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COPY QUALITY AND READABILITY OF DIP CONTAINING COPY PAPERS[1]

Prepared contribution
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Introduction

Environmental concern and landfilling problems around metropolitan areas have increased the use of waste paper as raw material for papermaking. Governmental recommendations and – in some places – requirements have accelerated the use of recycled fibres in office papers.

The objective of this study was to find out how the quality of DIP containing copy papers affect the copy quality and readability of these papers.

Nine DIP containing commercial copy papers and one fresh fibre based copy paper (reference) were analysed and tested for copy quality and readability. Two types of copy machines, one of Japanese and one of American origin, were used in the experiments[2].

The test pattern copied consisted of solid prints and line patterns of various width. Various image transfer characteristics were measured from the copied images.

1 Based on the MSc thesis of Mr J Mörö: Information capacity of recycled paper in copying (in Finnish), Helsinki University of Technology, 1992

2 All tested papers possessed a satisfactory runnability through the copiers

The readability of the copied paper samples was tested with two methods. In the subjective readability test pair comparison tests were used to see if the test persons could detect differences between the samples of the pair. The differences obtained were analysed with multidimensional scaling technique.

In the reading speed test the time consumed by the test persons to read a sheet (successive pages of a novel) – copied on each of the tested samples – was recorded.

I will concentrate on the readability results in the following.

Results

Paper properties

Table 1 depicts certain properties of the tested copy papers. From the values given it can be seen that the brightness of the papers varied between 55 to 75 ISO. The dirt count information of the papers is shown in Figure 1. Generally speaking the Japanese DIP containing copy papers are cleaner than the European papers. There was not a great difference in the average size of the dirt particles, but again the Japanese DIP containing copy papers had somewhat smaller dirt particles (Table 1). The Japanese copy papers were also smoother.

There seems to be a relationship between the brightness of the DIP containing copy paper and the share of mechanical pulp fibres in the furnish (Figure 2). Those points that are below the curve have also a larger than average number of dirt particles.

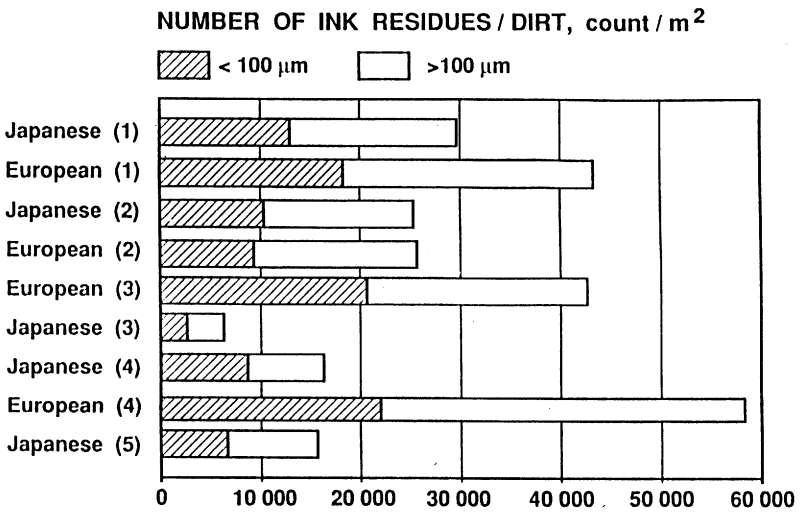

Figure 1. Amount of ink residues / dirt in DIP copy papers.

TABLE I. PROPERTIES OF TESTED COPY PAPERS

Sample identification	DIP content, %	Mech. pulp content, %	Bright-ness (ISO), %	Average size of dirt specks 10^{-2} mm^2	Roughness (Bendtsen) (98 kPa) ml/min	Relative area of dirt specks, mm^2/m^2 (Particle size)	
						< 0,08 mm^2	> 0.08 mm^2
Japanese (1)	50	25	63.5	21.4	229	-	-
European (1)	100	12	74.0	23.9	275	30	15
Japanese (2)	70	42	67.0	20.7	207	-	-
European (2)	100	71	58.0	23.6	263	-	-
European (3)	100	86	57.0	19.5	425	-	-
Japanese (3)	70	31	71.0	19.3	148	5.4	10
Japanese (4)	?	51	63.5	17.0	65	-	-
European (4)	100	42	55.0	24.6	333	-	-
Japanese (5)	70	48	66.0	20.4	157	7.5	11
U.S.A. (exp.)	100	3	83.0	19.1	293	7	7
European reference	0	0	88.0	0.8	205	-	-

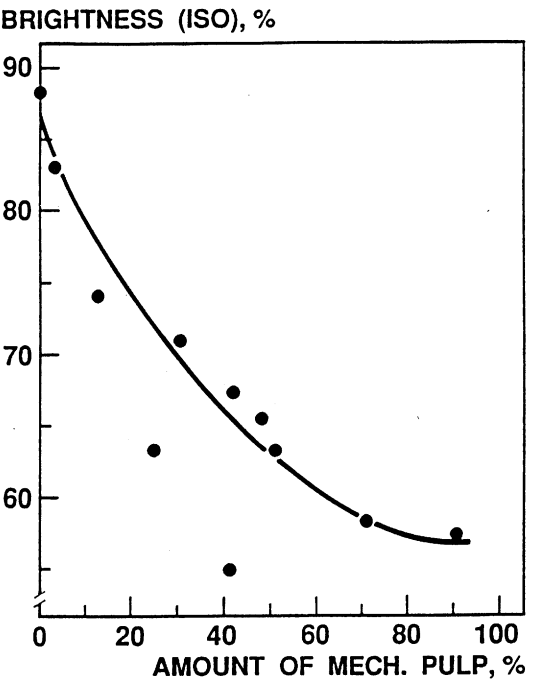

Figure 2. Brightness vs. Mechanical Pulp Content of DIP Containing Copy Papers.

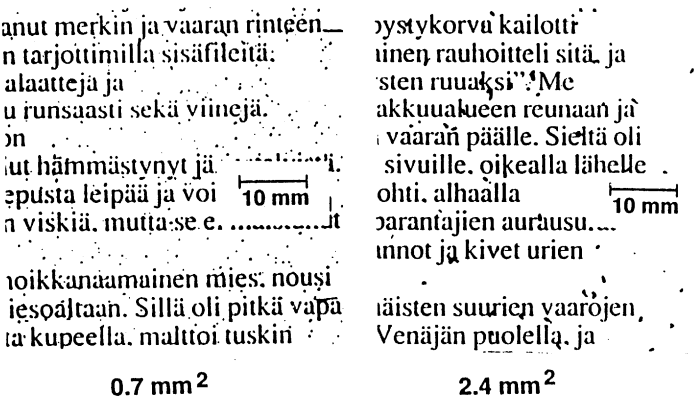

Figure 3. Copy of text on paper containing synthetic dirt with maximum particle size = 0.7 mm^2 and 2.4 mm^2

Readability

It turned out that the speed of reading was not sensitive to the brightness and dirt count variables measured. In other words, the tested DIP containing copy papers all satisfied their primary functional need well. This is significant since there were differences in the subjectively assessed quality of the papers (see later).

In a separate test series, reading speed was measured from sheets on which dirt specks had been generated synthetically[3]. It turned out that the area covered by the dirt specks and their average size needed to be about two orders of magnitude larger than in the commercial papers, ie around 1 mm^2, in order to have an influence on the reading speed (Figure 3).

The "subjective readability" results (from MDS analysis of pair differences) showed that in the tested group of papers the sheet brightness was by far the most important paper property. The dynamic range of the copy of the test pattern was statisticlly the second most important variable whereas the signal-to-noise ratio was only marginally significant.

It needs to be reckoned that brightness had a favourable influence on the dynamic range. The noise level of the copied images (on various tested paper grades) was not found to be related to the measured dirt count.

3 The dirt specks were generated by ink jet printer in such a way that the specks were positioned randomly on an A4 sheet and the size of the specks varied around an average value.

Conclusions

The predicted limit to the information capacity of the tested papers, ie when predicted from the optical properties of the uncopied papers, was about 1 bit higher than the information capacity actually measured from the copied images. In other words, the optical potential of the papers to render tone levels exceeded the number of tone levels resolved in the actual copied image by a factor of two.

The aesthetic (visual) appearance of the copied image (text) seemed to be greated affected by the brightness (greyness) of the copy paper.

Dr A Nissan, Westvaco Corporation, USA

Dr Ebeling aside from the speed of reading did you test comprehension? A person may read a passage quickly and accurately but 'dirt' may distract him and he would not comprehend its contents.

K Ebeling

This was a war time novel so I think the comprehension was there. The students were quite keen to read what was copied.

Prof J Lindsay, IPST, USA

Instead of using human readers which introduces a large source of variation that may obscure actual differences between papers, you might want to consider using optical character recognition, computer techniques in which you can then get a very accurate count, a very reproducible numerical account of accuracy as a function of ink content.

K Ebeling

The dirt count information shown was done with an image analyser system. It's sensitivity to dirt is truly orders of magnitude better than that of a human eye.

J Lindsay

The point is in using computers to read or scan text using computer optical character recognition, computers aren't as good at pattern recognition as humans are and they can make a lot of mistakes, thinking an 'e' is really a 'c' or 'b' is an 'a', a small piece of dirt on the paper can interfere with computer recognition of characters more than it would with humans and that might be a more sensitive way of comparing and evaluating papers.

K Ebeling

Why we used the human panel was that there are governmental recommendations to use recycled paper and therefore we just wanted to see the readability in a true application situation. You are absolutely right in pointing out that for scientific studies, a computer readability test would have been more valuable.