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Original scientific paper

CRITERION EVALUATION OF QUALITATIVE CHARACTERISTICS OF THE CONTEMPORARY OFFSET PRINTING

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Abstract: In this work researches had been made on color measurement patches of color control bar from the test form that was printed on waterless and conventional offset printing presses. The prints were printed with waterless and conventional offset printing technology on four widely used printing substrates which are: glossy fine art paper, matt fine art paper, coated woodfree paper and uncoated woodfree paper. The measurements on the prints were made with densitometer and results from objective research regarding to area coverage (tone value) in conventional and waterless offset printing are presented in tables. Marginal prints printed by International standards from both conventional and waterless offset printing were distinguished based on the results that came from researches.
Print reproduction curves for colors that are used in multicolor offset printing were made based on the measured results of research for both conventional and waterless offset printing.
Realistic print reproduction curves for prints made in conventional and waterless offset printing are shown in figures based on the area coverage (tone value) measurements.
Ratios in area coverage (tone value) and ratios in realistic print reproduction curves were established based on the results that came out of the measured prints made on conventional and waterless offset printing presses on different printing substrates, and the suggestion is given for optimization in multicolor printing reproduction.

Key words: Waterless offset printing, conventional offset printing, tone value area coverage, realistic print reproduction curve, optimization

1. INTRODUCTION

Improving the activities connected with the printing profession is closely bonded with the development of computers and laser technology, which resulted in the introduction of new printing technologies, so called Non Impact Printing (Glykas M. 2006; Kiphan H. 2001)
Electrophotography and InkJet as the main representatives of such technologies fulfill the demands of the market in printing small runs, but they still have not developed their potentials so that they can compete with the conventional offset printing in other segments.
Conventional offset printing, because of simple production of the printing form and the possibility of printing on different printing substrates with the technologically most contemporary machines, enables this printing technique to keep the leading role in the process of multiplying the qualitative multicolour reproduction, especially of great editions.
As electrophotography and InkJet haven't become stiff competitors to classical offset in recent years, especially in multiplying qualitative multicolor reproductions of greater editions, the waterless offset has been developed more and more, which, with its qualitative characteristics, can compete more and more with the classical offset in multicolor reproduction of small and medium runs.
In accordance with this, the technical and technological qualitative possibilities of the waterless offset printing in relation to the conventional offset have been researched in this work. The research aims were directed to determine, as much as possible, the boundary conditions in which the technical and technological parameters of the waterless offset enable the printing of high quality multicolor reproductions.
The boundary conditions in this case are defined as the ones in which the increased deformity of the screen elements appears, i.e. in which the decrease of the quality of the graphic product appears, independent on the printing technique.
According to the mentioned, the experimental part has been determined on the base of which numerous results were obtained, which helped in making the comparative analysis of the mentioned techniques and in pointing out the possible advantages of a particular technique.

2. PARAMETERS INFLUENCING THE REPRODUCTION QUALITY

The technology of the contemporary offset printing must be observed as the system with numerous parameters if one wants to achieve high top quality. The change of only one parameter among the numerous ones can have the immediate effect on the printing process.

As the technology of the conventional offset printing has been developing and improving for a long period it has more or less defined parameters which mostly influence the reproduction quality. The process of the conventional offset printing depends on many physical and chemical specific features of materials and components which are incorporated in the mentioned process.
The reproduction quality in the conventional offset printing is influenced by different elements:

- *The influence of the printing form*

- surface tension of the printing elements,
- surface tension of the non printing elements,
- capillary attraction, microstructure of the non printing elements,
- surface roughness, especially the roughness of the non printing elements,
- material type,
- production methods in the printing form preparation (mechanical or electrolytic roughening, etc.);

- *Influence of the inking rollers*

- characteristics of the material which covers the roller,
- surface tension of the material which covers the roller,
- surface roughness,
- viscosity- elastic characteristics of the rubber blankets,
- concentrical movements;

- *Influence of the rubber blanket*

- surface tension of the rubber blanket,
- compressibility,
- surface roughness,
-properties to accept and transfer the ink,
- properties to transfer the tone values,
- projecting, hardness, dimensional stability;

- *Influence of the printing ink*

- surface tension, the tension of the contact surface in connection with the dampening solution,
- rheological properties (viscosity, fluidity, etc.),
- temperature characteristics,
- characteristics of emulsions (dampening solution adsorption),
- composition of ink,
- drying characteristics;

- *Influence of the dampening solution*

- hardness and clearness of water,
- additives for the dampening solution (alcohol, puffer etc.),
- pH values, surface tension,
- rheological properties;

- *Influence of the printing substrate*

- propery of printing ability (smoothness, ability of adsorptionsoaking),
- pH values of the substrate,
- application characteristics (tension/stretching property, picking and tearing);

- *Influence of the printing machine(on the printing quality and stability of the process)*

- construction of the printing unit (precise, stable, resistant to vibrations etc.),
- construction of the dampening unit (contact dampening, non contact dampening),
- construction of the inking unit,
- temperature control;

- *Influence of parameters conncetd to the screen*

- types of screening,
- shape of the screen element,
- fineness of the screen element,
- screening angle;

- *Influence of other parameters*

Although the parameters are not so much defined in waterless offset which influence the reproduction quality, it is visible and clear that by comparing these two technologies, all the parameters influencing the reproduction quality in conventional offset printing influence the reproduction quality in waterless offset as well, except the parameters connected to the influence of the dampening solution.

3. EXPERIMENTAL PART

The market of the graphic production today must necessarily follow the criteria of economic rules of the market among which, except the price and the speed of the graphic services, the quality criterion dominates as well (Keif M. G. 2008). In this sense, one of the most important aims of the contemporary graphic production is the increase of the quality level of the final products and the valuation of the quality criterion (Mrvac N. 2003; Zjakić 2005). Because of that the stress of this work was to determine the elements necessary for the evaluation of graphic services quality on the example of the characteristics of the contemporary offset printing.
In order to determine the comparative advantages and disadvantages of the contemporary offset printing techniques the printing in the experimental part of this work was performed on four standard most often used printing materials. On the base of so performed testing and densitometric control of the printed samples, the instrumental and visual analysis was performed. In this way the evaluation of the criteria of qualitative characteristics of the contemporary offset printing was determined and the directions for determining the new standards were pointed out.
The researched prints were printed on uncoated offset paper, coated offset paper, matt fine art paper and glossy fine art paper
They were printed with the inks for conventional offset printing produced by Sun Chemical Hartmann, and with the inks for the waterless offset produced by BASF.
All research in the work was done under the set conditions suggested by ISO standard *12647-2:1996* which defined the production conditions in the offset printing.
In conventional offset printing the prints were produced on the machine Heidelberg Speedmaster SM 102 – 4 with Alcolor dampening system. The dampening solution was demineralized water artificially hardened with the conductivity values from 950-1100 mS, 7-10 ^{0}dH (Germ.), and 4,9-5,5 pH. The run was printed in standard conditions within the permitted tolerance limits. The printing form (CtP) was made on the device Luscher. The compressible rubber blankets on offset cylinder were made by the manufacturer Vulcan, and had the hardness of 75^{0}sh.
In waterless offset printing the prints were produced on the machine for waterless offset printing Karat 46. The printing form was done by direct illumination and

development on the machine itself. The rubber blankets which were used in waterless offset had higher hardness in relation to the rubber blankets for conventional offset printing.
The printed samples for research were obtained so that the integral ink coverage was gradually increased up to the final coverage value which was not less than the international values of ISO standards. Adding the ink on rollers was achieved by increasing the rotation of doctors for 5% more than the needed value.
In the moment when the quantity of ink was so high that it was not possible to satisfy the printing quality according to the rules of offset printing, the printing of the run was stopped.
Ten different samples of each group of paper in the range form the least to the highest ink coverage in the waterless and in the conventional offset printing were used.
The quality of the ink coverage ratio was controlled visually by means of the magnifier glass on the patches of the control stripe.
The patches for the control of the ink coverage ratio in conventional offset were 1%, 2%, 3%, 4%, and 5% as well as 90%, 95%, 96%, 97%, 98% and 99% tone value and in the waterless offset they were 0,5% ,1%, 2%, 3%, 4%, and 5% as well as 95%, 96%, 97%, 98% , 99% and 99,5% tone value.
Because the patches of the control stripe with the screen elements with the tone value from 0 – 100% were printed in the interval of 10%, the calculation and the construction of the curves of real reproduction were possible by measuring the integral ink coverage.
In order to achieve the most investigation qualitative analysis, with the defining the real reproduction curve the values of the ink coverage were analyzed as well as the ink coverage ratio (Koivula H. & all 2008);. The test printing forms which were used for printing contained the elements for measuring and visual control of printing quality.
The scheme of the research process is presented in figure 1.

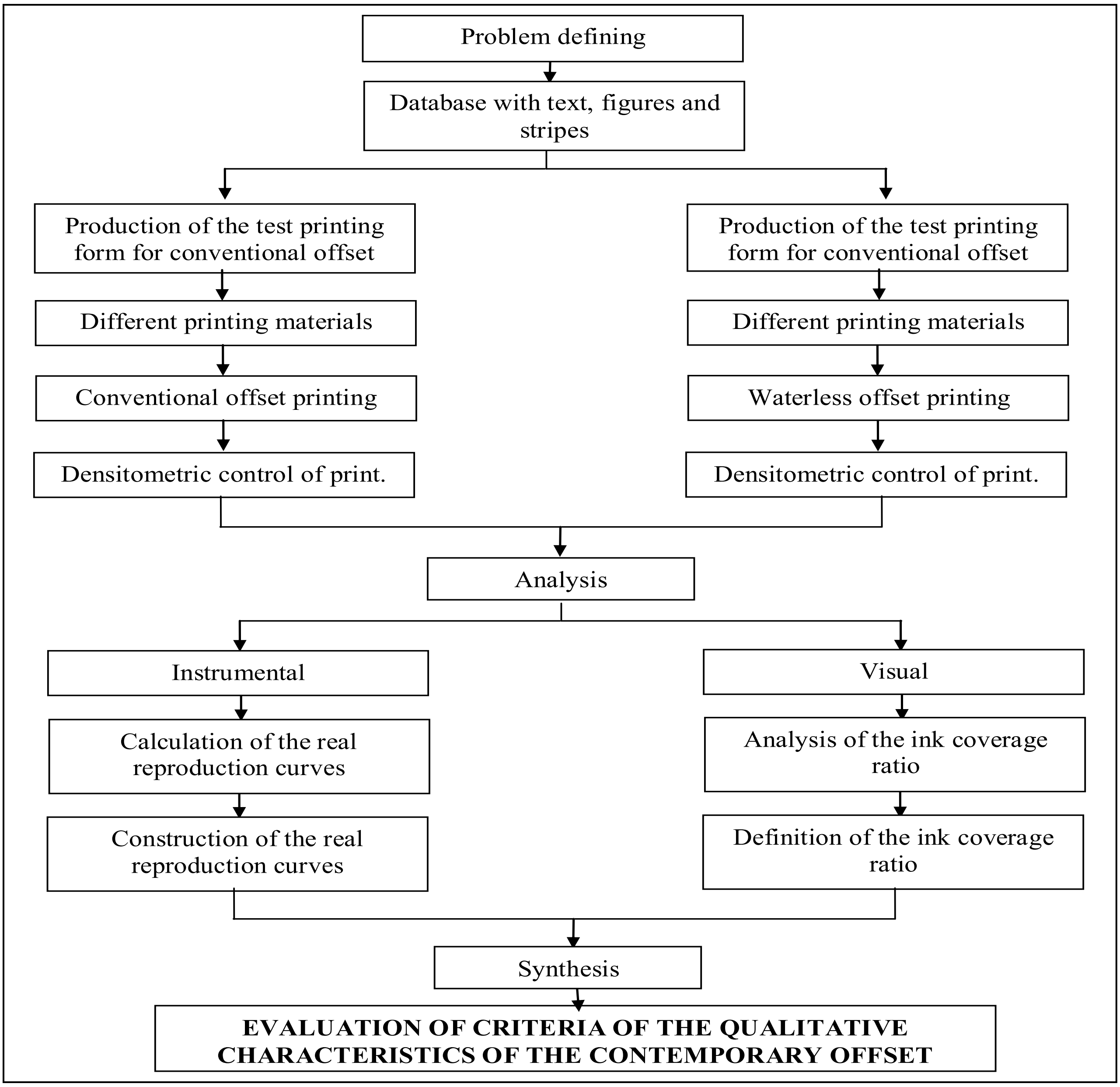

Figure 1. *Scheme of the research process*

The measured prints were printed on uncoated offset paper, coated offset paper, matt fine art paper and glossy fine art paper (Bileman J. 2001).
They were printed with the inks for conventional offset printing produced by Sun Chemical Hartmann, and with the inks for the waterless offset produced by BASF.

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4. RESULTS AND DISCUSSION

During each reproduction of visual information, especially when the high quality graphic products were processed, it is necessary to satisfy the conditions which enable the greatest possible ink coverage area (Berns R., S. 2000; Bolanča 1997). On the tested samples which were printed in the techniques of the waterless offset and conventional offset printing the ratio of the ink coverage was determined which was made by visual method by means of tools which increase the screen elements.
Grouping of samples according to the kind of the printing substrate was done so that the samples were sorted in four categories according to the kind of the printing substrate:
- uncoated offset paper 80g/m^2,
- coated offset paper 90g/m^2,
- matt fine art paper 90 g/m^2,
- glossy fine art paper 135 g/m^2.

Evaluations of the ink coverage ratio were done so that the observers gave the marks for the visibility of particular patches on the control stripe. The visible screen elements were marked with + and the invisible ones with.
Evaluation of the reproduction ratio was done under the illumination conditions in which the light source was D_{50}.For all the primary printing inks the research of the ink area coverage ratio was done and the results were recorded in tables. As we were not able to present all the results because of the volume of work, the tables contain the result for only 1st and 10th sample of uncoated offset paper and for fine art glossy paper, i.e. the sums and descriptions for all other samples.

Table 1. Results of visual evaluation of the area coverage ratio of prints made in conventional offset printing on uncoated offset paper

UNCOATED OFFSET PAPER 80 g/m^2 (1)											
TONE VALUE	1%	2%	3%	4%	5%	90%	95%	96%	97%	98%	99%
D_{iK} 1,39	-	-	+	+	+	+	+	+	+	-	-
D_{iY} 1,10	-	-	+	+	+	+	+	+	+	-	-
D_{iM} 1,20	-	+	+	+	+	+	+	+	+	-	-
D_{iC} 1,19	-	-	+	+	+	+	+	+	+	-	-
UNCOATED OFFSET PAPER 80 g/m^2 (10)											
TONE VALUE	1%	2%	3%	4%	5%	90%	95%	96%	97%	98%	99%
D_{iK} 1,51	-	+	+	+	+	+	-	-	-	-	-
D_{iY} 1,36	-	-	+	+	+	+	-	-	-	-	-
D_{iM} 1,40	-	+	+	+	+	+	-	-	-	-	-
D_{iC} 1,46	-	+	+	+	+	+	-	-	-	-	-

Table 2. Results of visual evaluation of the area coverage ratio of prints made in waterless offset printing technique – uncoated offset paper

UNCOATED OFFSET PAPER 80 80 g/m^2 (1)												
TONE VALUE	0,5%	1%	2%	3%	4%	5%	95%	96%	97%	98%	99%	99,5%
D_{iK} 1,45	+	+	+	+	+	+	+	+	+	+	+	-
D_{iY} 1,15	+	+	+	+	+	+	+	+	+	+	-	-
D_{iM} 1,25	+	+	+	+	+	+	+	+	+	+	-	-
D_{iC} 1,24	+	+	+	+	+	+	+	+	+	-	-	-
UNCOATED OFFSET PAPER 80 80 g/m^2 (10)												
TONE VALUE	0,5%	1%	2%	3%	4%	5%	95%	96%	97%	98%	99%	99,5%
D_{iK} 1,44	+	+	+	+	+	+	+	+	+	-	-	-
D_{iY} 1,18	+	+	+	+	+	+	+	+	-	-	-	-
D_{iM} 1,26	+	+	+	+	+	+	+	+	-	-	-	-
D_{iC} 1,25	+	+	+	+	+	+	+	+	+	-	-	-

The ideal reproduction would be the one which would transfer the screen values in the range from 0% to 100% on the printing material (Gregory P., 2006; Gustavson S. 1997).

In this way the screen elements from 1% to 99% screen value would be visible and not covered. In real graphic production in conventional offset printing, the reproduction with the visible screen elements from 1% screen value is possible in printing on expressively homogeneous qualitative printing substrate.

In conventional offset printing, greater problem is the reproduction of the screen elements above 96% tone value because the coverage appears i.e. the elements join together and they are experienced as one tone. Because of that, in the temporary offset printing, the qualitative reproduction is considered to be the one which shows the screen elements of 3% tone value and on which the screen elements of 97% do not cover.

Because of that reason, only the evaluation of the transfer quality of the area coverage for small screen values were noted (reproduction of lighter area coverage), i.e. for great screen values, i.e. (the reproduction of darker coverage).

Table 3 Results of visual evaluation of the area coverage ratio of prints made in the conventional offset printing on glossy fine art paper

FINE ART PAPER, GLOSSY 135 g/m^2 (1)											
TONE VALUE	1%	2%	3%	4%	5%	90%	95%	96%	97%	98%	99%
D_{iK} 1,72	-	+	+	+	+	+	+	+	+	+	+
D_{iY} 1,30	-	+	+	+	+	+	+	+	+	-	-
D_{iM} 1,35	-	-	+	+	+	+	+	+	+	+	-
D_{iC} 1,38	-	+	+	+	+	+	+	+	+	+	-
FINE ART PAPER, GLOSSY 135 g/m^2 (10)											
TONE VALUE	1%	2%	3%	4%	5%	90%	95%	96%	97%	98%	99%
D_{iK} 2,20	+	+	+	+	+	+	+	+	-	-	-
D_{iY} 1,60	-	-	+	+	+	+	+	+	-	-	-
D_{iM} 1,88	+	+	+	+	+	+	+	-	-	-	-
D_{iC} 1,90	+	+	+	+	+	+	+	-	-	-	-

Table 4. Results of visual evaluation of the area coverage ration of prints made by waterless offset printing on glossy fine art paper

FINE ART PAPER, GLOSSY 135 g/m^2 (1)												
TONE VALUE	0,5%	1%	2%	3%	4%	5%	95%	96%	97%	98%	99%	99,5%
D_{iK} 1,72	+	+	+	+	+	+	+	+	+	+	+	+
D_{iY} 1,30	+	+	+	+	+	+	+	+	+	+	+	+
D_{iM} 1,40	+	+	+	+	+	+	+	+	+	+	+	+
D_{iC} 1,44	+	+	+	+	+	+	+	+	+	+	+	+
FINE ART PAPER, GLOSSY 135 g/m^2 (10)												
TONE VALUE	0,5%	1%	2%	3%	4%	5%	95%	96%	97%	98%	99%	99,5%
D_{iK} 2,25	+	+	+	+	+	+	+	+	-	-	-	-
D_{iY} 1,59	+	+	+	+	+	+	+	+	+	-	-	-
D_{iM} 1,80	+	+	+	+	+	+	+	+	-	-	-	-
D_{iC} 1,83	+	+	+	+	+	+	+	+	-	-	-	-

With smaller aberrations the results of other samples are linearly arranged. As one of the most important characteristics, in defining the quality in the system of multicolor reproduction, is the possibility of reproduction the area coverage ratio as much as possible, these results get the importance in this sense. The research shows that in the waterless offset printing, in the determined conditions, the darkest tones can be well reproduced up to 99,5 % screen value on some printing substrates, which is not possible in the conventional printing process because of the presence of the dampening solution.
In the waterless offset printing the screen elements of a very small screen values up to 0,5% screen value are also visible.
Because of the volume of the work, only the curves of the real reproduction for 1st and 10th sample on uncoated offset paper are presented and for 1st and 10th sample for fine art glossy paper.

From the research results it can be concluded that on the prints produced on uncoated offset paper, under the maximal area coverage ratio the dot gain of 20% for both researched printing techniques is almost identical in cyan and magenta, it is 10% on prints made with yellow and 40% on prints printed with black.
On screen values greater than 20% for cyan and magenta, and greater than 10% for yellow and greater than 40% for black, the dot gain is greater in conventional offset printing in relation to the dot gain in waterless offset for approximately 4,3% in cyan, 5.1% in magenta, 14,5% in yellow and 2,8% in black.

Observing the prints made on the uncoated offset paper, it can be concluded that the dot gains of all the colours are almost identical up to 10%. In other values of the reproduction range the dot gains in all the colours are greater on the prints printed in conventional offset printing for approximately 10,6% in cyan, 5% in magenta, 14,3 % in yellow and for 8,8% in black.
On matt fine art paper the differences of the dot gain are the same in magenta and cyan up to 20%, in yellow up to 10% and in black up to 30%. In greater values than the mentioned ones the dot gain is grater in conventional offset printing for all the colours on the mentioned paper. The value increase of the dot gain is approximately greater for 4,7% in cyan, 5,7% in magenta, 12,6% in yellow and 1,7% in black.
From the research results of the prints made on glossy fine art paper it was determined that the differences in the dot gain in all the colours except magenta are similar to those on prints printed on matt fine art paper. Dot gain difference on the researched paper was determined in magenta and almost the same dot gain up to 40% was determined on the prints made in conventional and waterless offset technique. On all the researched prints the dot gain was greater in conventional offset printing for 3,8% in cyan, 4% in magenta, 11,4% in yellow and 3,6% in black color.

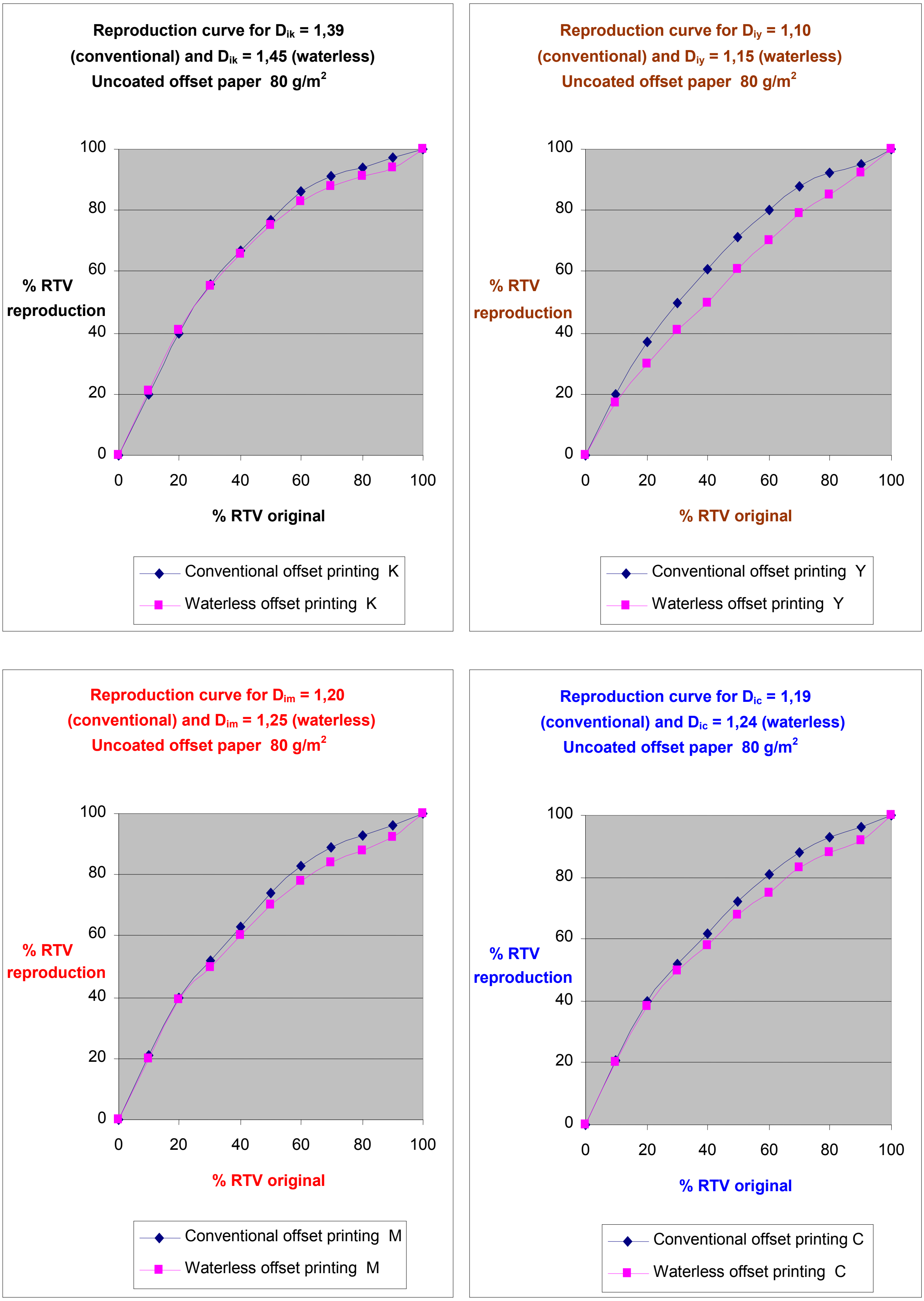

Figure 2. *Curve of the real reporduction sample 1 – uncoated offset paper 80 g/m²*

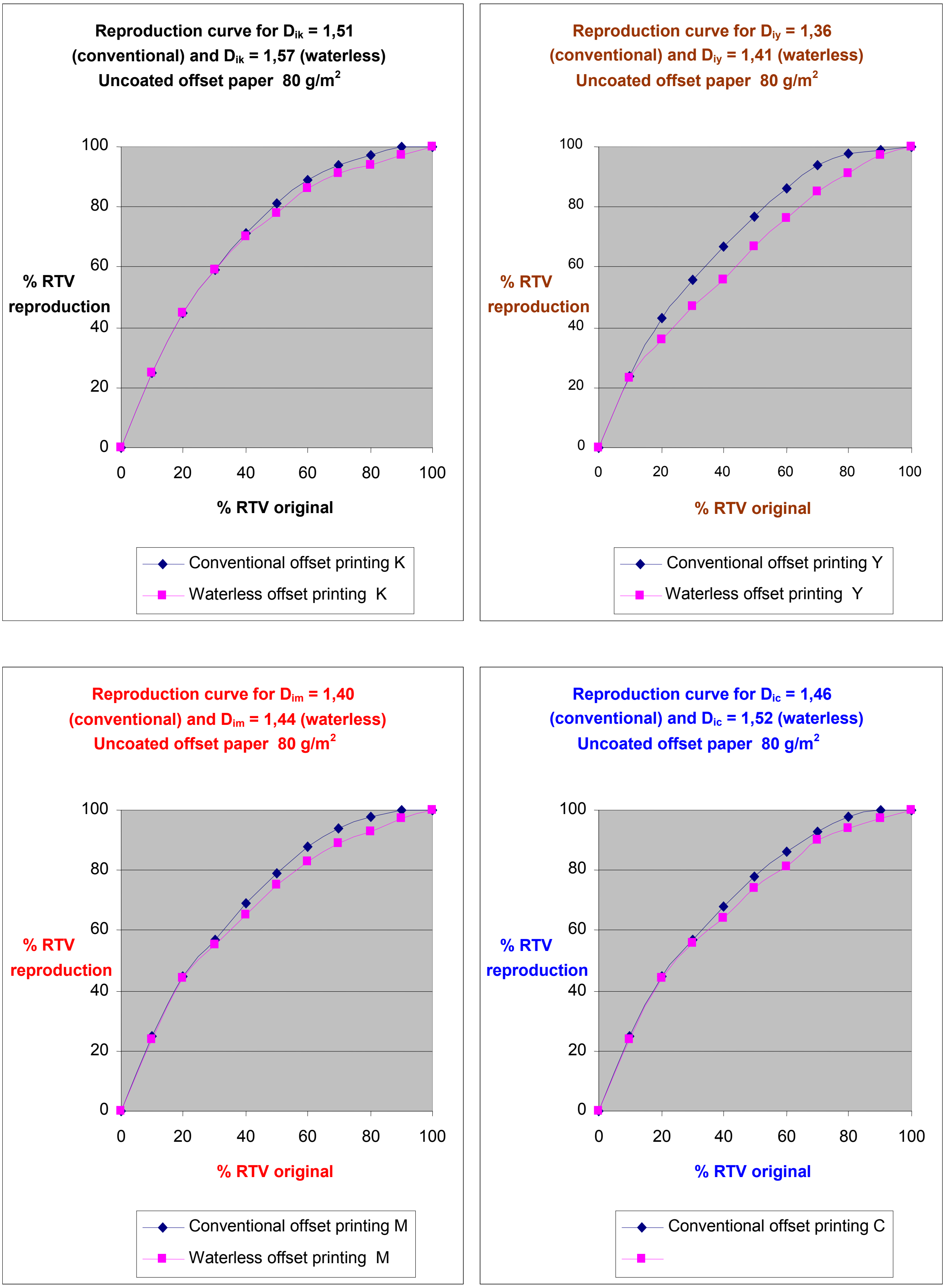

Figure 3. *Curves of the real reproduction sample 10 – uncoated offset paper 80 g/m²*

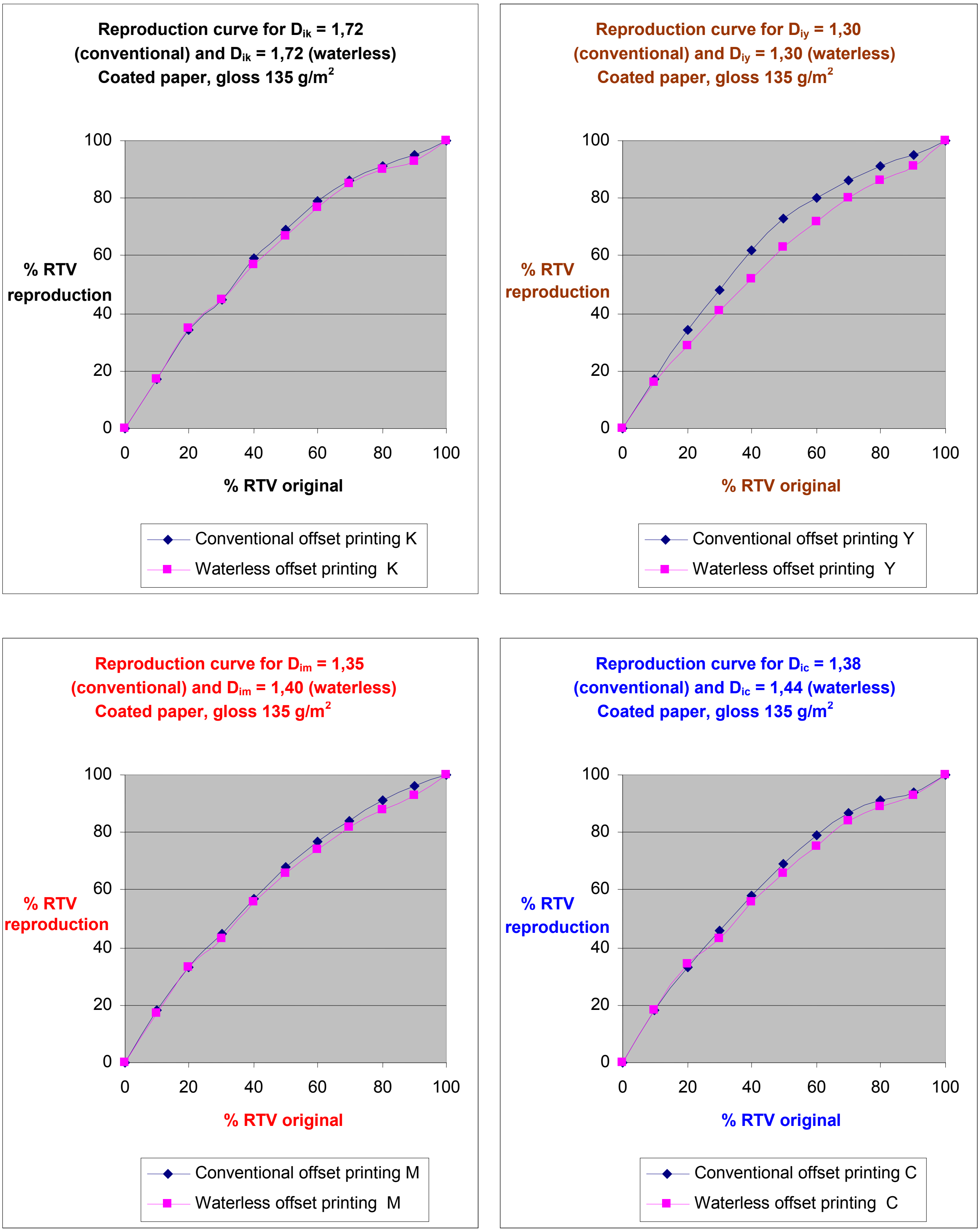

Figure 4. *Curves of the real reproduction of the inking density for conventional and waterless offset printing –sample 1 – glossy fine art paper 135 g/m²*

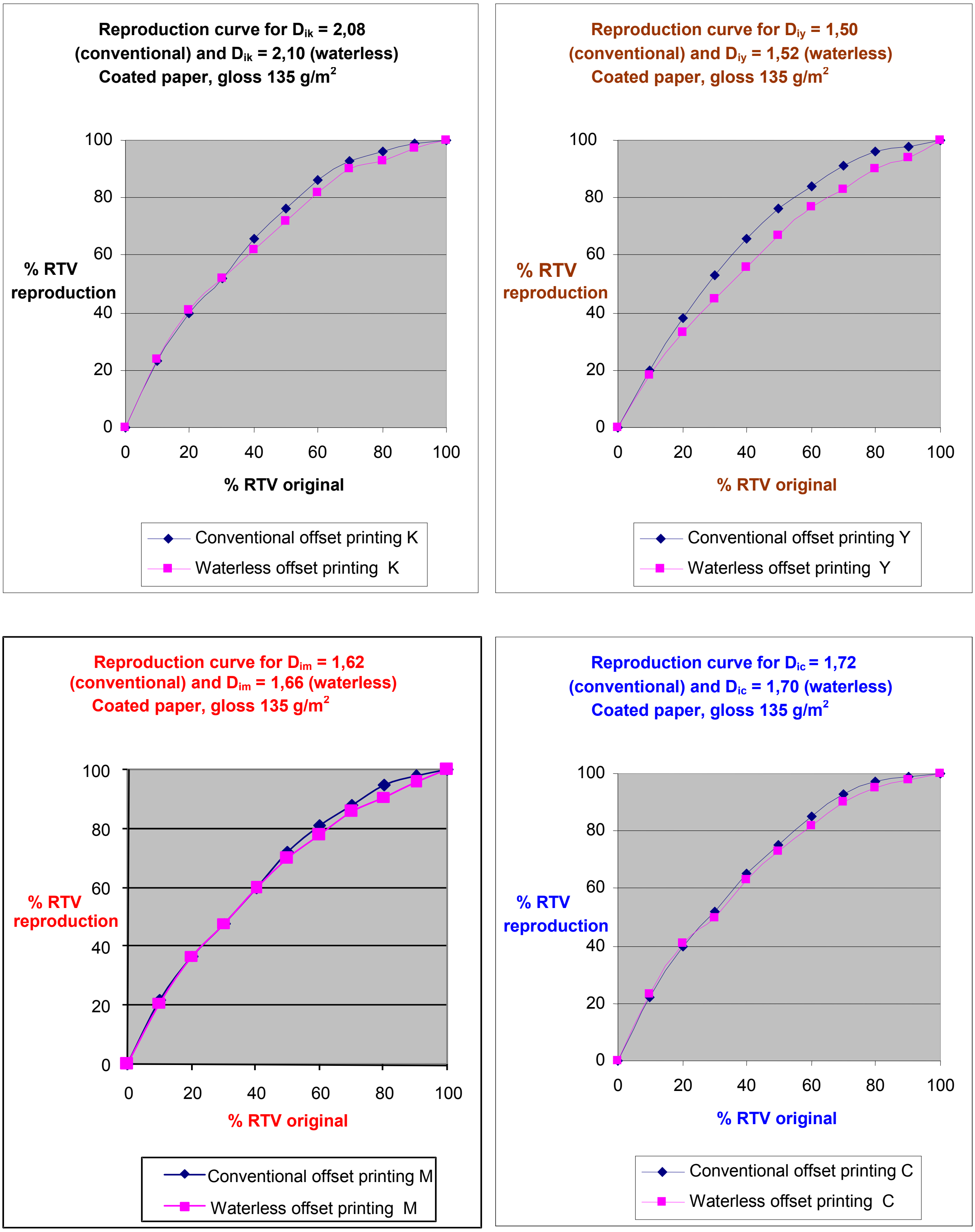

Figure 5. *Curves of the real reproduction of the inking density for conventional and waterless offset printing – glossy fine art paper 135 g/m*^{2}

5. CONCLUSION

Based on the results of this work, obtained from the samples printed in conventional and waterless offset printing, it is visible that it is possible to print the darkest tones up to 99,5% under the real printing conditions, which is not possible in conventional offset printing, as a rule, because of the presence of the dampening solution. In the waterless offset printing the screen elements of very low values up to 0,5% screen value are also visible. In principle, the dot gain is different for each of the primary colors regardless the samples are printed on materials of the same kind. This is valid for both of the printing techniques.

On the base of the performed research in this work, it was proved that it is possible to print with higher inking densities in waterless offset in relation to the conventional offset printing.

Based on the performed research the values for achieving the maximal area coverage ratio were determined and the dot gain was defined in both contemporary offset printing techniques on the observed printing substrates and in accordance with this we suggest the synchronizing of the standards in both the printing techniques.

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