Limits and advantages of digital printing techniques

Direct Imaging and Copy Press vs Electrophotography

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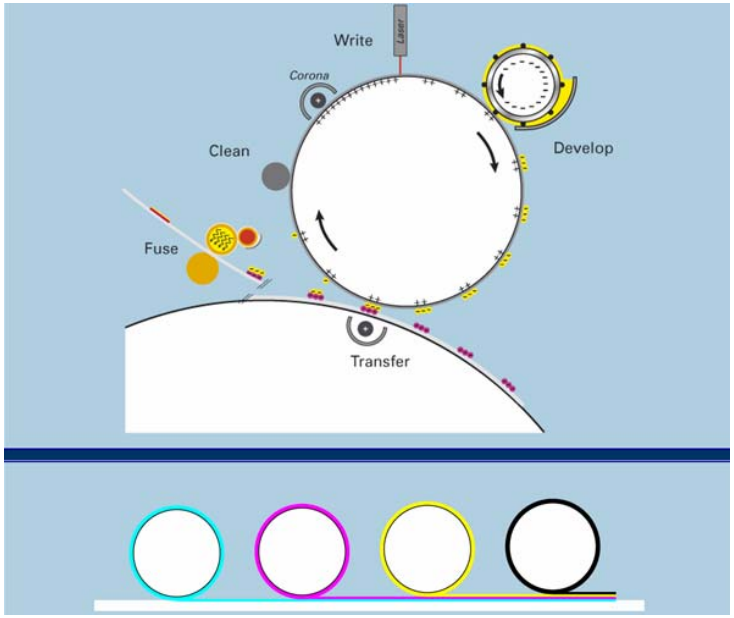
The aim of our research was to find out the limits of two different digital technologies:

- Direct Imaging and Copy Press (Océ)
- Electrophotography (Xerox)

In this study we wish to answer on these questions – which technology could give us:

- better mechanical stability
- better light fastness
- wider colour gamut
- ….

Electrophotography



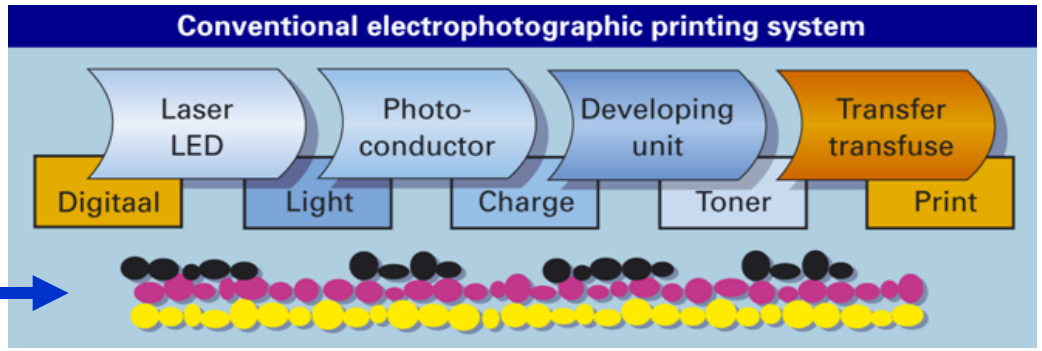
Electrophotography is well known 70 years old technology.

- the drum gets charged by corona
- a latent image is developed as toner is attracted by the charge
- process is repeated for each color
- (4) toner layer is fused on the media

The coluor is determined by the amount of toner put on paper:

more toner = darker colour = **more charge**
less toner = lighter colour = **less charge**

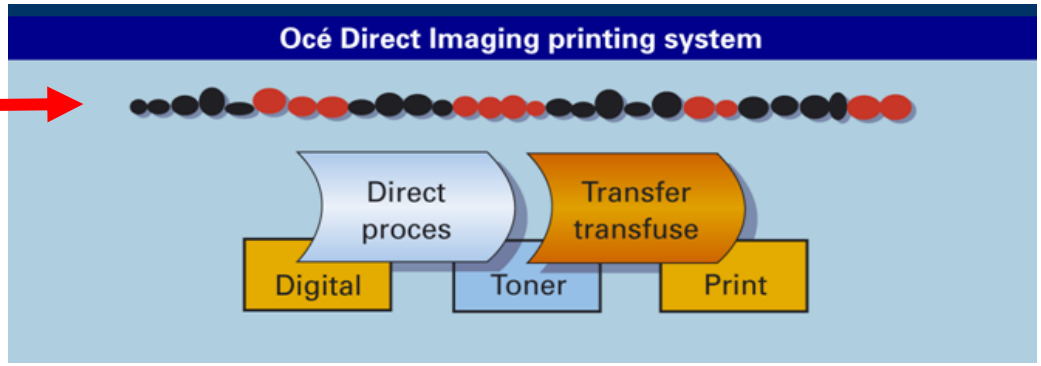
The charge is easy influenced by light, temperature, moisture, etc.



2, 3, 4 layers

Traditional: 3 process steps and 3 variables (light, charge, toner) needed to create the image. This will hard to be stable, especially when printed in four layers.

1 layer



Direct imaging: single process with no variables. Direct addressing of toner particles and placing them next to each other: **stable mono layer**.

Colour generation

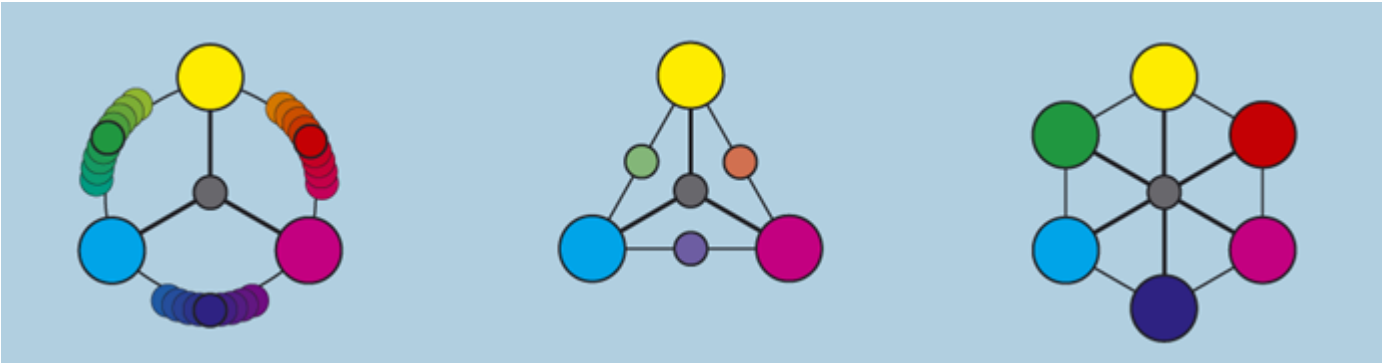
Conventional:
layered CMYK toner

toner side by side

Direct imaging:
• non transparent toner
• (1) CMY combination can not reproduce secondary colours

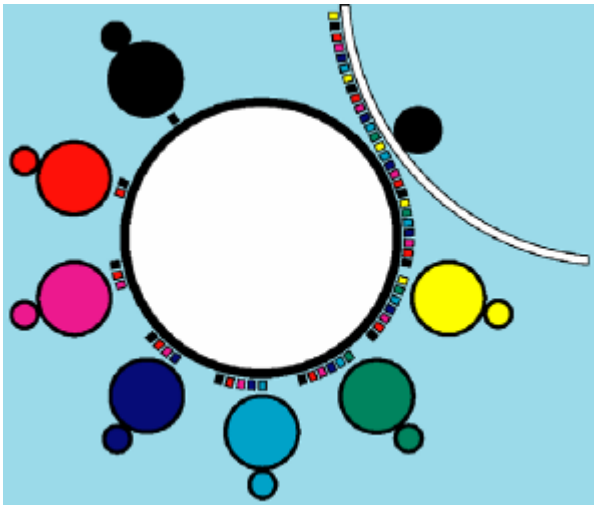
• (2) when the colors are palaced next to each other, the colour gamut is limited

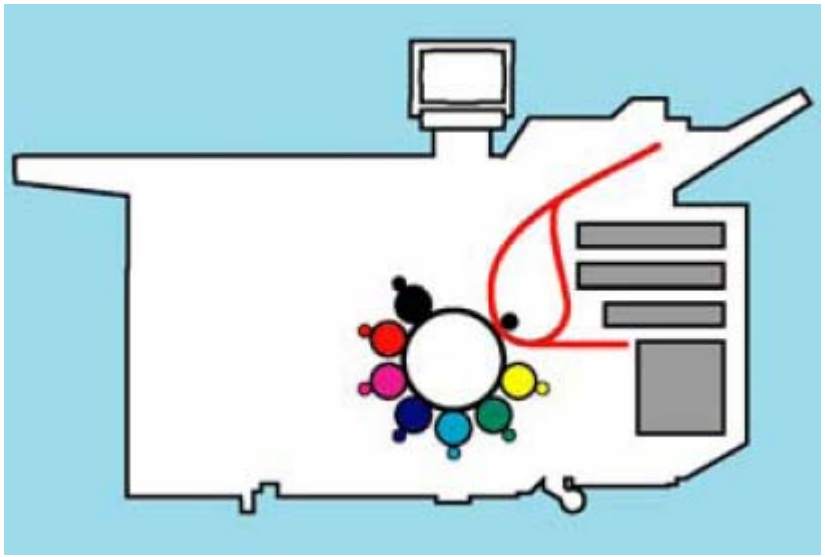
• (3) the addition of 3 extra colours R, G and B – stable process



Extra colours are not used for:
• additive combined with subtractive color mixing
• adding spot colours to the process

Direct Imaging and Copy Press technology





The 7 colour printing units are located around the central intermediate (a cylinder with a rubber layer).

The toner images formed by the individual colour printing units adhere to the rubber and than the toner is transferred to paper.
The pressure roll transfers all collected toner from the intermediate to the paper in a single pass by pressure and heat.
After the transfer, the paper is post-fused by rolls.

Direct Imaging and Copy Press technologies

Toner (one component toner) particles can only adhere to the intermediate if there is direct contact with the rubber - a monolayer of toner.

Unlike traditional EP, no sensitive electrical charging - which can be influenced by humidity and temperature - is needed.

The fusing T is relatively low (110 ˚C vs. more than 180 °C at EP).

After transfer the paper is post-fused to fix the toner particles on the paper and to improve the colour saturation and contrast.

Benefits of the Direct Imaging and Copy Press technologies

Reliable finishing with a monolayer toner
• a good bonding of the monolayer of toner on the paper.

Better readability with less gloss
• less oil is needed to post-fuse the toner onto the paper - the gloss level is low.

Uniform printing of large area
• monocomponent toner with Copy Press system results in uniform transfer.
The printed colour is uniform across the page.

Uniform printing on embossed media
• a broad range of paper structures can be printed (embossed paper - linen structured paper).
EP is more sensitive to the homogeneity of the substrate.

Benefits of the Direct Imaging and Copy Press technologies

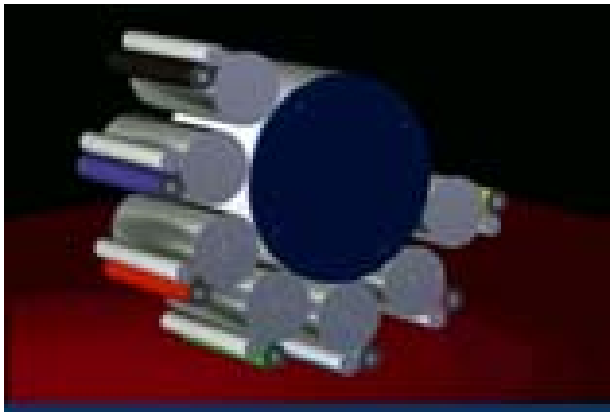
Higher productivity and lower costs without calibration

Lower toner usage

Better care for the environment
EP uses corona to charge the photoconductor and attract toner particles - toxic ozone gas is generated.

Higher productivity with thicker media
A broad range of paper weights can be printed; 80 g/m^2 to 300 g/m^2, without reduction in printing speed.

Colour reproduction with 7 colours



Setup toner

Image generation

Halftone screens

The colour-mixing screens:
- classic halftone screens
- dynamic colour-mixing screens

A dynamic colour mixing screens:

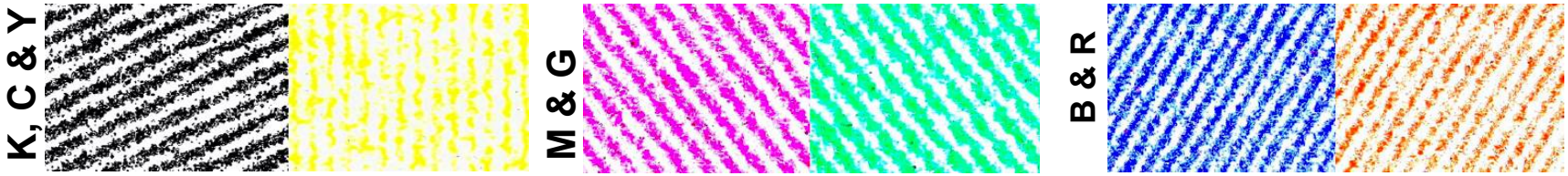
- optimise (reduce) graininess of lighter colours
- minimises the visibility of the halftone screening
- improves sharpness.

In the dynamic colour-mixing scheme, the halftone screens are **fixed** in:
- frequency and
- angle

Halftone screens

Dynamic colour-mixing halftone screens

	K	R	M	B	C	G	Y
Screen frequency [lpi]	168	160	202	160	200	202	200
Screen angle [degrees]	63	-30	38	-30	0	38	0

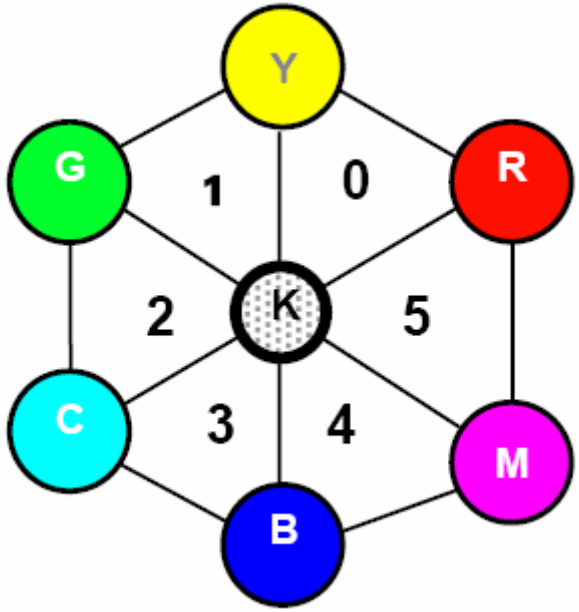


In the dynamic quality mode grey-defined text, line graphics and images are printed with K toner only – special halftone screen (minimal graininess, an angle of 0°, and cannot interfere with other colour screens).

Selection of colour mixing schemes

In Oce printing machines two colour-mixing schemes are used:
- the classic
- the dynamic

The classic colour-mixing scheme uses 6 different colour combinations.



Only 3 toner units are involved in creating a specific colour.

In general, a colour is built up using:
- one of the R, G or B colours,
- one of the C, M or Y colours,
- black and the white of the paper.

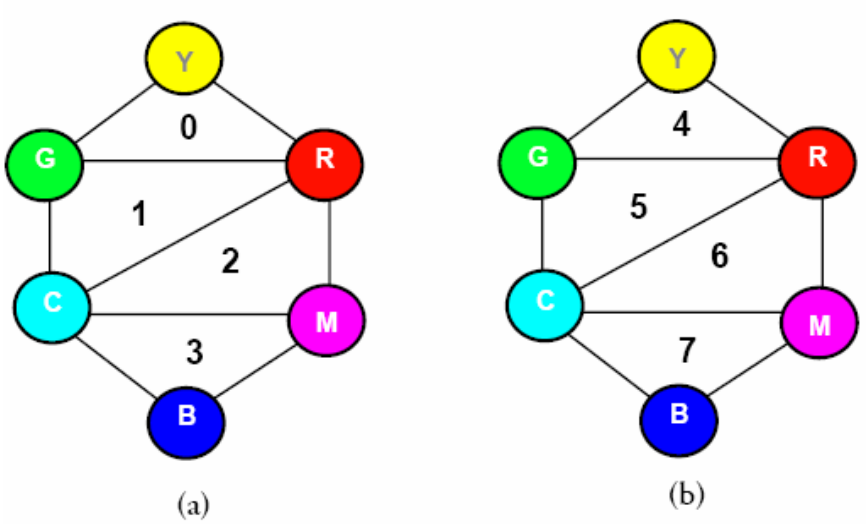
The colour gamut is divided into 6 segments.
Each segment uses the adjacent two colour toners to define a specific colour.

Colour-mixing schemes

Dynamic colour-mixing scheme
uses 8 colour combinations.

In general, a colour is built up using:
- 3 different colours with
- black and the white of the paper

Each segment defines the three or four toner units which are used to define a specific colour.

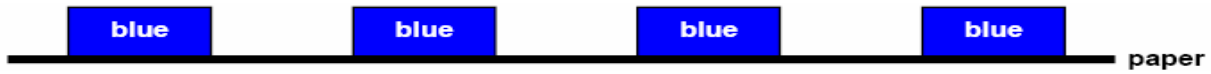


8 segments without black (a) and with black (b).

Colour-mixing schemes

The example – reproduce of a bluish pastel colour

1. The classic colour-mixing scheme the colour is built up with a low B coverage and the W of the paper. The higher the contrast (toner/paper), the higher the graininess level will be.

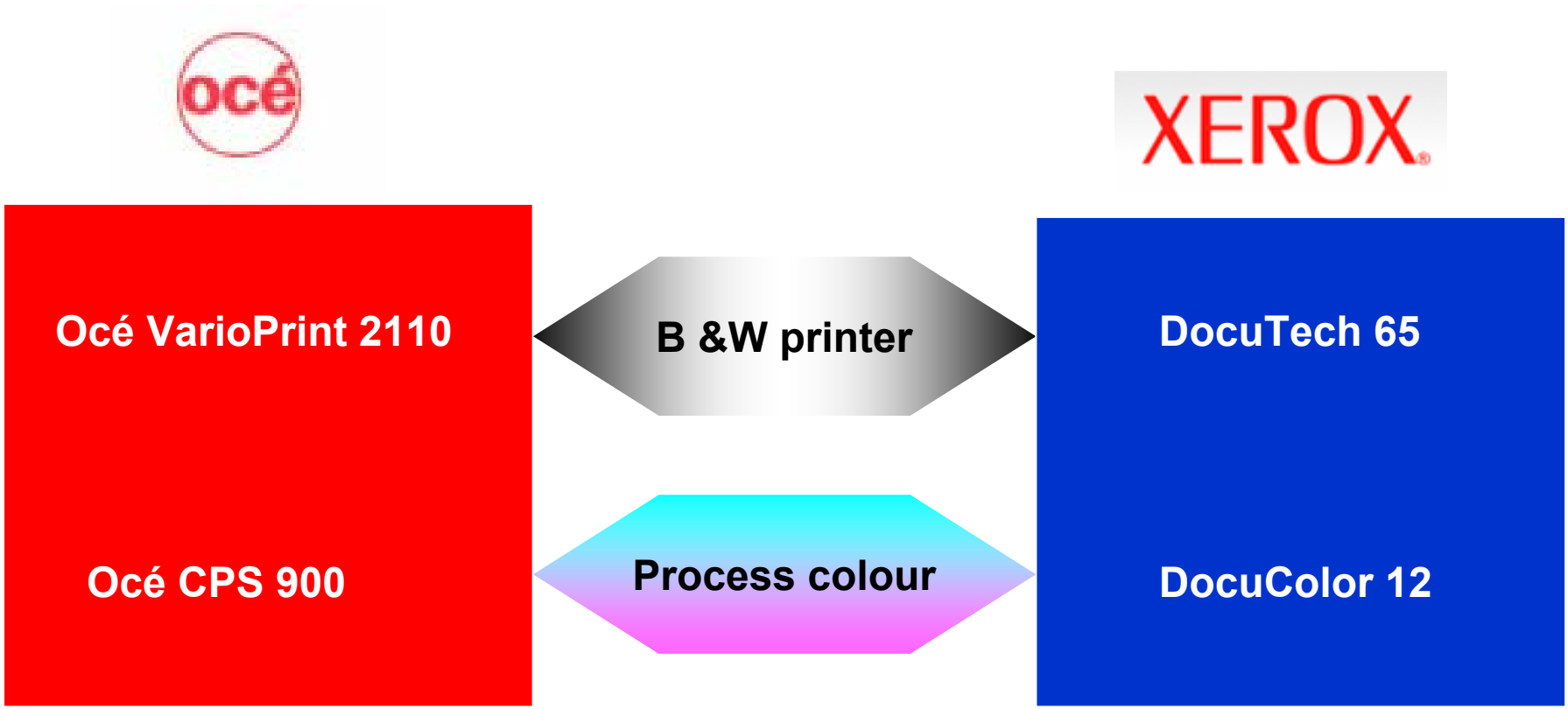


2. The dynamic colour-mixing scheme, light blue is defined by segment 3 - only M and C are used.

Two lighter toner have:
• a lower contrast with the W of the paper - lower the graininess.

With the combination of C and M, the saturation is limited.
For a more saturated colour B toner is added.

Printing machines



Printing material

océ

- Top Colour Paper [100 g/m²]
- Top Coated Paper Matt [135 g/m²]
- Coloured Paper TFC [80 g/m²]
- Snake Structure Soft White [200 g/m²]

XEROX

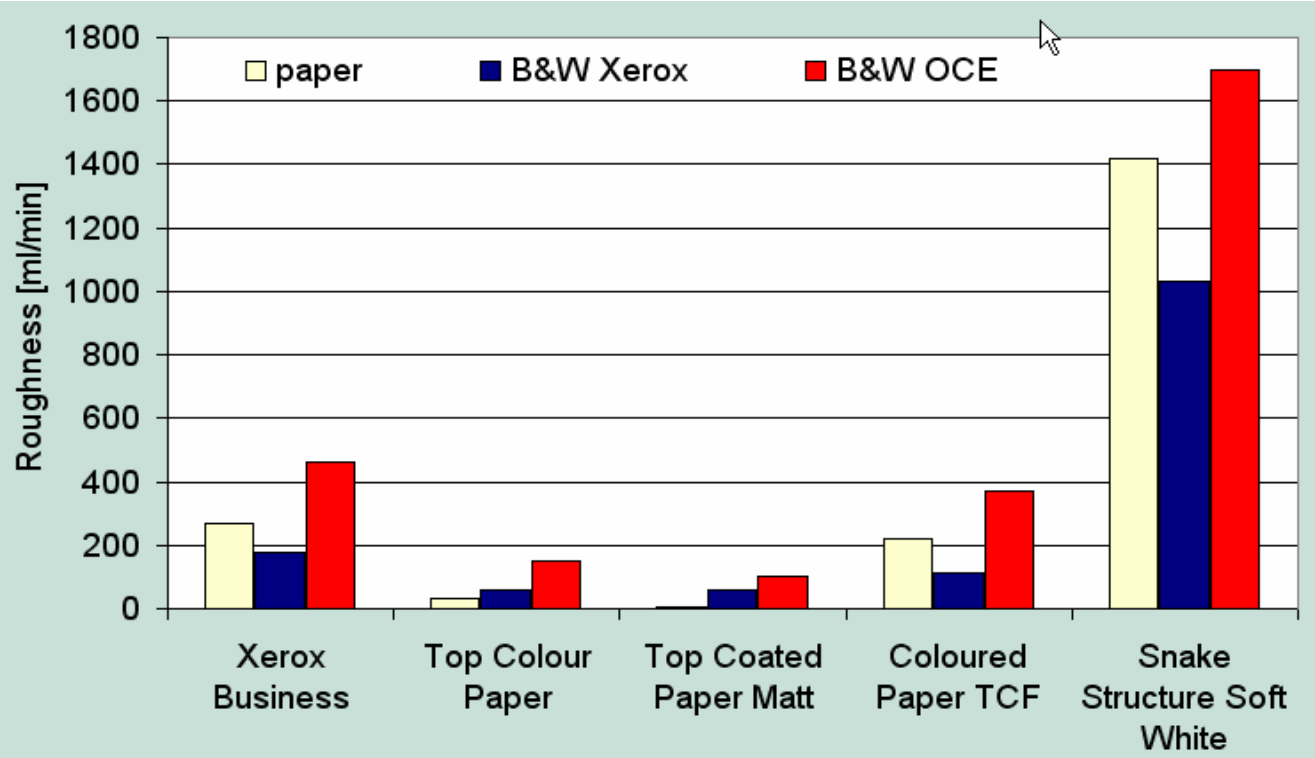
- Xerox DuraPaper [200 g/m²]
- Xerox Business [80 g/m²]

On printed samples we measured:

- roughness
- dynamic of water penetration – DAT
- bending ability
- surface rub-off resistance – Quadrant
- lightfastness of prints – Xenotest
- gradation curve
- colour gamut

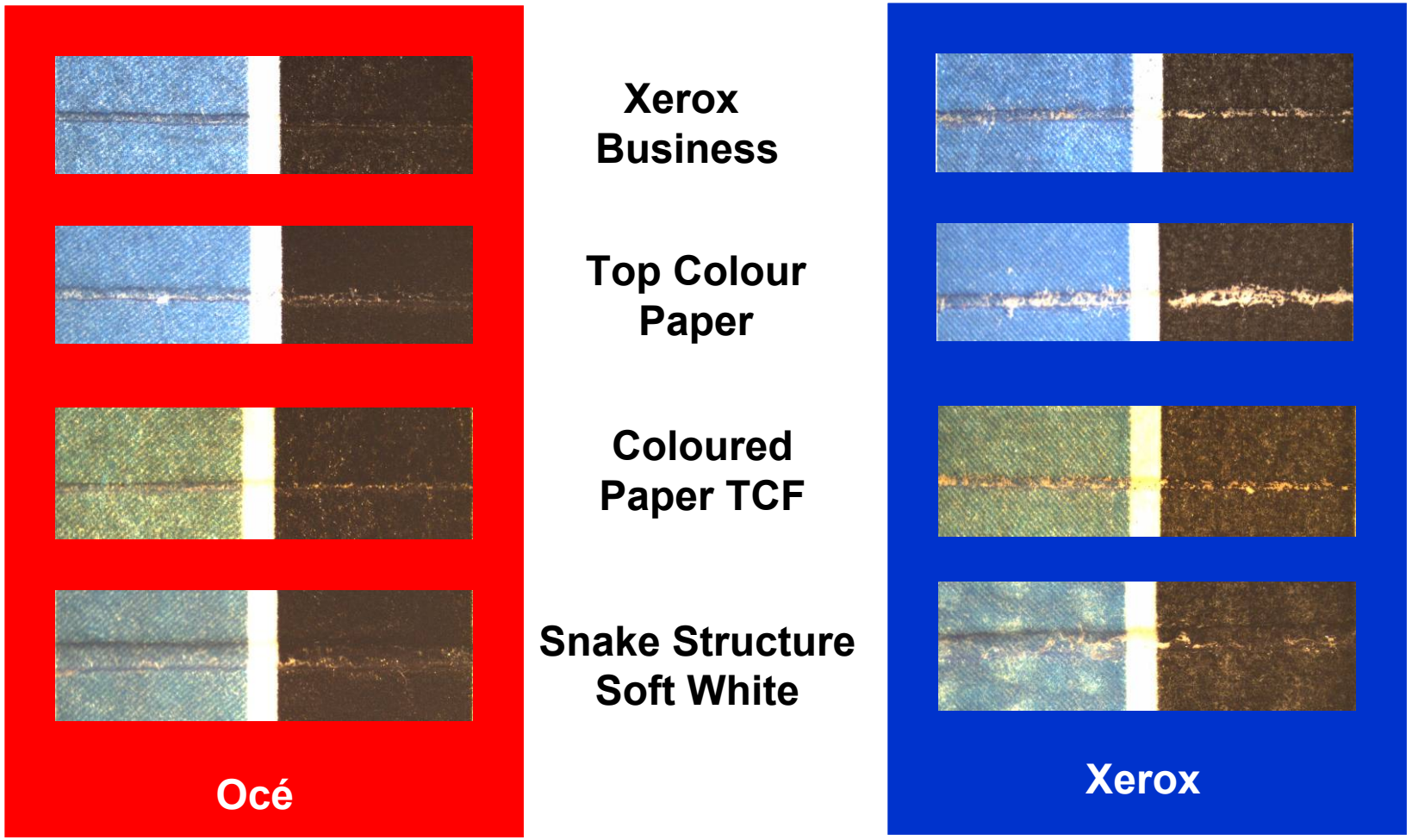
Roughness - Bendtsen

Monostat 1,47 kPa (medium), [ml/min]



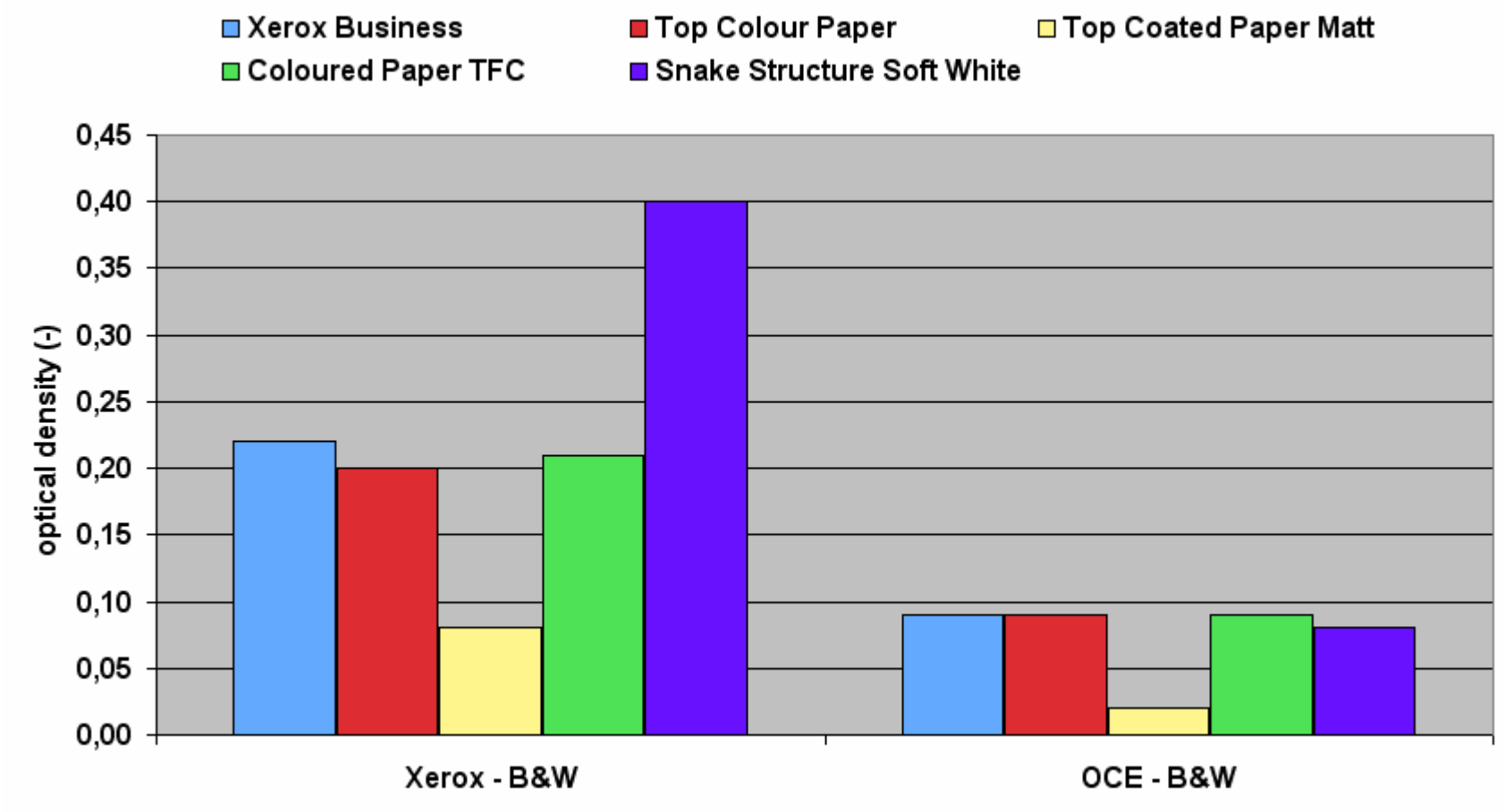
The roughness of printed surfaces is the highest on Océ B&W prints.
At colour prints the differences between both techniques are not so obvious.

Bending ability (paper deformation after bending)

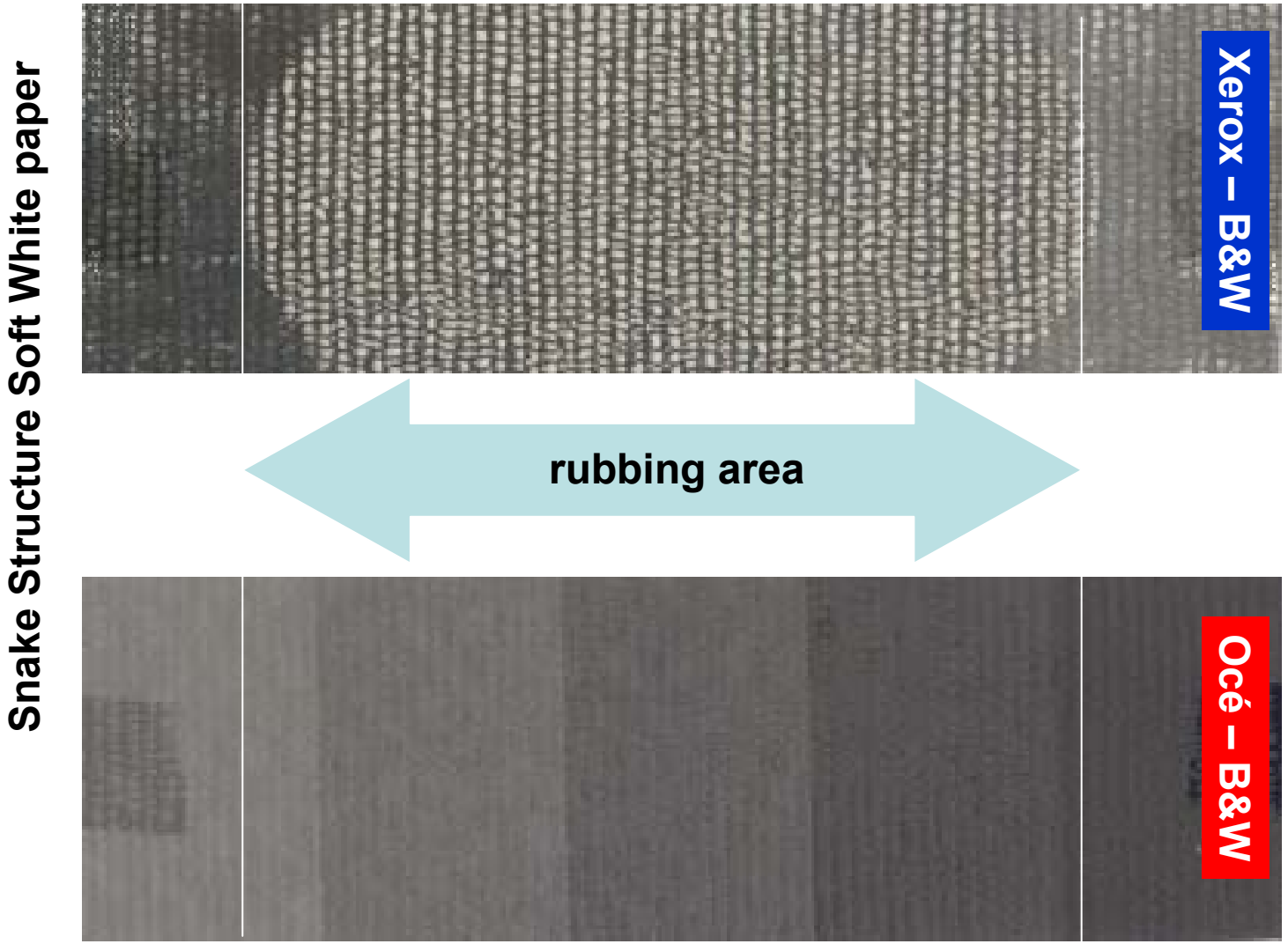


Bending ability of Océ prints is better than Xerox, so reliable finishing could be done (folding, cutting …).

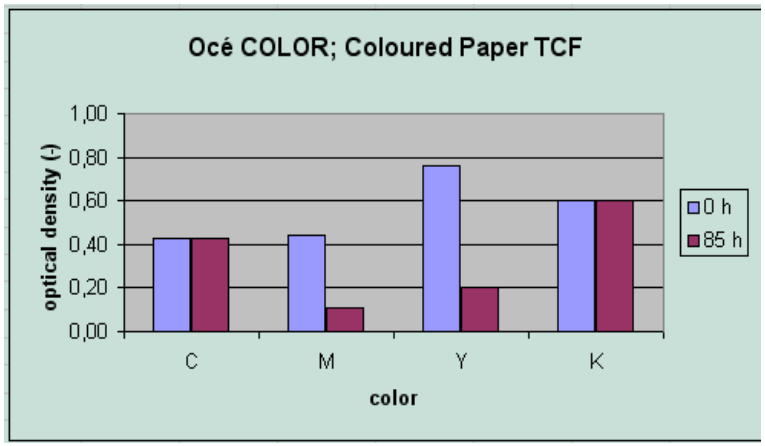
The surface rub-off resistance - Quadrant

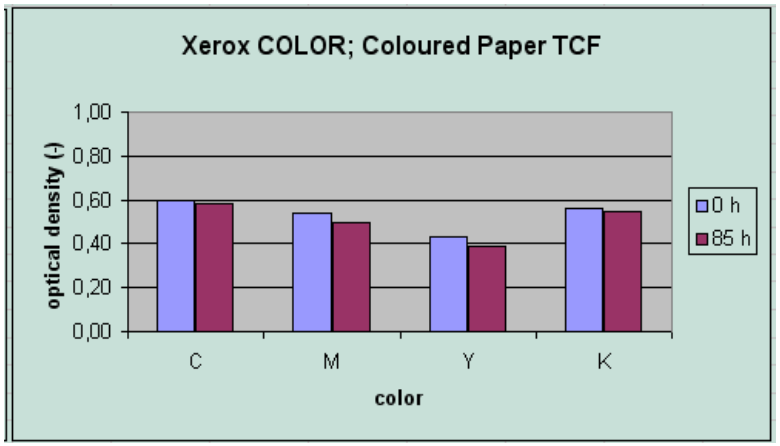


The surface rub-off resistance - Quadrant



Lightfastness of prints – Xenotest
(Exposure time 85 hour)



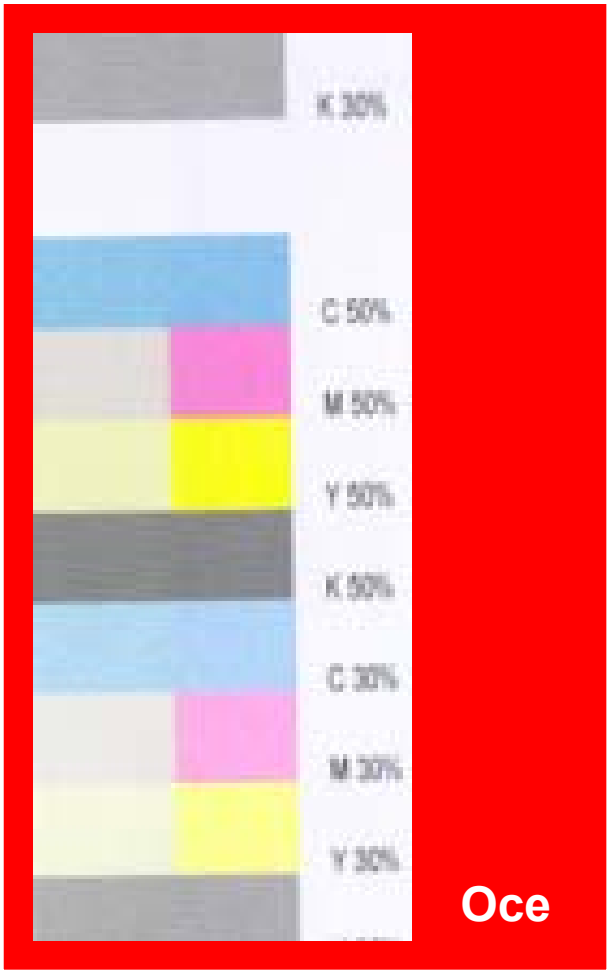


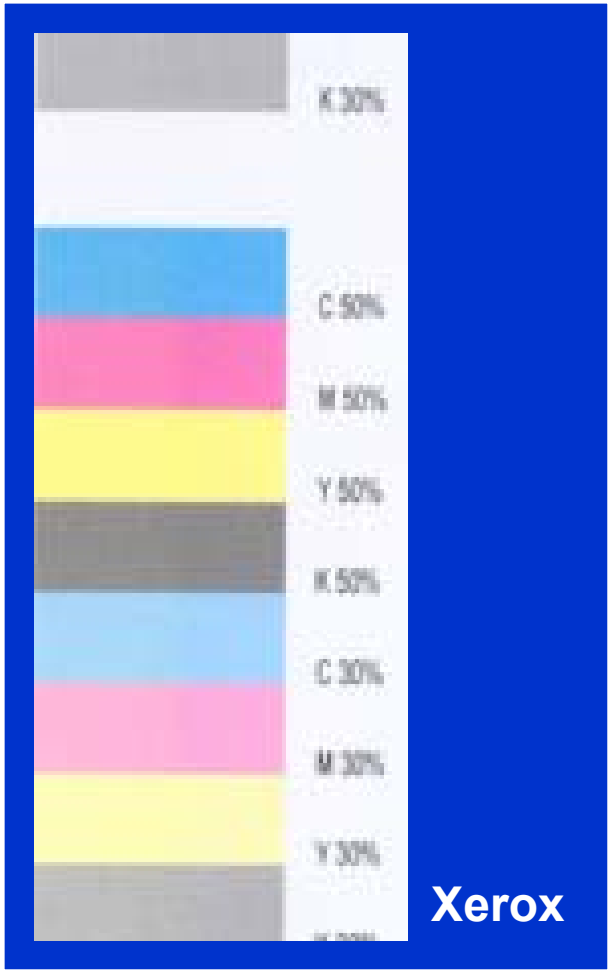
The lightfastness if we observe all colors together is better on Xerox prints, but if we look the colors separate the C and K on Océ prints are stable, while M and Y are not.

Lightfastness of prints – Xenotest

Top Colour Paper

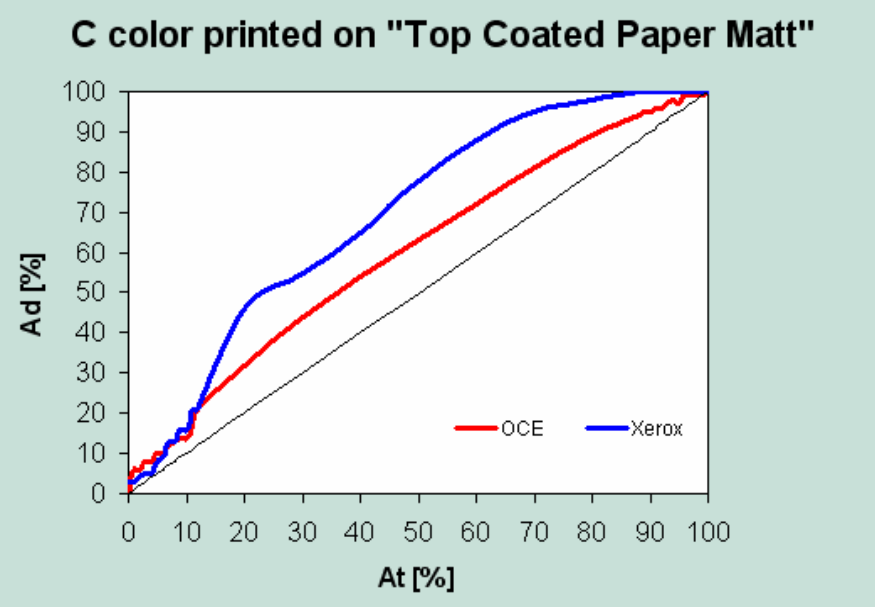
(Exposure time 85 hour)

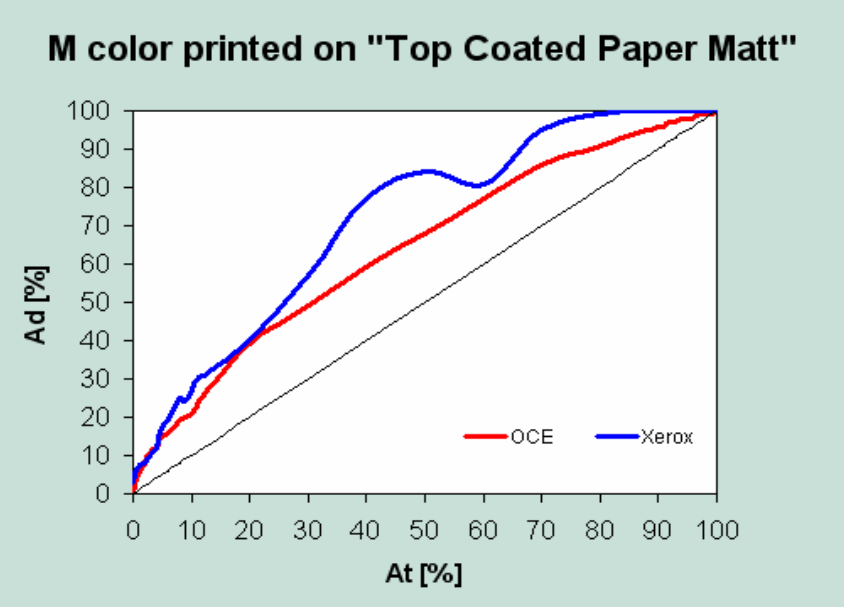




Poor lightfastness on Océ prints and good resistence of Xerox prints.

Gradation curve

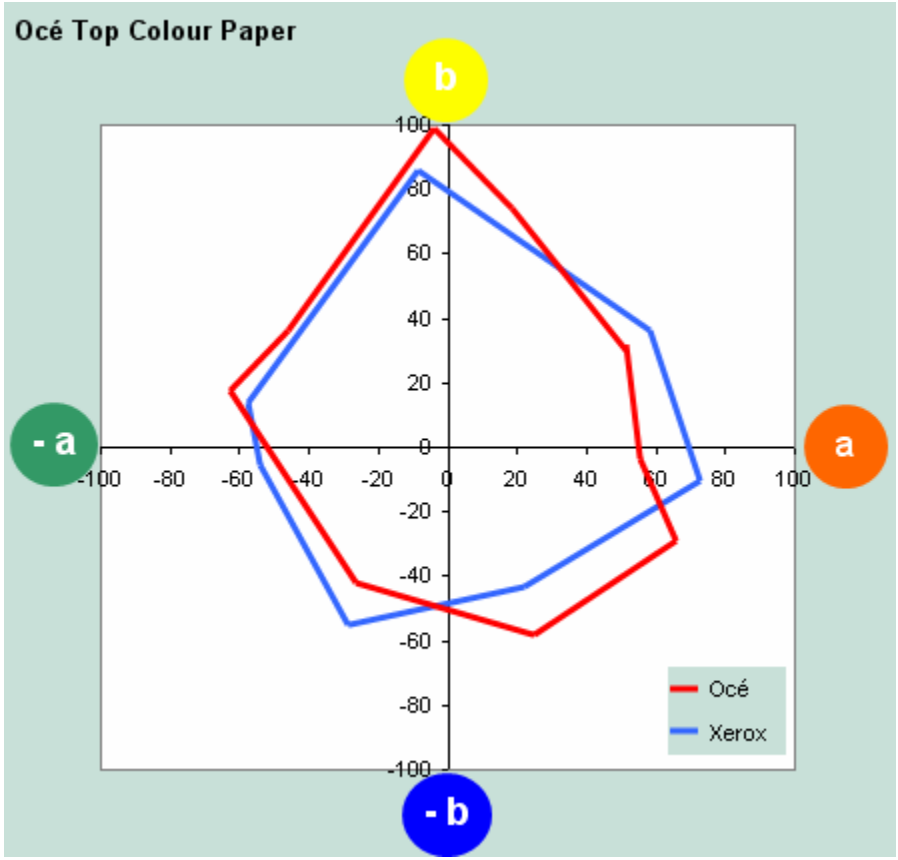


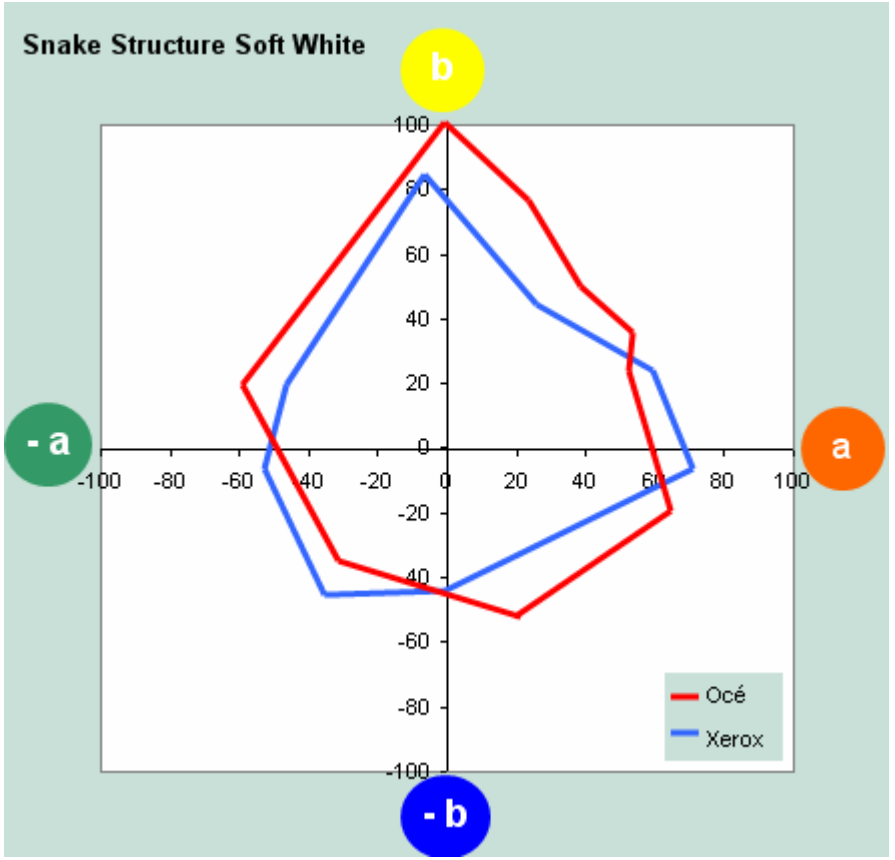


The dot gain on Océ prints is lower than on Xerox.
It is easier to control the process of printing.

Color gamut

(GretagMacbeth SpectroScan, measure target TC3.5 CMYK+Calibration)

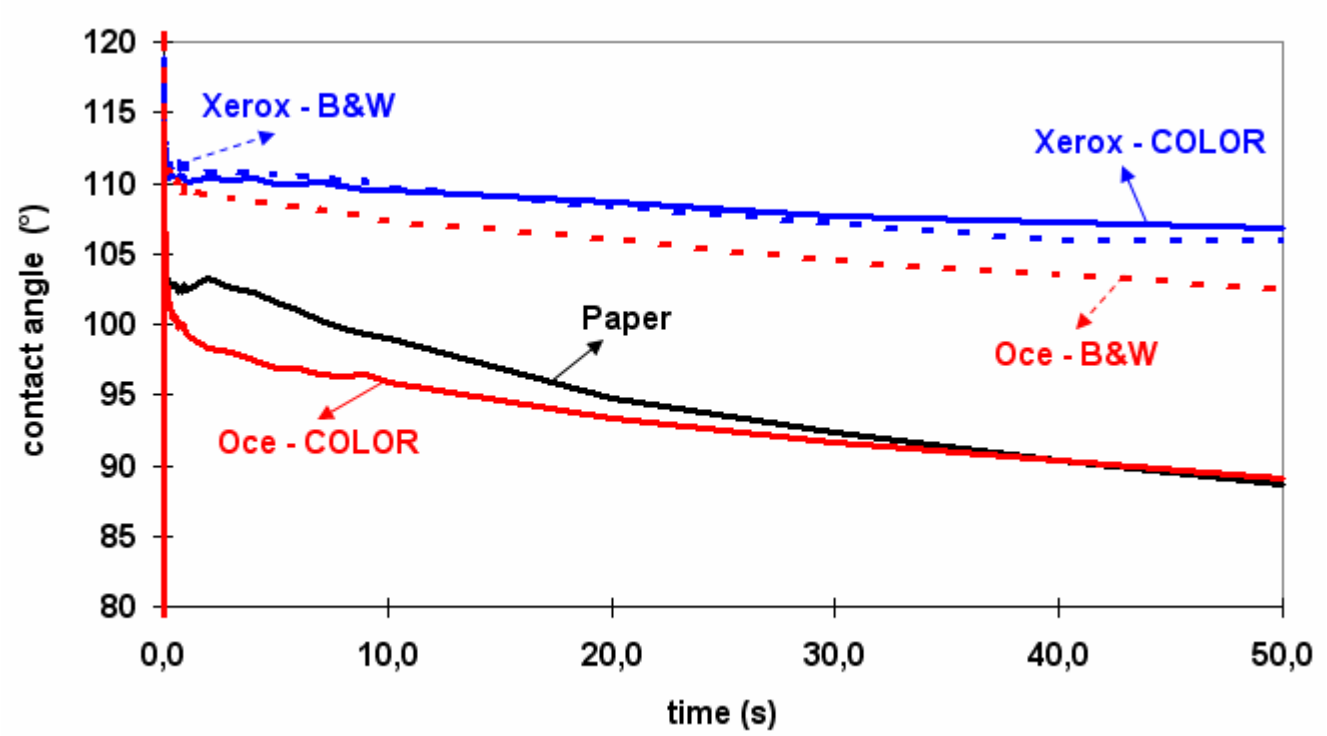




The colour space of Océ prints is comparable with Colour space of Xerox in spite of using no-transparent toner and printing toner side by side.

Dynamic of water penetration – DAT

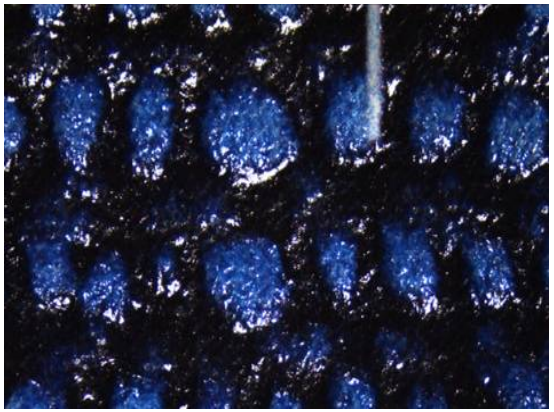
• measured on the Xerox – Business paper



The Xerox prints (B&W and Colour) are more hydrophobic than Océ prints.

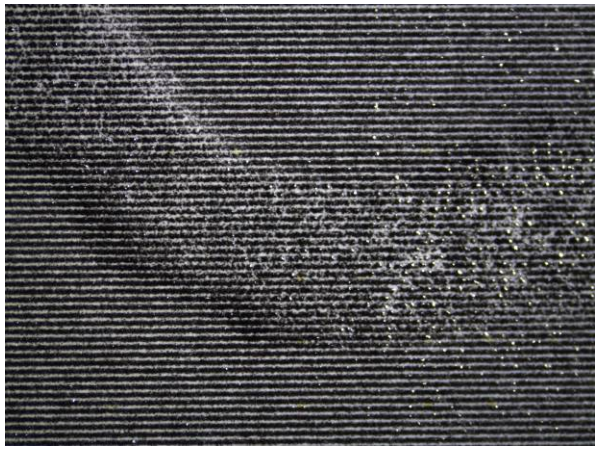
Electrophotography

- the lightfastness of EP (Xerox) prints are higher than prints from DI (Océ) technology



- more sensitive on the structure of the paper surface and on the thickness of the substrate

- at coated paper the negative phenomena was occurred



- low rub-off resistance

- low bending ability

Direct image technology with Copy Press confirms statements:

• poor lightfastness

• excellent rub-off resistance

• in spite of printing toner side by side, the colour space is comparable with the space of EP (Xerox)

• a broad range of paper structures can be printed (embossed paper, linen-structured paper)

• the gradation (printing curve) dot gain is lower on prints by DI (Océ)

• higher roughness, less gloss – good influence on better readability

• bending ability **-** good bonding of the toner´s monolayer on the paper **-** reliable finishing - folding and cutting

	DI and Copy Press (Océ)	Electrophotography (Xerox)
Roughness	+	-
Rub-off resistance	+	-
Bending ability	+	-
Colour gamut	+	+
Gradation Curve	+	-
Lightfastness	-	+
Printability; • Structured papers • foils with low T stability	 + -	 - +

This experimental work present the start of our future researches.

References

Digital printing, Océ, 2005, 9th edition, 432 pp.
Océ White papers:
Océ Direct Imaging and Copy Press, 2005, 6 pp.
Halftone screens related to quality modes, 2005, 8 pp.
Selection of Colour mixing schemes, 2005, 6 pp.