# Development of a multipurpose paper with good printability for offset, rotogravure and digital printing

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1) WEIPATECH, 2) SBP RESOURCES, 3) SUED-CHEMIE

Future developments of printing papers – arguments to produce a multipurpose paper

Competition: printed versus electronic media

Challenge of new printing technologies: non-impact and digital printing

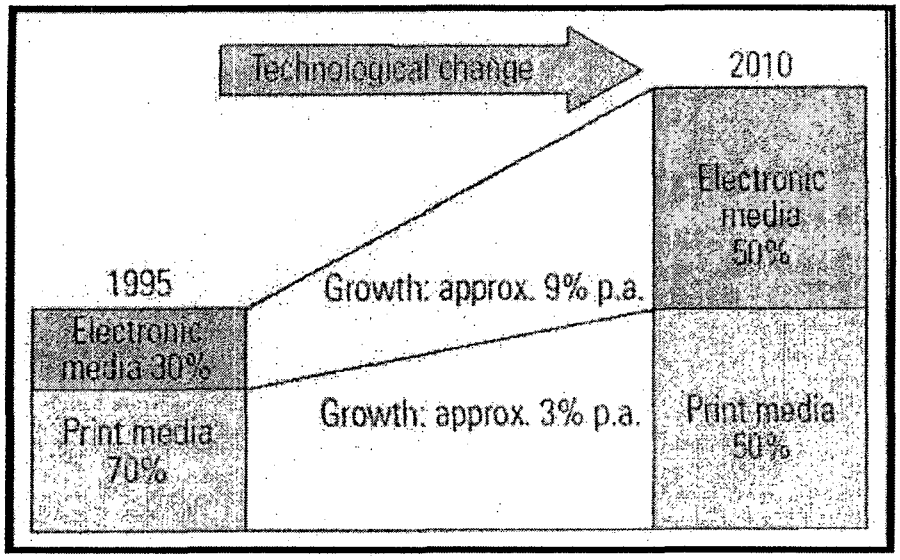
Trend towards smaller printing volumes (< 5000 copies)

Possibilities to substitute existing paper grades to get better margins (for example: SC-B instead of SC-A)

More flexibility and therefore higher capacity of the paper machines ( interesting for smaller machines)

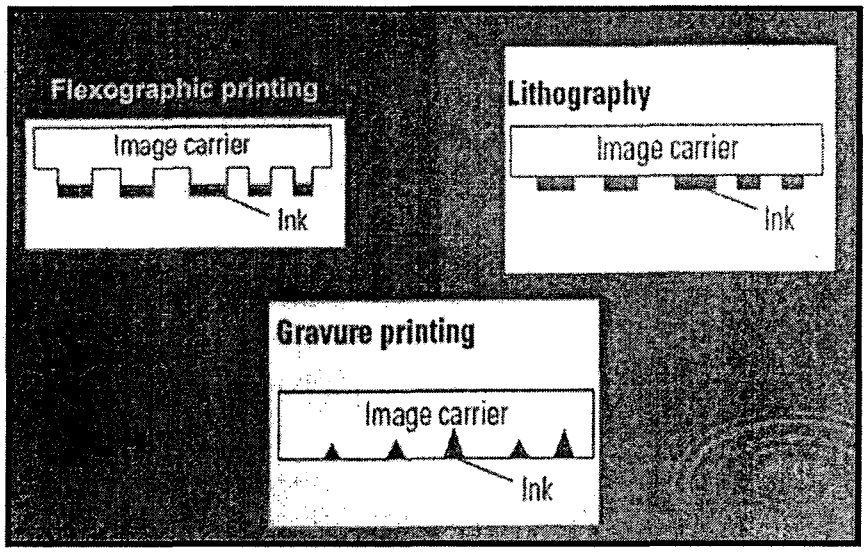
Demand for high quality multipurpose papers with excellent runnability and printability (color printing) for advertisement

Future Trends in Printing market Segments




Source: National Printing Laboratory

Three Main Printing Technologies Totaling 84%




Source: National Printing Laboratory

Printing Market Share Affects Choice of Coating Minerals

| | 1990 | 1995 | 2000 | 2025 |
|---|---|---|---|---|
| Lithographic | 47 | 47 | 45 | 30 |
| Gravure | 19 | 20 | 20 | 20 |
| Flexography | 17 | 18 | 19 | 20 |
| Letterpress | 11 | 7 | 4 | 2 |
| Screen | 3 | 3 | 3 | 2 |
| Non-Impact | 3 | 5 | 9 | 26 |

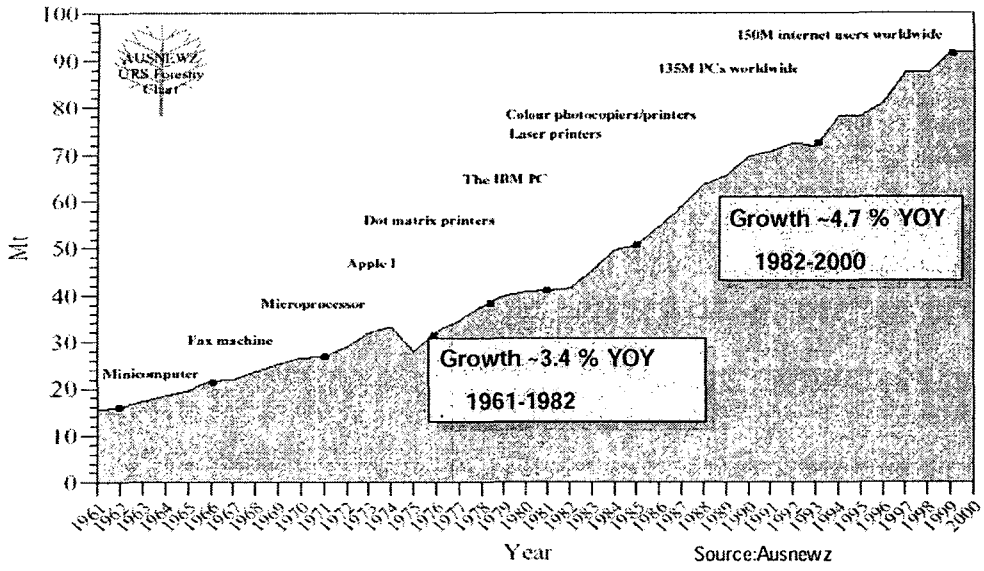
Source: National Printing Laboratory

Comparison of the 3 Main Printing Technologies

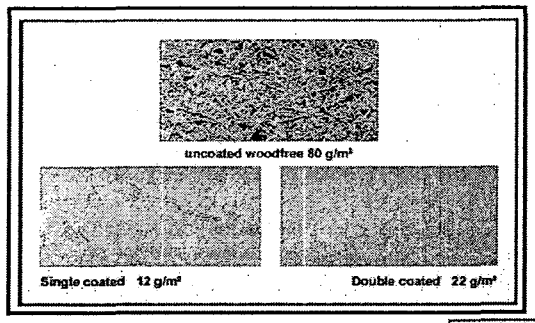
| | PRODUCTS | CHARACTERISITICS |
|---|---|---|
| Flexography | Bags<br>Labels<br>Envelopes<br>Corrugated Containers<br>Wrapping Papers<br>Folding Cartons | Liquid Inks<br>Soft/Flexible Plates<br>Low Printing Pressure<br>Low Cost<br>Short / Medium Runs |
| Gravure | Magazines<br>Catalogues<br>Wallpaper<br>Specialised Packaging<br>Postage Stamps | Liquid Inks<br>Chrome Plated Steel Cylinders<br>Long Runs |
| Lithography | Newspapers<br>Magazines<br>Catalogues<br>Packaging | Paste Inks<br>Metal Plate / Rubber Blankets<br>Low / Medium Cost<br>Medium / Long Runs |

Global Apparent Demand for Printing & Writing Papers

1961-2000 (Millions of tonnes)

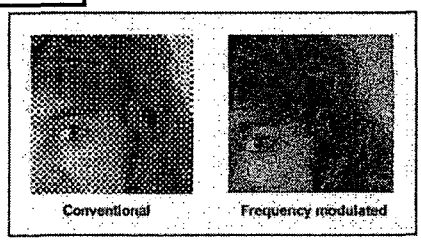



Paper Surfaces & Coating Amounts




The Technology

The Result



Coated Paper production & export trends

1) Paper production & shipment of Taiwan in 2002 & 2003

(Unit : 1,000MT)

| | 2002 | | | 2003 | | |
|---|---|---|---|---|---|---|
| | Production | Domestic shipment | Export | Production | Domestic Shipment | Export |
| **Cultural paper** | | | | | | |
| ·coated P&W | 354 | 255 | 99 | 359 | 260 | 101 |
| ·uncoated P&W | 345 | 300 | 43 | 327 | 290 | 39 |
| ·others | 14 | 17 | - | 10 | 11 | - |
| sub-total | 713 | 572 | 142 | 696 | 561 | 140 |
| **Household paper** | 274 | 241 | 36 | 286 | 254 | 36 |
| **Packaging paper** | 54 | 55 | 2 | 55 | 49 | 1 |
| **Specialty paper** | 84 | 81 | 4 | 83 | 79 | 4 |
| **PAPER TOTAL** | 1,126 | 948 | 184 | 1,120 | 942 | 182 |
| **Paper board** | | | | | | |
| liner & corrugated | 2,349 | 1,860 | 521 | 2,504 | 1,888 | 603 |
| Duplex | 671 | 369 | 311 | 655 | 362 | 297 |
| other | 247 | 220 | 25 | 256 | 230 | 25 |
| sub-total | 3,267 | 2,448 | 857 | 3,414 | 2,480 | 925 |
| **PAPER&BOARD TOTAL** | 4,393 | 3,396 | 1,041 | 4,533 | 3,422 | 1,107 |

2) Paper production & export of Taiwan, Korea & Japan

- Taiwan

(Unit : 1,000MT)

| | 2002 | | 2003 | |
|---|---|---|---|---|
| | **production** | **export** | **production** | **export** |
| Coated P&W | 354 | 99 | 359 | 101 |
| Uncoated P&W | 345 | 43 | 327 | 39 |
| Sub-total | 699 | 142 | 686 | 140 |
| Total Paper&Board | 4,293 | 1,041 | 4,533 | 1,107 |

-Korea

| | 2002 | | 2003 | |
|---|---|---|---|---|
| | **production** | **export** | **production** | **export** |
| Coated P&W | 1,687 | 929 | 1,807 | 1,006 |
| Uncoated P&W | 853 | 4 | 778 | 7 |
| Sub-total | 2,540 | 933 | 2,585 | 1,013 |
| Total Paper&Board | 9,812 | 2,378 | 10,148 | 2,662 |

-Japan

| | 2002 | | 2003 | |
|---|---|---|---|---|
| | **production** | **export** | **production** | **export** |
| Coated P&W | 6,387 | 479 | 6,380 | 426 |
| Uncoated P&W | 4,844 | 265 | 4,798 | 247 |
| Sub-total | 11,231 | 744 | 11,178 | 673 |
| Total Paper&Board | 30,674 | 1,578 | 30,458 | 1,326 |

3-1) Paper production & consumption of China

**(Unit : 1,000MT)**

| Year | Production | Import | Export | Consumption |
|---|---|---|---|---|
| **1990** | 13,719 | 962 | 252 | 14,428 |
| **1995** | 28,123 | 3,029 | 530 | 30,662 |
| **2000** | 30,500 | 5,970 | 720 | 35,750 |
| **2001** | 32,000 | 5,662 | 800 | 36,830 |
| **2002** | 37,800 | 6,369 | 855 | 43,320 |
| **2003** | 43,000 | 6,350 | 1,290 | 48,060 |

3-2) Paper Production of China (Paper Grade by Grade)

(Unit : 1,000MT)

| | 2000 | 2003 | 2010 |
|---|---|---|---|
| Newsprint | 1,450 | 2,070 | 3,200 |
| Printing & Writing | 7,000 | 12,000 | 13,250 |
| Daily Necessaries | 2,500 | 3,470 | 4,250 |
| Packageeing | 4,200 | 4,800 | 5,000 |
| Duplex Board | 2,500 | 5,500 | 5,600 |
| Liner | 3,700 | 6,800 | 8,400 |
| Corrugated | 5,500 | 6,700 | 9,500 |
| Specialty Paper & Board | 660 | 1,660 | 2,000 |
| **Total** | — | 43,000 | 51,200 |

3-3) Paper Production & Pulp Supply of China

(Unit : 1,000 MT)

| Year | 2000 | | | 2005 | | | 2010 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Paper Production** | 30,500 | | | 38,000~40,000 | | | 50,000~53,000 | | |
| Fiber Source & Pulp Supply | F.S. | Pulp | % | F.S. | Pulp | % | F.S. | Pulp | % |
| | 41,900 | 27,810 | 100 | 48,000 | 36,950 | 100 | 57,600 | 48,000 | 100 |
| **1) Wood** | - | 5,350 | 19 | - | 9,250 | 25 | - | 13,450 | 28 |
| Domestic | 9,000 | 2,000 | 7 | 16,650 | 3,700 | 10 | 32,400 | 7,200 | 15 |
| Import | - | 3,350 | 12 | - | 5,500 | 15 | - | 6,250 | 13 |
| **2) Non-wood** | 27,650 | 11,060 | 40 | 26,750 | 10,700 | 29 | 28,800 | 11,500 | 24 |
| Weed | 2,500 | 1,000 | 4 | 3,000 | 1,200 | 3 | 4,000 | 1,600 | 3 |
| Bamboo | 750 | 300 | 1 | 4,000 | 1,600 | 4 | 7,500 | 3,000 | 6 |
| Baqasse | 750 | 300 | 1 | 1,000 | 400 | 1 | 1,300 | 500 | 1 |
| Straw | 21,550 | 8,620 | 31 | 17,250 | 6,900 | 19 | 15,000 | 6,000 | 13 |
| Others | 2,100 | 840 | 3 | 1,500 | 600 | 2 | 1,000 | 400 | 1 |
| **3) Recycled** | 14,250 | 11,400 | 41 | 21,250 | 17,000 | 46 | 28,800 | 23,050 | 48 |
| Domestic | 10,540 | 8,430 | 30 | 13,250 | 10,600 | 29 | 9,800 | 15,850 | 33 |
| Import | 3,710 | 2,970 | 11 | 8,000 | 6,400 | 17 | 9,000 | 7,200 | 15 |

* Source : China Tappi Jaurnal (2004)

3-4) Top 20 Producing companies in China based on tonnage

(Unit : 1,000MT)

| No. | Name of Paper Company | Output (tonnes) | | |
|---|---|---|---|---|
| | | 2003 | 2002 | % change |
| 1 | Shandong Chenming Paper | 1,270 | 1,043 | 21.7 |
| 2 | Gold East Paper (Jiangsu) Co. Ltd. | 1,214 | 1,113 | 9.1 |
| 3 | Dongguan Nine Dragons paper Industries | 913 | 725 | 26.0 |
| 4 | Sun paper | 597 | 517 | 15.5 |
| 5 | Shandong HuataiGroup | 585 | 450 | 30.0 |
| 6 | Lee & Man paper Mfg. Co., Ltd. | 568 | - | |
| 7 | Ningbo Zhonghua Paper Co., Ltd. | 472 | 476 | ▲ .8 |
| 8 | Shandong Bo Hui Paper Co. Ltd. | 410 | 225 | 82.2 |
| 9 | Guangzhou Paper Group | 397 | 382 | 4.1 |
| 10 | UPM-Kymmene Group | 368 | 343 | 7.0 |
| 11 | Syanying Paper Industry | 367 | 198 | 85.7 |
| 12 | Yueyang paper | 348 | 261 | 33.2 |
| 13 | Gold Huasheng Paper (Suzhou Industrial Park) Co. Ltd. | 326 | 263 | 24.2 |
| 14 | Ningxia Meili Paper Industry Co., Ltd. | 307 | 194 | 58.0 |
| 15 | Shangdong Tralin Paper Co. Ltd. | 273 | 195 | 40.4 |
| 16 | Nanzhi Co., Ltd. Fujian | 267 | 242 | 10.4 |
| 17 | Zhongshan Rengo Hung Hing Paper Manufacturing Co., Ltd. | 263 | 196 | 34.4 |
| 18 | Yinhe Paper Group | 250 | 170 | 47.1 |
| 19 | Zhejiang Jingxing paper | 248 | 187 | 32.7 |
| 20 | Fujian Qingshan paper Industry co., Ltd. | 245 | 213 | 15.1 |

* Source :China Tappi.

Targets of the development:

Production of a coated paper with suitability for all conventional and new printing technologies (MULTIPURPOSE PAPER)

High quality claims without costs increase by offering a 'reactive, functional coating layer"

Decrease of the paper grammage without quality loss

New paper quality for new paper markets

Possibility of high production speeds > 1.800m \min

High efficiency without variation the formulations (pulp\coating : for example offset-rotogravure-offset )

Better capacity of the paper machines

Good recycling behaviour of the new paper grade

Reversal demands for coated printing papers:

·Adapted pigment and binder systems:

- RG and Flexo with low demand of binder (high binder amount means quality loss)
- Offset with high binder demand (high binder amount create problems concerning Heatset-printing)

·Coated special papers for example inkjet, NCR need active surface:

- Pigments with high specific surface area ( silica etc. )
- High binder demand and therefore loss of active surface
- High production costs because of expensive raw materials and limited production speeds (low capacities)

1. Case Study : Helicoater (speed=650m/min)

| Trial No. | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
|---|---|---|---|---|
| Pigment: | | | | |
| Calciumcarbonate (GCC) | RG coating colour | 60 | - | - |
| Kaolin | out of the production | 40 | - | - |
| Modified Bentonite | - | - | 100 | 100 |
| Binder / Additive: | | | | |
| Offset Binder | - | 8,5 | - | - |
| PVA 4-98 | - | 1,5 | 3,5 | - |
| Modified Starch | - | 2,5 | - | - |
| Optical Brightener | - | 0,8 | - | - |
| HF-Resin | - | 0,3 | 0,8 | - |
| Cross Linking Agent MFP | - | 0,5 | 0,3 | 1,5 |
| Solid Content [%] | - | 58,2 | 15,3 | 17,0 |
| BV 100 RPM [%] | - | 740 | 1100 | 1200 |
| Coating Weight [gm2] | 7,0 | 7,2 | 1,2 | 1,4 |
| Gloss 75° [%] | 48,0 | 52,1 | 22,6 | 24,6 |
| Smoothness Bekk [sec.] | 2660 | 2280 | 1770 | 1821 |
| Brightness R457 with UV [%] | 70,4 | 70,9 | 65,8 | 66,1 |
| Opacity [%] | 90,6 | 89,3 | 87,5 | 88,7 |

Evaluation of the Heliocoater trials

| Trial No. | Trial 1 (RG-Colour) | Trial 2 (Offset-Colour) | Trial 3 (mod. Bentonite without CLA) | Trial 4 (mod. Bentonite without Binder) |
|---|---|---|---|---|
| Offset Suitability: | | | | |
| Printing Gloss | 17 | 18 | 14 | 14 |
| Optical Density | 1,42 | 1,5 | 1,33 | 1,38 |
| Penetration Behaviour | 600 | 600 | 1800 | 1800 |
| Picking with Pre-Wetting | Strong Picking | Picking | Picking | No Picking |
| Picking without Pre-Wetting | Strong Picking | No Picking | No Picking | No Picking |
| Rotogravure Suitability: | | | | |
| Gloss (Whole Area) | 8 | 7,5 | 6 | 7 |
| Density Depth 40 | 2,39 | 2,42 | 2,43 | 2,38 |
| Missing Dots | + | (+) | + | + |
| Inkjet Suitability: | | | | |
| Visual Evaluation | - | (-) | + | + |
| | | | | |
| Paper Gloss | 48,0 | 52,1 | 22,6 | 24,6 |

Summary of Helicoater trials:

·Gloss development of 'functional coating' (Trial 4) is only suitable for matte or semi-matte papers in spite of increased calender conditions (bentonite is

a matte pigment), but is offering high printing gloss

·Compared to standard matte papers there are no problems with partial gloss spots caused by further processing (fingernail test, friction gloss)

·The coated paper (Trial 4) is printable with good results using different print options

·The high smoothness and 'active coating surface" is very positive for the RG-printability (coated RG-Matte-Papers are less calendered)

Laboratory optimisation work showed:

·With pigments having : silicate layer structure, high specific surface area, requested pore volume and aspect ratio

·With special cross linking agents creating bonds between the SiOH

( Silanol functional groups ) of the pigment and the OH-groups of the fibres

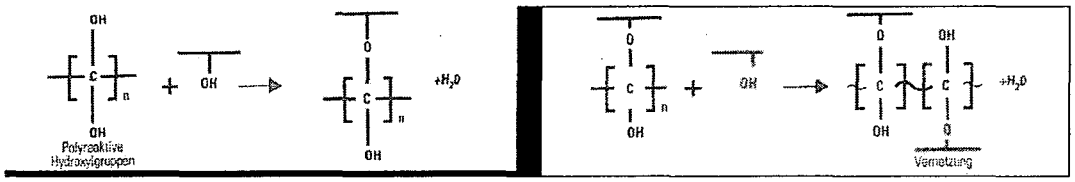
and therefore a good fixation to the coating base paper

·We produce a 'functional coating layer" without binder but high active surface suitable for all print operations getting good results (MULTIFUNCTION PAPER)

Mechanism of

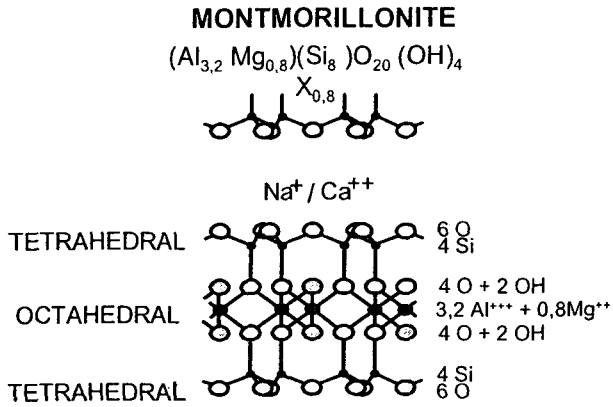
- Modified Glyoxal Compound -

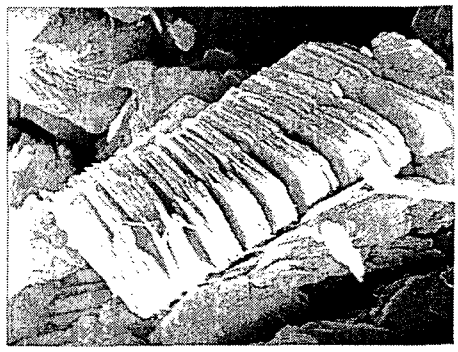
Modified and stabilised Glyoxal-resins react preferred with -OH groups but obviously also with -SiOH groups of the pigment:




Advantages of the modified and stabilised Glyoxal compound:

- No linking reaction in water (viscosity increase)
- Improved adsorption of the non-ionic compound to the pigment
- Based on the non-ionic behaviour usable in anionic and cationic coating formulations
- Strength development already in the drying section of the CM
- No difficulties with smelling or environment (formaldehyde and AOX)
- No tendency for yellowing
- No problem with broke recycling because temporary wet strength



Comparison different minerals

| microstructure | Kaolin<br>2- layer silicate | Bentonite<br>3- layer silicate | Talc<br>3- layer silicate |
|---|---|---|---|
| layer charge | weak anionic | anionic | 0 |
| cation exchange capacity | 1-10 mval/100g | 60-120 mval/100g | low |
| swelling capacity | low | well | none |
| delamination | milling | simple dispersing | difficult |
| viscosity (thixotropy) | low | large | low |
| shape factor | 8-15 | 20-50(dry)<br>up to 1000 (disp.) | 30 |
| specific surface | 9-15 $m^2/g$ | 40-80 $m^2/g$ (dry)<br>up to 750 $m^2/g$ (disp.) | 5-12 $m^2/g$ |
| fibre adhesion | low | well | low |

2. Case Study with Pilot Coater -VESTRA-

Base Paper: 100 % DIP 54 g/m2

VESTRA-Pilot Coater: Width 59 cm, SM-velocity 50 m/min - 2500 m/min

Coating Unit: Film press Jagenberg

Drying: Krieger INFRA-AIR-Dryer CB-AIR-Dryer

Super Calender: Voith Sulzer, 12 rolls

Speed 50 -600 m/min

Nip Pressure 110-320 KN/m

Temperature 40 -95C

Trial 1-Trial 4 papers were calendered with following conditions:

Velocity: 400 m/min

Nip Pressure: 160 N/min

Temperature: 95 C with 4 Nips

LWC-RG and some papers of Trial 1, Trial 4 and Trial 5 were calendered with following conditions:

Velocity: 600m/min

Nip Pressure: 180 N/mm

Temperature: 90 C with 11 Nips

Coating formulations:

| **Pigment/Additive/Parameter** | **T1** | **T2** | **T3** | **T4** | **T5** |
|---|---|---|---|---|---|
| Bentonite I | 100 | 100 | | | |
| Bentonite II | | | 100 | 100 | 75 |
| Kaolin | | | | | 25 |
| Optical Brightener | 0.5 | 0.5 | 0.5 | 0.5 | 0.8 |
| PVA | 0.8 | | | 0.8 | 1.3 |
| Modified PVA | | 1.5 | | | |
| Glyoxal-Compound | 1.5 | 1.7 | 2.0 | 1.8 | 1.7 |
| Thickener | 0.2 | | 0.1 | 0.2 | 0.1 |
| Binder | | | | | 2.0 |
| pH-value | 8.5 | 8.5 | 8.5 | 8.7 | 7.8 |
| Viskosiät Brookfield 100 rpm | 290 | 850 | 620 | 460 | 360 |
| Solid Content (%) | 14.4 | 13.3 | 22.6 | 22.4 | 25.5 |
| Base Paper: | DIP | DIP | DIP | DIP | DIP |
| Rod Type | C25 | C25 | C22 | C22 | C30 |
| Velocity (m/min) | 1000 | 1000 | 1800 | 1800 | 1800 |
| Coating weight per side ($gm^2$) | 2.1 | 1.9 | 1.9 | 2.1 | 2.2 |

All amounts calculated as dry material, only OBA handled with commercial solid content

Results of Pilot Coater trials

| Parameter | T1 | T2 | T3 | T4 | T5 | LWC-Offset | LWC-RG |
|---|---|---|---|---|---|---|---|
| Brightness R457 with UV | 76.1 | 76.6 | 77.2 | 76.8 | 77.5 | 85.6 | 76.5 |
| Opacity | 91.7 | 91.8 | 91.8 | 91.5 | 92.4 | 94.0 | 93.8 |
| Paper Gloss (45°) | 18.1 | 16.7 | 15.5 | 16.1 | 20.5 | 40.3 | 49.7 |
| Printing Gloss (60°) | 8 | 7 | 8 | 8.5 | 24.5 | 14 | |
| Mottling | Weak Mottling | Weak Mottling | Weak Mottling | Weak Mottling | Weak Mottling | Weak Mottling | - |
| Penetration (sec) | 60 | 600 | 600 | 600 | 500 | 300 | - |
| Wet Picking | No | No | No | No | No | No | No |
| Dry Picking | No | No | No | No | No | No | No |
| Missing Dots | Very good | Less | Less | Very good | Very good | - | less |
| Printing Smoothness | Very good | Good | Good | Very good | Very Good | - | Very good |
| Flexo Suitability | Very good | Suitale | Suitable | Very good | Good | - | good |
| Inkjet Suitability | Very good | Good | Very good | Very good | Good | Bad | Very bad |
| Laser Suitability | Good | Good | Good | Good | Good | Very good | good |

With Adjustment of the calender it was possible to get an additional quality improvement for RG, Flexo and Inkjet

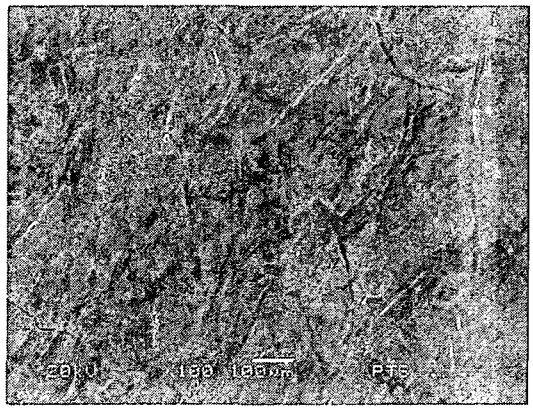
For comparison we produced LWC-Offset- and LWC-RG paper (same base paper)

Offset: 80 parts CaCO3, 20 parts Kaolin + 12 parts Binder/Rotogravure: 80 parts Kaolin, 20 parts Talc + 5 parts Binder (coating weight for both: 7.5 g/m )

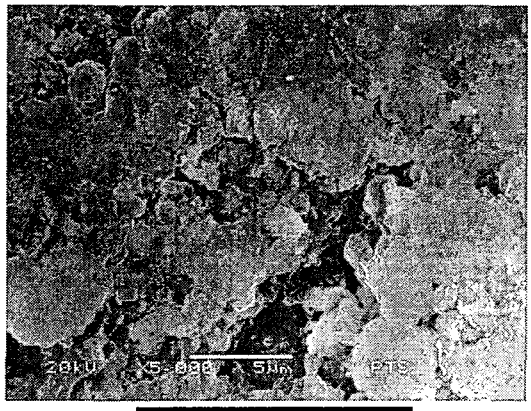
Summary of Pilot Coater Trial:

- ·Very good runnability of the CM with velocity up to 1800 m/min (control of the coating weight without problems)
- ·The papers with 'functional coating" could be printed with different options and resulting good quality
- ·The printing gloss – Offset and RG – increased with improved calender conditions without influencing the paper gloss too strong
- ·With additional calender variation we are getting a reasonable printability for RG, Flexo and Inkjet

REM-photos of the functional coating



V4 - 100x enlarged



V4 - 5000x enlarged

Reactive Functional Coating without Binder:

Layer silicate with high specific surface area

Cross linking agent (compound) 1,2-2% to pigment

Coating weight 0,8 - 3,5 g/m2, preferred 1,3 - 1,8 g/m2

Coating unit: Film press

Calender conditions adapted to the paper application

Remarks:

·Coating colour: viscosity >500 mPas BV/100 (to avoid the penetration of the CLA into the base paper)

·PH-value <9,0

·Temperature of the coating colour <60Celsius

·Base paper not too strong sized