraction. Is the flow rate to low, more and more inorganic particles get in the organic fraction.

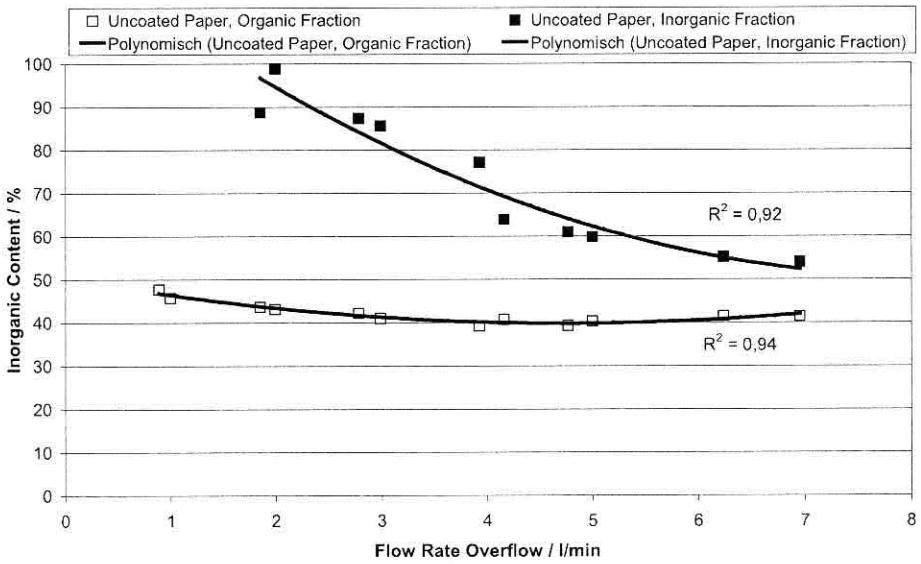


**Figure 2:** Inorganic content of the organic and inorganic fraction depending on the flow rate

The wrong fibre fines concentration also degrades the separation. Insufficient fibre fines generate the decline of the separation effect, because not more all fibre fines get into a flock. Too many fibre fines also causes a decline of the separation effect, because the fibre fines embed more and more inorganic particles in the flocks through the strong flocculation. The flocks disturb themselves more and more in sedimentation behaviour. The relationship between fibre fines content and separation effect shows **Figure 3**. This basic relationship is applied for all counter-flow sedimentation cells. But the position of the curve depends also on the cell geometry and on the operational mode.

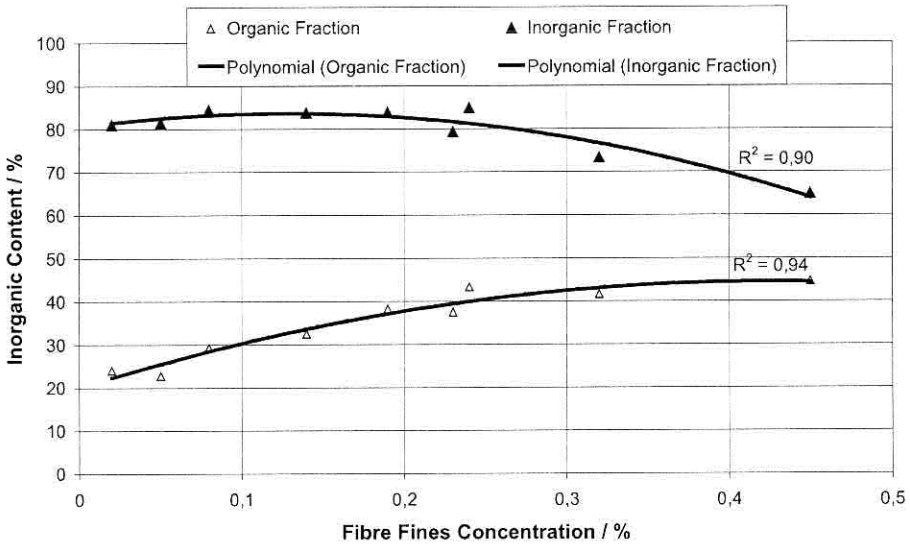


**Figure 3:** Inorganic content of the organic and inorganic fraction depending on the fibre fines concentration

Comparative trials were carried out between the sedimentation process and the flotation process with the uncoated paper. Before the separation process in the conical sedimentation cell and in the flotation cell the uncoated paper was pretreated in the Beken-Kneader. The flotation trials were performed in the PTS flotation cell with the standard chemicals of INGEDE Method 11, an established method in the paper industry. The trials showed that the flotation is not very selective. The sedimentation process outclassed the flotation process in the separation effect under these conditions as **Figure 4** shows. Figure 4 displays the separation results of the uncoated paper in the PTS flotation cell and in the conical sedimentation cell. In the trials with the sedimentation cell the organic fraction were caught (1st Pass) and fed again in the sedimentation cell (2nd Pass). With the second pass further inorganic particles could be removed which embedded in the fibre fines flocks during the first pass.

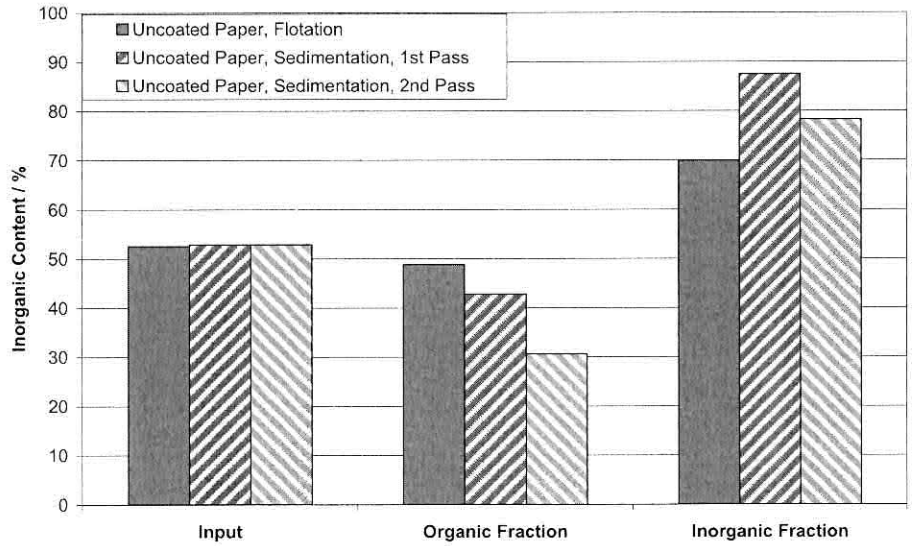


**Figure 4:** Inorganic content of the uncoated paper before and after separation in the PTS flotation cell and in the conical sedimentation cell

The counter-flow sedimentation process can solve the separation task, but this sedimentation process has just a low capacity. An economical use is doubtful. If it is possible to transfer the separation in the centrifugal field the separation might be economically useful.

## 5. Summary

The growing content of inorganic particles in recovered paper causes more and more a problem for the producers of packaging paper, graphic paper and hygienic paper. Therefore, the selective removal of inorganic particles is a target for the producers of recycling paper. But the common separation technology in the paper industry cannot afford this selective removal, because all these separation devices lock out fibre fines or fibres with the inorganic particles. A new separation technique which removes the fibres by screening in the first step and separates the fibre fines from the inorganic particles by sedimentation can solve this separation task. The fibre fines build flocks which settle faster than the inorganic particles although the inorganic particles have a much higher specific gravity. Because the fibre fines are strongly bound with inorganic particles in recovered paper suspensions, the fines have to be treated with a thermo-mechanical process. After a thermo-mechanical treatment the fibre fines can be separated from the inorganic particles in a counter-flow sedimentation process. Next to fluid flow conditions in the sedimentation device the most important influence on separation is given by the content of fibre fines. The sedimentation process can be carried out batch wise and continuously, but the capacity of the sedimentation is very low. An economical use of sedimentation for removing inorganic particles is doubtful. In order to make the separation process more economical it has to be transferred to the centrifugal field.

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## References

1 European List of Standard Grades of Recovered Paper and Board: 2007-June

2 Erhard, K.; Strunz, A.-M.: „Verbesserung der mechanischen Eigenschaften von Wellpappenrohpapieren durch selektive Abtrennung anorganischer Komponenten im Prozess der Stoffaufbereitung", PTS Heidenau, Forschungsvorhaben BMWA-1129/02, Forschungsbericht PTS-FB 17/04, Heidenau 2004.

3 ISO 1762: 2001-12-01. Paper, board and pulps – Determination of residue (ash) on ignition at 525 °C.

4 INGEDE Method 11: 2007-January. Assessment of Print Products Recyclability – Deinking Test.

5 Kumar, P.; Ramarao, B. V.: Enhancement of the sedimentation rates of fibrous suspensions. Chem. Eng. Comm. 108:381-401, 1991.

6 Herzhaft, B.; Guazzelli, E.: Experimental study of the sedimentation of dilute and semi--dilute suspensions of fibres. J. Fluid Mech. 384:133-158, 1999.

7 Feist, M.; Nirschl, H.; Wagner, J.; Hirsch, G.; Schabel, S.: Experimental results for the settling behaviour of particle-fibre mixtures. Physical Separation in Science and Engineering, vol. 2007, Article ID 91740, 6 pages, 2007. doi:10.1155/2007/91740.

8 Feist, M.; Hirsch, G.; Nirschl, H.: Sedimentationsuntersuchungen zum Trennverhalten von Faser-Partikel-Suspensionen. Chemie Ingenieur Technik 81 No. 6: scheduled publication date is June 2009.