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DETERMINATION OF THE DEVIATIONS TOLERANCES OF THE PROCESS-COLOUR SOLIDS FROM THE OK PRINT IN OFFSET PRINTING METHOD

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Quality of printing image is function of supporting of printing process parameters in precise boundaries.

The valuation of quality of printing image can be done by the visual perception and by colourimetric methods.

In the practice we use two methods to measure the quantity of printing ink:

- **Densitometric methods** – used for control and management of printing processes. The measurement of the optical density refers to solid and raster images, which are printed by the basic colours – cyan, magenta, yellow and black. The measurement results cannot used to estimate the visual perception of colour.

- **Colourimetric methods** – based on colour difference ΔEab, needed to estimate the first approved printing sheet (OK print) related to the printing proof, to compare printing-run process to OK print, to compare process colour solids to colours defined in ISO standards, etc.

All the two methods have advantages and disadvantages.

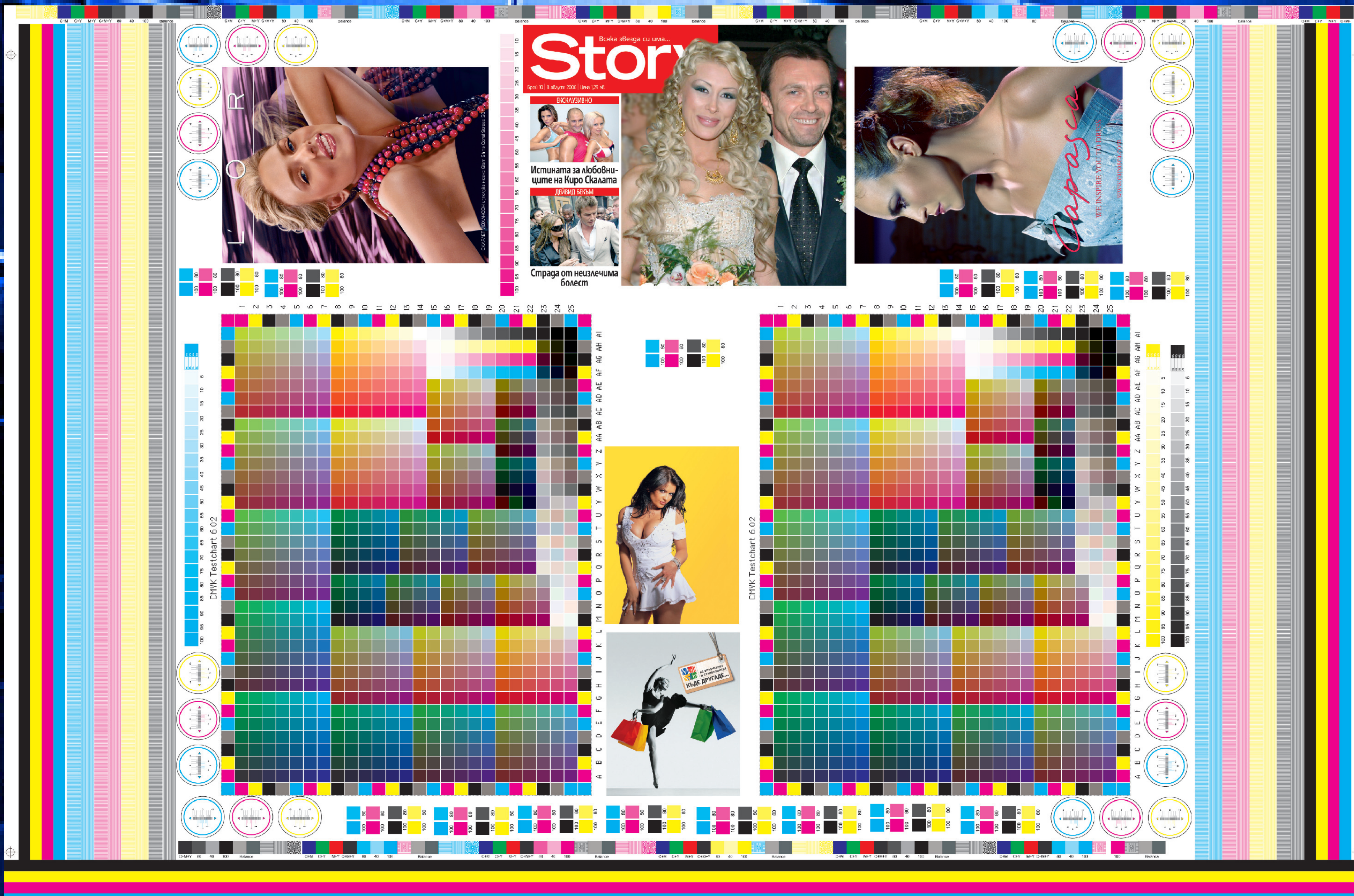
MAIN GOALS OF THIS RESEARCH

The main goals of this research are to define the correlation between optical density and colour difference of process inks colours – cyan, magenta, yellow and black in printing on two types of paper – glossy coated paper and uncoated paper, on four colour sheet-fed offset printing machines.

The purpose of this experimental research is formulated on the base of the advantages and disadvantages of the densitometry and colourimetry, as follows:
to determine the dependence between the optical densities and the colour differences of the process colours solids.

The end result of this research is to define and to determine the limits of the optical density deviation from the optimal values for various ink-paper combinations, by provision of colour differences in compliance with the international standards.

TEST FORM USED FOR THE EXPERIMENTAL



MEASUREMENTS, PRINTING CONDITIONS

Printing plates, which has been used are positive-acting and exposed on CtPlate system Lüscher XPose 130.

The offset printing machine, which has been used, is five colour sheet-fed HEIDELBERG SM 74-5-P+L.

The two papers, which have been used, are 150 g/m^2 coated glossy paper (Neo gloss), and 80 g/m2 uncoated paper (Amber offset).

All measurements are in accordance with ISO 12647-1:

- D50 illuminant
- 2° observer
- 0/45 or 45/0 geometry
- black backing

Colour characteristics of used papers (print substrate colour) are in accordance with ISO 12647-2 tolerances (L±3, a±2, b±2).

EXPERIMENTAL

For defining the optimal inking by the method of maximum print contrast for Cyan, Magenta, Yellow and Black, were printed series of samples characterized by gradual smooth changes in ink quantity - from underinking to overinking.

Series of measurements of Dv and Print Contrast have been performed. The optimal inking was determined. Experimentally defined values for optimal quantity of printing inks for both papers are shown in Table 1.

Table 1. Experimental defined values for optimal quantity of printing ink for the two types of paper.

Type of paper	**Dv** (optical density of 100% solids)			
	Cyan	**Magenta**	**Yellow**	**Black**
Glossy coated	1,57	1,59	1,46	1,85
Uncoated white paper	1,07	1,07	0,95	1,25

EXPERIMENTAL

From the already printed paper fortuitously are taken printed sheets, which have not a slur defect. For the each type of paper are measured the four process colours in solid fields, which are parallel to the generant, the deviation of optical density from optimal value and the colour difference related to the reference.

The reference colour is a field, which have an optimal density (table 1). The numbers of measurements are different for four colours and it is determined from the variety of colour differences – from minimum up to in excess of determinate wide limits.

ANALISYS AND MATHEMATICAL MODELING

In order to express the analytical dependence between ΔD and ΔEab, it is needed to apply mathematical modeling. It is recommendable to use regression analyses for data processing and to determine the deviation tolerances Dv for the process colours, taking into consideration the human perception for various paper types.

It was determined, that the experimental curve is a square function – parabola, described with the formula: **$y=ax^2+bx+c$** (in this concrete case - **$\Delta E= a.\Delta D^2+b.\Delta D+c$**).

After experimental data analyzes, for some of the cases the coefficient "**b**" was omitted. Therefore the function type was transformed to: **$y=ax^2+c$** (in this concrete case - **$\Delta E= a.\Delta D^2+c$**).

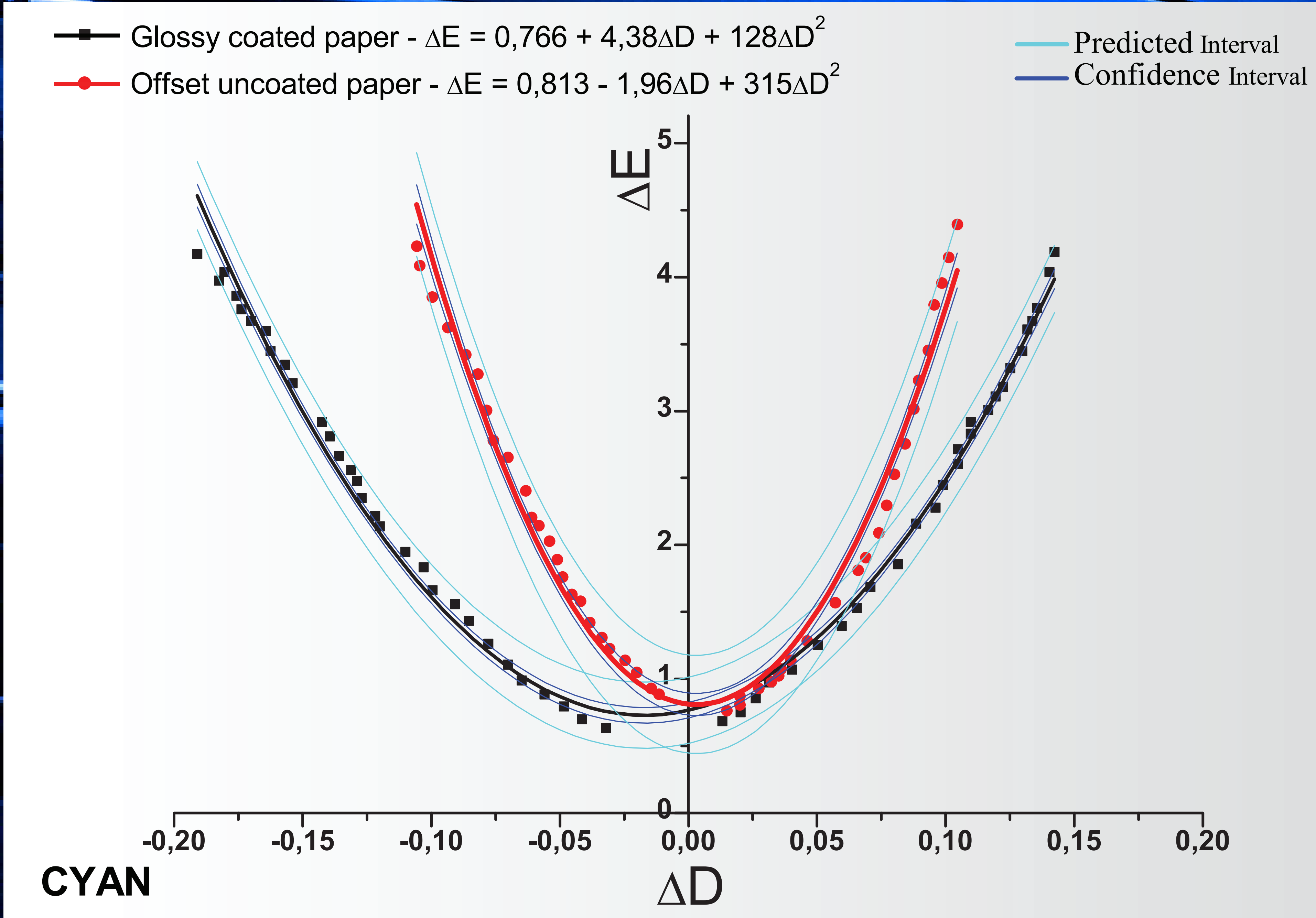


Fig. 1 ΔD – ΔE function for Cyan

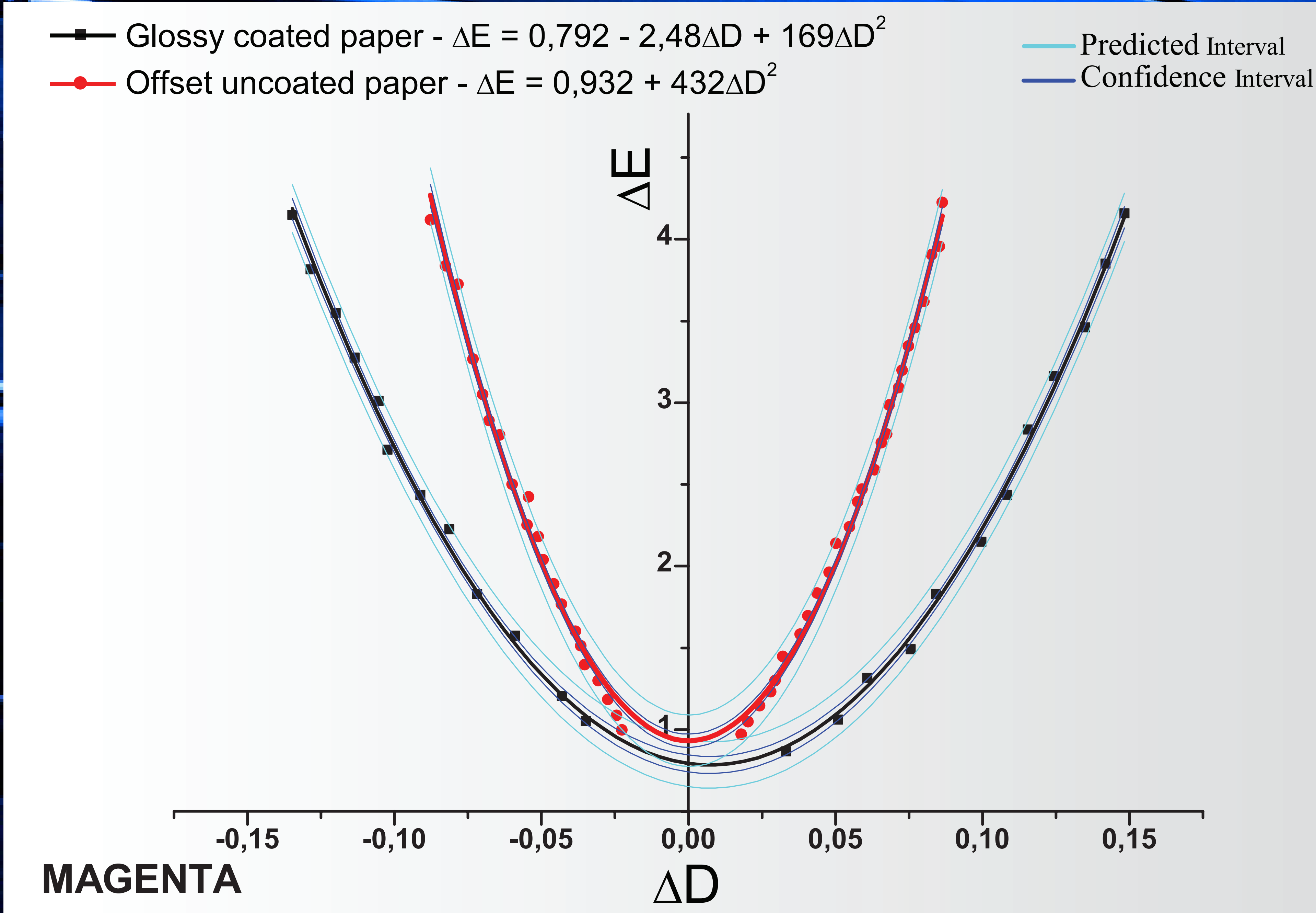


Fig. 2 ΔD – ΔE function for Magenta

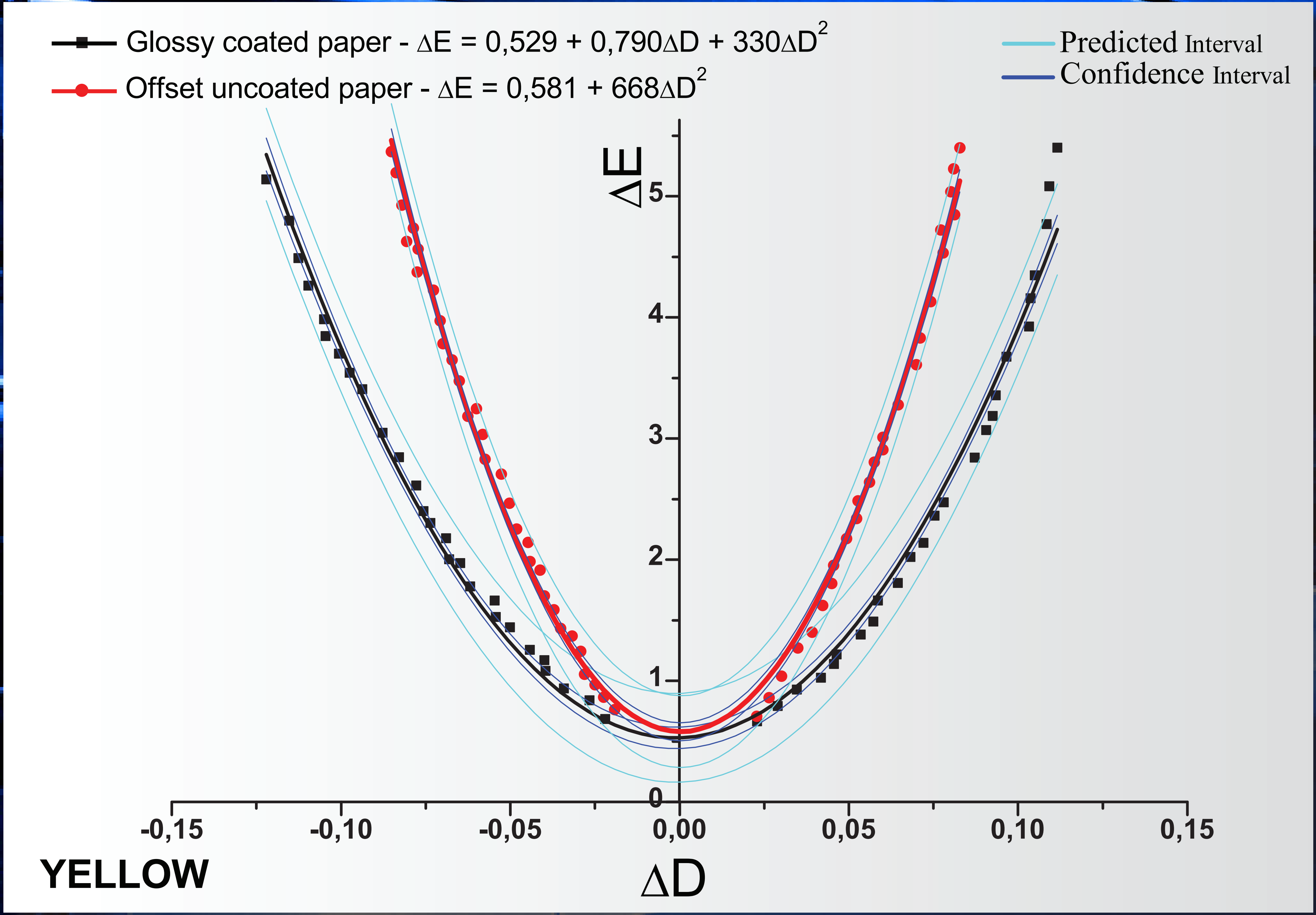


Fig. 3 ΔD – ΔE function for Yellow

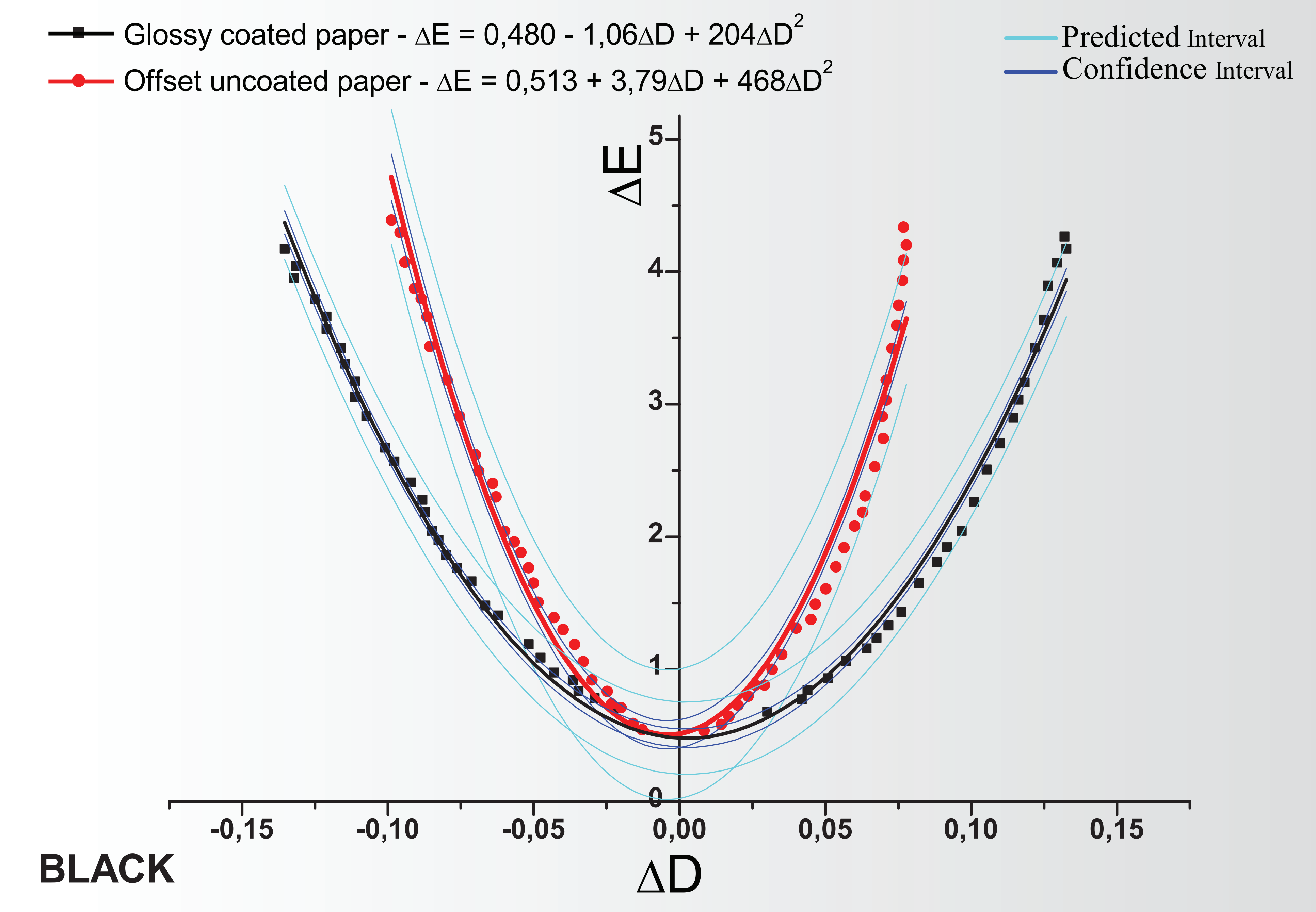
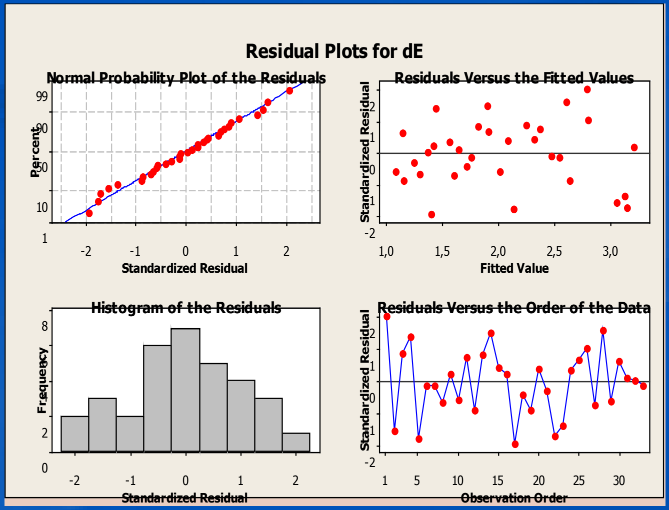


Fig. 4 ΔD – ΔE function for Black

STATISTICAL ANALYSES OF REGRESSION MODELS

One of the most important conditions, that guarantee formulation of realistic and practically applicable model - ΔE= f(ΔD), is the statistical analyses of the regression model. This analyses consists of several steps:

1. Dispersion analyses
2. Examination of the hypothesis for coefficient significance
3. Examination of the significance of determination coefficient - R^2
4. Examination of the adequacy hypothesis of regression model through repetitive trials



REGRESSION MODELS

The regression models obtained by experimental data are presented in table 2.

Table 2. Regression models $\Delta E=f(\Delta D)$ obtained by experimental data for C, M, Y, K and two types of paper

Paper Type	$\Delta E = a.\Delta D^2 + b.\Delta D + c$ ($y=ax^2 + bx + c$)			
	Cyan	**Magenta**	**Yellow**	**Black**
Glossy coated	$\Delta E = 0{,}766 + 4{,}38\ \Delta D + 128\ \Delta D^2$	$\Delta E = 0{,}792 - 2{,}48\ \Delta D + 169\ \Delta D^2$	$\Delta E = 0{,}529 + 0{,}790\ \Delta D + 330\ \Delta D^2$	$\Delta E = 0{,}480 - 1{,}06\ \Delta D + 204\ \Delta D^2$
Offset uncoated	$\Delta E = 0{,}813 - 1{,}96\ \Delta D + 315\ \Delta D^2$	$\Delta E = 0{,}932 + 432\ \Delta D^2$	$\Delta E = 0{,}581 + 668\ \Delta D^2$	$\Delta E = 0{,}513 + 3{,}79\ \Delta D + 468\ \Delta D^2$

REGRESSION MODELS

When ΔEab is restricted with accepted in ISO 12647-2 limits, graphical and analytical can be determined for which values of ΔD limitations are executed for each colour and for each combination paper-ink.
The results are in Table 3.

Table 3. Density difference limitations (deviation tolerances) for plus (+) and minus (-) direction for two types of paper

Paper	ΔD			
	Cyan	Magenta	Yellow	Black
Glossy coated	+ 0.143 - 0.177	+ 0.130 - 0.145	+ 0.115 - 0.118	+ 0.128 - 0.134
Uncoated white paper	+ 0.097 - 0.104	+ 0.084 - 0.084	+ 0.081 -0.081	+ 0.082 - 0.090

RESULTS AND DISCUSSION

Analyses of the achieved results shows:

1. For glossy coated and for uncoated papers, the coefficients for main ink colours are different, “a” have a biggest value for yellow, and lowest value for cyan (fig.1-4). Therefore for yellow we have smaller limits, and for cyan more wide limits. Coefficient “b” shift the parabola for 5 of equations - $\Delta E=f(\Delta D)$ in right hand direction, and for 3 cases in left hand direction. Therefore for 5 cases the limits in plus (+) will be higher, and for 3 cases in negative (-).

2. When we compare the main colours in the different type of papers we determine that the coefficient “a” is from 2 to 3 times bigger for the uncoated paper. Therefore for uncoated paper we have lowest limits. The reason is in optimal ink quantity for uncoated papers.

CONCLUSIONS

1. For first time via experimental research in real production conditions, the deviation tolerances for optimal inking were determined, taking into consideration the human optical perception and the specific production conditions – print substrate – ink – printing machine. It is unallowable to use equal limits for deviations of optical density from optimal inking value for different types of paper.

2. The obtained results can be used in practice for preparing for print for sheet feed offset machines and for quality control of printing process, if we in advance are determined the optimal ink quantity by maximum print contrast method. The limits for different types of paper, does not depend of used equipment. If the print house have only a densitometer, by the black and white drawings can be approximately determined the colour differences, which are result of measured deviations of optical density.

CONCLUSIONS

3. The obtained from the regression models, deviation tolerances for optimal inking relevant to different paper types, differ between each other.The obtained from the regression models, deviation tolerances for optimal inking for different colors relevant to specific paper type, differ between each other.

4. For most of the process colors, deviations in different directions – positive or negative, were observed. From the total of 8 developed models, 6 of them are characterized by different tolerances in positive or negative direction. The deviation tolerances' values for 2 models are similar.

5. The results achieved are important from scientific and practical point of view. For the first time in an experimental way a well-grounded proof has been achieved with regard to the limits of the optical density deviation from the optimal values for various ink-paper combinations, by provision of colour differences in compliance with the international standards.

THANK YOU!