THE STICKY POTENTIAL OF ADHESIVE APPLICATIONS FROM PRINTED PRODUCTS

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ABSTRACT
A laboratory test method for the evaluation of the sticky potential of graphic paper products is described and values presented which recycling friendly paper products should fulfill. The test procedure helps to determine the recyclability of existing printed matter, but can also be used during the development of adhesives to improve the recyclability behavior during recovered paper processing. Examples of the sticky potential are given for different adhesive applications.

INTRODUCTION
Usually paper is recyclable as it is produced on paper machines. During converting of paper into paper products materials can be applied on paper which can impair its recyclability, e. g. wax, printing ink or adhesive applications. Usually, the first additive is related to packaging material only, the second one is of relevance only for the reuse of printed matter in deinking mills, but the last one is relevant for both, graphic paper products as well as packaging material. Therefore, the behavior of adhesive applications during recycling is of particular interest for all paper mills using recovered paper

POLITICAL ISSUES
In Germany as well as in Europe recycling targets exist for paper. In a certain way Germany has become the front runner for the recycling politics of the European Union. The Packaging Ordinance regulates the recycling of packaging materials from paper, board, glass, plastic and other materials. It was released in 1991 in Germany with targets to be fulfilled over time for each material. As Packaging Directive a similar law was issued for the EU in 1994. In Germany 1994 an Ordinance on Avoidance, Recycling and Disposal of Waste was enacted, which became legislation in 1996 as the EU Council Resolution of "Strategy on Waste".

To avoid a special regulation on recycling of graphic paper products in Germany, in 1994 the graphic paper chain enacted a voluntary agreement about the recycling of graphic paper products. The recycling targets were fulfilled by the graphic paper chain and a prolongation was signed in 2001 to stabilize the recycling ratio for graphic paper products on a level of 80 % ± 3 % in the future. Another voluntary agreement was also presented by the CEPI (Confederation of the European Paper Industry) in 2000 with the "European Declaration on Recovered Paper". In contrast to the German agreement the European declaration covers all paper products and sets a recycling target of 56 % in 2005 for all paper products.

To make progress in the improvement of the recyclability of graphic paper products a "Task Force Deinking" within the German paper chain under guidance of INGEDE was established in 1997. This committee agreed one year later on a "Guide to an Optimum recyclability of printed graphic paper". This "Guide" was translated into English and signed by the European associations:

- CEPE (Conseil Européen de l'Industrie des Peintures, des Encres d'Imprimerie et des Couleurs d'Art)
- CEPI (Confederation of European Paper Industries)
- FAEP (Fédération Européenne d'Éditeurs de Périodiques)
- FEICA (Fédération Européenne des Industries de Colles et Adhésifs)
- INGEDE (International Association of the Deinking Industry) and
- INTERGRAF (International Confederation for Printing and Allied Industries a.i.s.b.l.)

The "Guide" has been released on a European level in 2002 and describes the actual status of the recycling of graphic paper products, their general requirements and the demands for the future.

Nevertheless, objective procedures and criteria are necessary to evaluate the recyclability and to decide between poor or good recyclable graphic paper products. On a German level a first draft on "Orientation Values for the Recyclability of Printed Graphic Paper" is discussed in the Task Force Deinking as a supplement to the already signed "Guide". The recyclability parameters and numeric values which are under discussion now are based on results obtained after the development of laboratory test methods for the evaluation of the recyclability which were initiated and financed by INGEDE. These methods are getting now finalized in a harmonizing procedure between the leading European paper institutes working in the area of recycling: CTP (Centre Technique du Papier, Grenoble/France), PTS (Papiertechnische Stiftung, München/Germany) and PMV (Fachgebiet Papierfabrikation und Mechanische Verfahrenstechnik (former: IfP), Darmstadt/Germany).

DEFINITIONS
The sub-committee "Recycling Technology" of the German association of the pulp and paper engineers and chemists – ZELLCHEMING – has defined the term stickies as the tacky components resulting from the raw material recovered paper [1, 2]. The term tacky component is a generic term which covers also pitch or white pitch.

Stickies are classified according to their sources as primary and secondary stickies. The first group of stickies is introduced by the recovered paper and creates tacky particles under testing conditions. Secondary stickies are also tacky under testing conditions, but those particles originate from physico-chemical effects during recovered paper processing.

A differentiation between macro and micro stickies is given by their size. Criterion of the determination is the dimension of the slot width during laboratory screening. For graphic papers a slot width of 100 µm is recommended. Detected stickies in the reject (= over flow) are named as macro stickies, whereas the tacky particles in the accept (= through flow) are named as micro stickies. Due to the three dimensional shape of the sticky particles, the slot width is the differentiation criteria in macro and micro stickies only, but does not correspond to the maximum dimension of the sticky particles in the accept.

TEST METHODS

The test method for the evaluation of macro stickies from adhesive applications on graphic paper products is described in detail in the INGEDE Method No. 12 and is published in the internet under www.ingede.com [3]. Figure 1 includes the final modifications made in cooperation between CTP, PTS and PMV, but not yet published in the internet (Date: 01.08.04). Beside improved explanations in the method the most important modifications are related to:

- the used material for pulping (woodfree copy paper instead of short fiber pulp)
- the screening device (beside the Haindl classifier also the Somerville screen is allowed)
- the image analysis system (beside the Domas system now also the Simpatic system is allowed).

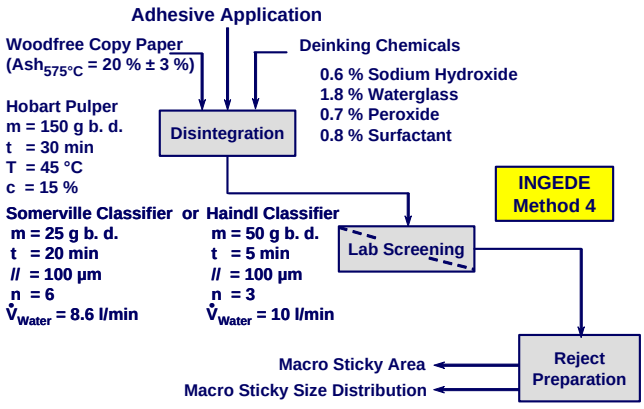

Figure 1: Simulation of lab scale adhesive fragmentation for printed matter according to INGEDE Method No. 12.

For the determination and visualization of the sticky particles in the screening reject INGEDE Method No. 4 is used [4]. This method applies aluminum oxide powder with a certain grain size instead of the marking paper in the TAPPI "Pick-Up" Method T277 [5], better known in North America. From test comparisons with DIP we know that both methods give similar results and show the same trends, but the INGEDE Method is more sensitive for pulps with low sticky content.

STICKY EVALUATION CRITERIA

The criteria evaluated for the differentiation of the sticky potential of adhesive applications are accepted by the Task Force Deinking. Actually, the numeric values which have to be fulfilled by a recycling friendly adhesive application are under discussion.

Two parameters are observed at the moment. This is the proportion of the sticky area in percent of all particles below an equivalent circle diameter of 2 000 µm. Additionally, the total area of all particles below this equivalent circle diameter of 2 000 µm should not exceed a certain level per kilogram of printed matter. Figure 2 shows the numeric values discussed in this context actually.

Under Discussion

Targets	Evaluation Parameters	Requirements
High Screenability of Stickies	Share of Sticky Area ∅ < 2 000 µm, %	> 0 to ≤ 30 %
Low Sticky Content in Accept	Sticky Area ∅ < 2 000 µm, mm²	≤ 4 000 mm²/kg b.d. paper product

⇨ Evaluation of the total reject of lab screening with 100 µm slot width

Figure 2: Orientation values for the sticky potential of adhesive applications.

The 2 000 µm size limit for the macro stickies was determined by a pilot scale trial with identical adhesive applications at Voith Paper in Ravensburg/Germany and by lab scale trials. The adhesive applications used were hotmelt and dispersion adhesives for catalogue binding, a thin film dispersion adhesive and a PSA with a total adhesive mass of 0.2 % related to paper. After high consistency pulping with deinking chemicals it was found in the accept of the pilot scale screening process (three stage forward) with 150 µm slot width, that no more macro stickies were observed by the lab test according to INGEDE Method No. 4. Figure 3 shows the removal efficiency of macro stickies in this pilot trial. Stickies above 2 000 µm equivalent circle diameter are not any more detectable in this pulp. Similar results with other adhesive applications were obtained in pilot trials at the CTP in Grenoble [6]. Additionally, we examined in modern DIP lines that after fine screening practically no macro sticky particles above a equivalent circle diameter of 2 000 µm can be observed with the sticky determination method described.

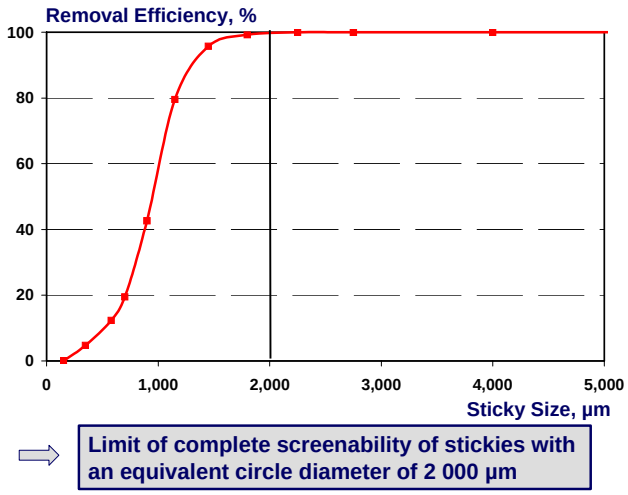

Figure 3: Removal efficiency of macro stickies by pilot screening depending on sticky size in pilot trials.

By the two parameters established by INGEDE it becomes the target that adhesive applications fragment into sticky particles as large as possible. The larger the particles after pulping the higher is the opportunity that they can be removed during an industrial screening process. Figure 4 shows three examples for bookbinding adhesives which results in a different fragmentation behavior. From the point of the most recycling friendly adhesive application the example on the right hand side shows with the largest sticky particles the most promising behavior during recycling.

Numerous small stickies. In comparison unfavourable fragmentation.

Larger sticky particle size distribution. More advantageous fragmentation.

Exclusive large stickies. Optimum fragmentation.

Figure 4: Samples of the macro sticky evaluation of bookbinding adhesives.

By the two parameters evaluated in the sticky potential test – the proportion of the sticky area below 2 000 µm in percent compared to the total sticky area and the absolute sticky area below 2 000 µm equivalent circle diameter – we examine the frequency distribution of the sticky particle size. Figure 5 makes evident that the theoretical distribution curve of the adhesive application A is better in comparison to B. Adhesive application A creates larger particles and the sum of all particles below 2 000 µm is on a lower level in total.

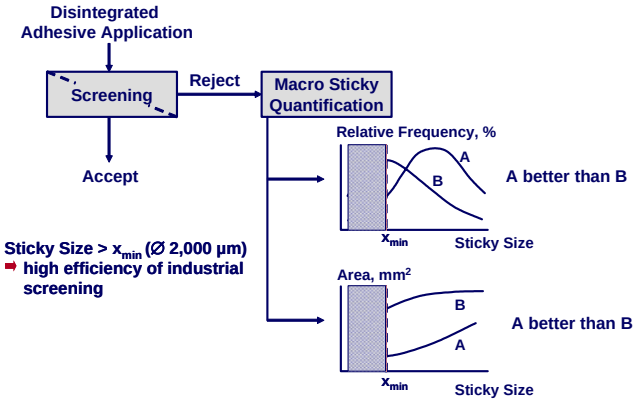

Figure 5: Assessment of the sticky potential test according to INGEDE Method 12.

The pulping conditions in INGEDE Method No. 12 were developed in a way that the fragmentation behavior of the adhesive applications in lab and pilot scale are similar. Figure 6 shows the cumulative macro sticky area of two PSA applications pulped in lab scale and described as "Hobart Pulper" in comparison to pilot pulping ("Helico Pulper"). It is obvious that for both PSAs the sticky size distribution and the resulting cumulative sticky areas are comparable between lab and pilot scale.

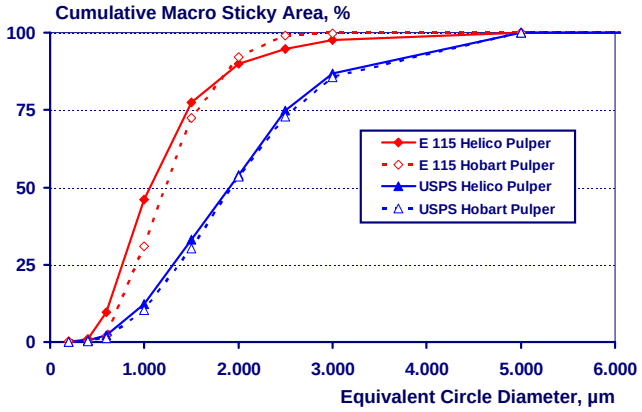

Figure 6: Cumulative macro sticky area after pilot and lab disintegration of two different PSAs.

RESULTS

The following results are related to lab scale trials with several adhesives, pulped with beech sulphite chemical pulp which was the former fiber raw material for this test according to INGEDE Method No. 12. All screenings were performed with the Haindl classifier equipped with a 100 µm screen plate. The adhesive applications tested were:

- Public catalogues
- Business catalogues
- Magazines
- Business reports
- PSAs on magazines
- PSA sheets used for model calculations.

Bookbinding Backs

Figure 7 shows the share of macro stickies below 2 000 µm for adhesive applications on magazines, catalogues and business reports. Most of these adhesive applications are based on hot melts. Except three samples all other applications fulfill the requirement of a maximum proportion of 30 % for the total sticky area of all particles below an equivalent circle diameter of 2 000 µm.

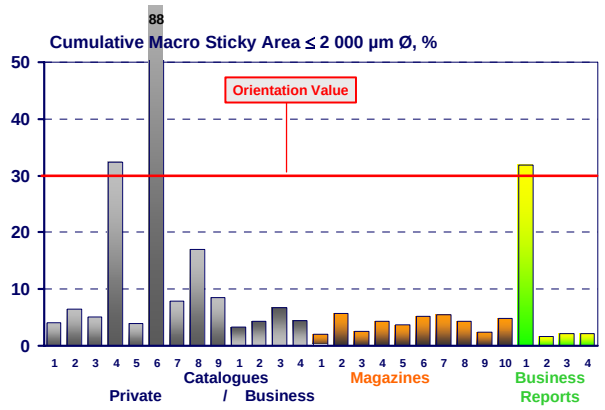

Figure 7: Cumulative macro sticky area below 2 000 µm in percent for bookbinding back.

A similar result is presented in Figure 8 for the total sticky particle area below 2 000 µm per kilogram of b. d. pulp. Two of the three samples mentioned before exceed also the orientation value of 4 000 mm²/kg for adhesive applications. In general the adhesive applications for bookbinding backs seem to be not critical regarding the actual orientation values for stickies, at least for hot melt applications. In the future it becomes possible that lower orientation values will be stipulated for this type of adhesive applications.

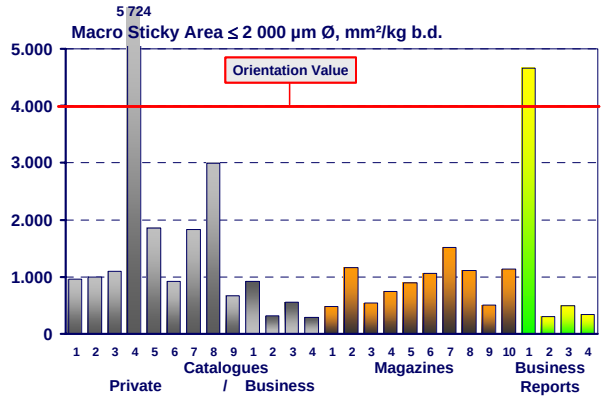

Figure 8: Cumulative macro sticky area below 2 000 µm in mm²/kg for bookbinding back.

Pressure Sensitive Adhesives (PSA)

The observed results look very different for PSA applications at magazines. In Europe for special events like Christmas, Eastern or Valentine's Day a lot of magazines add a large PSA page with stickers around the magazine cover which can be used for several purposes. If such magazines enter to a certain amount the recycling mills – especially as returned magazines in which the area of PSA becomes very high compared to paper mass – almost every paper mill becomes serious sticky problems. Figure 9 makes obvious that the 30 % proportion for the cumulative particle area below 2 000 µm equivalent circle diameter is exceeded by all products – except one. Most of all products have a proportion above 75 %.

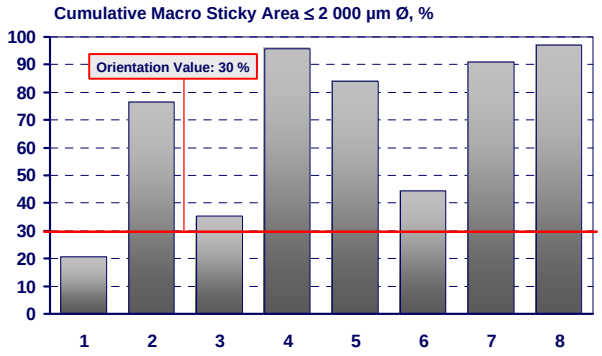

Figure 9: Cumulative macro sticky area below 2 000 µm in percent for PSA applications on magazines.

In Figure 10 the total sticky area of all particles below 2 000 µm equivalent circle diameter is shown. The orientation value of 4 000 mm²/kg is exceeded manifold. The best of the 8 PSA products contributes with an area of 28 000 mm²/kg print product (No. 1) to the sticky load of the recovered paper. 80 % of the particles removed by lab screening are larger than 2 000 µm equivalent circle diameter. A second PSA product creates a similar sticky area of about 28 000 mm²/kg print product (No. 7). In contrast, this area is formed by 91 % from particles below 2 000 µm equivalent circle diameter which are in general more difficult to be removed completely by industrial screening. Additionally, it has to be expected that an adhesive application which fragments to 90 % in particles below 2 000 µm equivalent circle diameter creates a much higher proportion of particles which are below the scanner based sticky detection limit of 100 µm compared to an adhesive application which contributes only to 20 % of particles between 100 µm and 2 000 µm. These particles – below 100 µm – are by definition micro stickies and it can be expected that they are only removed to a certain extend by industrial screening.

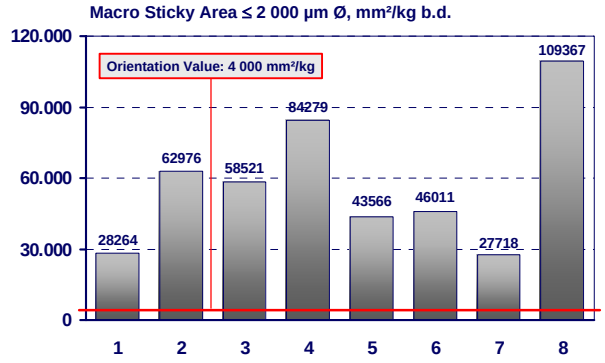

Figure 10: Cumulative macro sticky area below 2 000 µm in mm²/kg for PSA applications on magazines.

The result obtained until now for PSA application on magazines does not tell anything if a recycling benign PSA application does exist or not. More than 35 different types of PSA were tested from various suppliers in a model test performed with 100 cm² PSA in 150 g b. d. chemical pulp. Beside several USPS approved PSAs, European market products as well as experimental adhesives were used in the test. Figure 11 shows the cumulative sticky area in percent for all particles below 2 000 µm equivalent circle area. 25 % of all PSAs fulfill the first criteria of the orientation value of ≤ 30 %. Some of the best products are solvent based adhesives. Products which obtain more than 80 % of particles below 2 000 µm might be classified as redispersible adhesives.

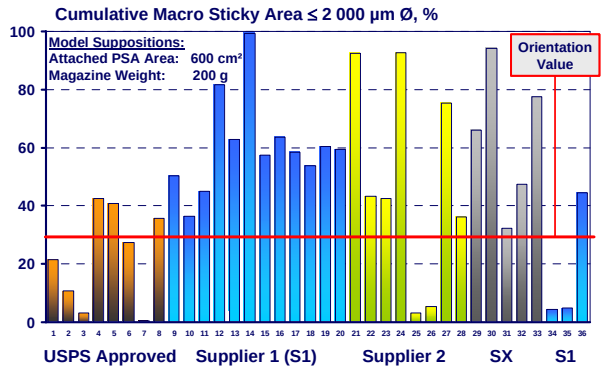

Figure 11: Cumulative macro sticky area below 2 000 µm in percent for PSAs in model tests.

For the model calculation of the PSAs used for a magazine cover it was supposed to apply a PSA area of 600 cm² and a magazine weight of 200 g which corresponds at 60 g/m² to a magazine volume of about 55 pages. Figure 12 shows the result of the cumulative macro sticky area below 2 000 µm equivalent circle diameter for the given model suppositions. It becomes obvious that only three PSAs fulfill both requirements completely (marked with a check ✓). The one column below 4 000 mm²/kg without the check (No. 12) creates a low sticky area below 2 000 µm equivalent circle area, but has a proportion of more than 80 % in this size category and is definitely a redispersible PSA.

Three other PSA products achieve almost the second requirement of the orientation values (4 000 mm²/kg) and are therefore marked with a circle (O). At least four of this 6 PSA products (in total) are solvent based PSA and one is available on the European market in minimum. We are looking forward to perform together with INGEDE an industrial trial in printing, converting and manufacturing of a PSA cover for a magazine with such a recycling benign adhesive application to confirm the lab findings with pilot trials.

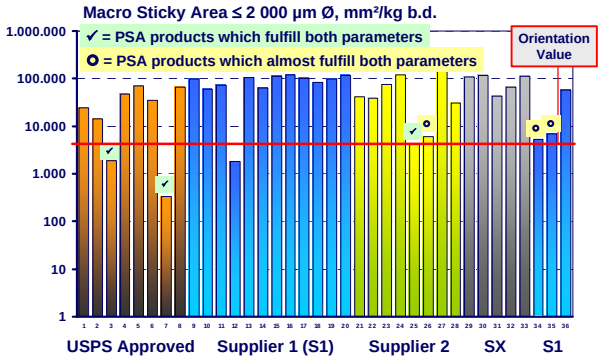

Figure 12: Cumulative macro sticky area below 2 000 µm in mm²/kg for PSAs in model tests.

CONCLUSIONS

For paper products recyclability should become a quality criterion such as runability, strength characteristics or printability. In terms of graphic paper products recyclability comprises deinkability and the sticky potential of adhesive applications. The developed laboratory test method serves for the evaluation of the sticky potential of adhesive applications on printed products. This laboratory INGEDE Method No. 12 was proven in pilot scale trials at two different locations regarding the sticky fragmentation behavior of adhesive applications. The comparison of lab and pilot scale trials shows good agreement of sticky fragmentation values, which is a prerequisite for a laboratory screenability test of stickies. From pilot scale it becomes evident which particle size spectrum of stickies is required to achieve maximum separation efficiency during industrial screening processes.

Numeric values are under discussion for recycling friendly adhesive applications. This criterion include the proportion of the sticky area (in percent) as well as the total area related to the mass of the print product below 2 000 µm equivalent circle diameter. From the results of various adhesive applications (bookbinding backs of magazines, catalogues, business reports, PSAs) it becomes obvious that the development and use of a recycling friendly PSA is much more difficult than for bookbinding back. In bookbinding several products exist which do not cause serious sticky problems, whereas only a few recycling

benign types of PSA exist which fulfill the actual requirements of INGEDE.

In general, recycling friendly adhesive applications should be improved in their screenability by high cohesive films. This can be realized by high softening points of the films, hard films and chemical curing. Thick adhesive applications also improve the cohesion of the film and that means that bead or film applications are better than dot applications.

Together with all parties of the paper chain INGEDE will continue to work on general improvements of the recyclability of printed matter.

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