RESEARCH ON THE CAPABILITIES OF COLOR TONER-BASED PRINTER FOR QUALITY PRINTING USING CUSTOM GENERATED ICC COLOR PROFILES

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Abstract: *The paper presents some of the results, obtained during the research on scientific project at TU-Sofia № 171ПР0012-06 "Research on the influence of using raster image processors (RIP) on the quality of color printing of digital proofing systems"[1]. The purpose of the paper is to present a research on the quality of color printing of and toner based printer using custom generated ICC profiles. Before the current research, the printer is properly adjusted, calibrated and linearized according to the method published in previous research of the author. The generated profiles are then thoroughly tested and analyzed using specialized software. Their color gamut is compared to the standard offset gamut. The color rendering of the profiles is evaluated through testing and a general conclusion of the benefits of the process is provided.*
KEYWORDS: *COLOR MANAGEMENT, COLOR PRINTER, PRINT QUALITY, COLOR GAMUT, ICC PRINTER PROFILES*

1. Introduction

At present, the benefit of individualized profiling of color printers worldwide is still underestimated. It is a common practice for printers in digital printing houses and studios to work with their factory settings. It should be remembered that these settings were valid when the printer was new and there was no wear in the printing components and the inks in it were original. Also in recent years the whiteness of paper has increased many times. As a result, factory settings and color profiles do not characterize the current state of the printer, and print output will have measurable and visible color deviations over its digital original, resulting in final customer dissatisfaction. The purpose of the publication is to examine the print quality of a Konica Minolta Bizhub C350 toner-based printer with installed color server RIP by measuring printed reference colors and analyzing the accuracy of the generated color profiles.

2. Characterization and profiling the color server and printer with i1Profiler software

Figure 1 shows the process of generating customized color profiles for the color server using i1Profiler software and X-Rite i1Pro spectrophotometer.

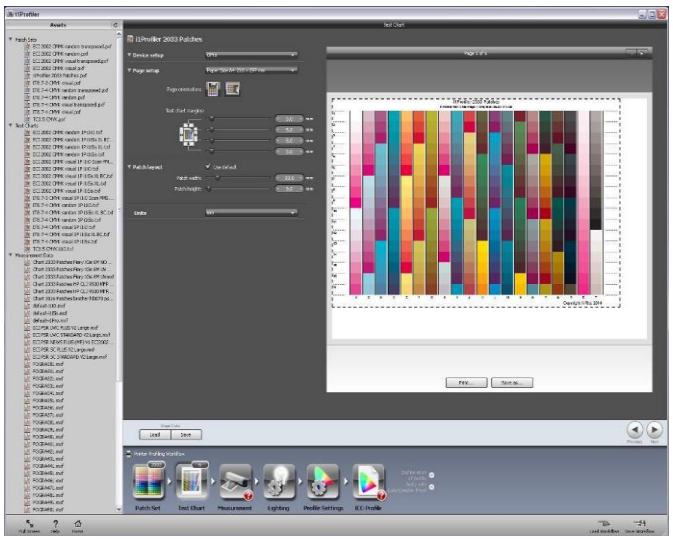

Fig.1 *– Reference profiling target without color management as it will actually be printed and measured (only page 1 of 6 shown)*

One important point has to be noted - color measurements are performed with a i1 Pro spectrophotometer which has no standardized UV radiation (measurement M0). The printing paper used is highly fluorescent (as is the recent trend), and the failure to take this effect into account may cause the colors on the display to not match with the printer's printouts. This problem is particularly important and pervasive in the world, and at present there is a newer version of the spectrophotometer used for profiling which successfully deal with fluorescence effects. As a compromise solution, the author has generated two color profiles for the researched printer - with and without taking into account the ultraviolet content of the paper used. This was achieved by using a Roscolux # 0314 ultraviolet filter with a known spectral transmittance curve placed between the printed color targets for profiling and the spectrophotometer to generate the UV-Cut profile. After generating the customized color server profile, it is necessary to install the profile in the color server and set it as the default source profile.

3. Characterization and profiling the color server and printer with EFI Fiery Color Profiler Suite 4.9 software

Because of the problems discussed, in a previous study, in order to avoid double color management, the author has also provided specialized profiling software specially developed for more advanced color servers from their EFI Fiery manufacturer. EFI Company claims that it sends raw CMYK data to the print server for profiling by skipping the printer's current output profile and only using its current calibration. This should correctly describe the current behavior of the printer to generate the most accurate individualized printer profile. Using the EFI software, proven and optimized for the color server profiling settings have been achieved. The end result is generating a third individualized printer profile. Before the software reference pages generated by the software are printed, it is also necessary to set the correct settings on the color server. This is done through the modern version of the Fiery Server Color Management Software - Fiery Command Workstation 5 (Figure 2). The figure clearly shows with arrows the path of the color data before profiling. Specifically, CMYK data without an attached profile skips the color management and conversion through the output profile of the printer and is directly printed only by using the printer calibration - that is the purpose of this procedure. One special feature of the profiling approach used here must be noted - two sets of test pages of consecutive and randomly arranged colors were printed and measured for greater accuracy of the measurements. Subsequently, the measurements are averaged and the generated profile is more accurate. In Figure 3 only the first page of the reference colors is shown.

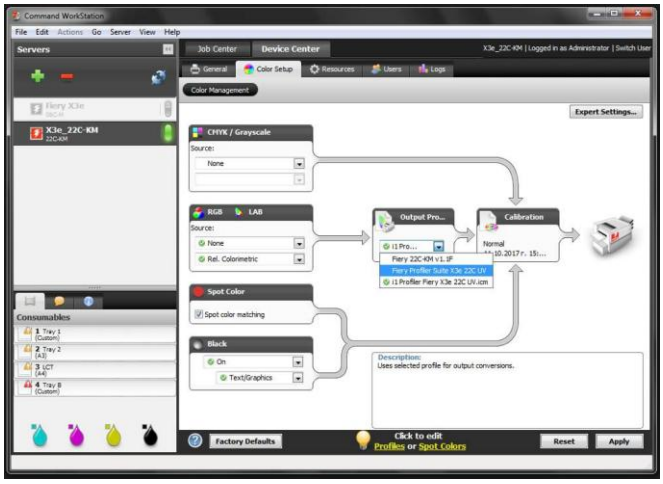

Fig.2 - *Color settings of the server before profiling*

Fig.3 *– Results from measurement and averaging of color values during profiling (mean Delta E2000 error = 0.6)*

4. Optimization of a color profile created with i1Profiler software by improving its neutral balance – AutoGray procedure

The presented research includes investigation of a new feature offered by the more advanced Fiery X3e 22C-KM color server - AutoGray procedure (gray balance). Profile neutrality is an important parameter for the quality of color printing. In the graphs below, it is shown graphically by calculating color vector graphics of the color error achieved. In some cases these errors may be significant (delta E2000> 5). Such values are easily noticeable and unacceptable when assessing print quality. By using AutoGray procedure, they can be significantly reduced. The procedure involves choosing an individualized color profile that has already been downloaded on the color server, analysis from the server software, generation of an individualized test page, printing on the specific printer with the specified profile, and scanning the page from the pre-calibrated scanner of the printer with the ColorCal feature. A Kodak Q13 reference neutral target is used together with the scanned test page, which serves as an absolute reference for white, black and grayscale monochrome gradations. The scan result is visualized in the form of optical density curves of the four colors of the printer, just as with the calibration process. The user also has the option of further curve adjustments when needed. The measurements are recorded in the specific profile. An evaluation of the achieved neutrality of the optimized profile is made in chapter 5. Figure 4 shows the actual printed and scanned test page:

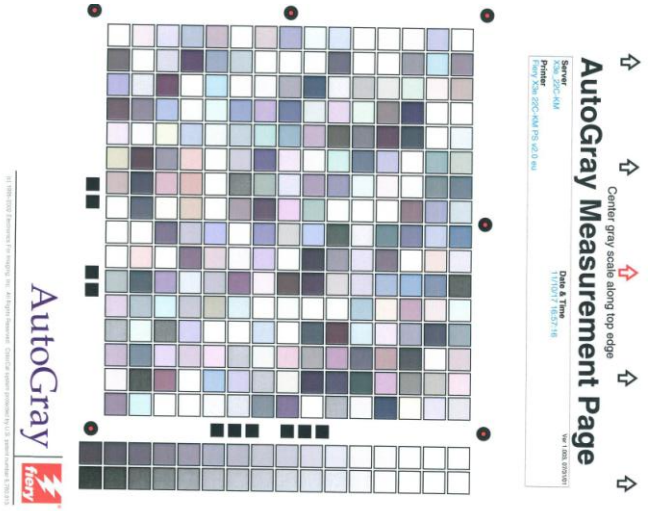

Fig.4 *– Actual printed, scanned and measured test page for optimization of the neutrality of a generated individualized profile with i1Profiler software*

5. Evaluation of the accuracy of color rendering of the generated profiles using ColorThink software

An analysis is made of the color rendering accuracy, neutrality, and color gamut for the two color profiles generated using i1Profiler software and subsequent AutoGray optimization; the Fiery Color Profiler Suite software generated profile and a factory profile for the color server model. Figure 5 shows the basic parameters of the color profiles studied for the particular color server.

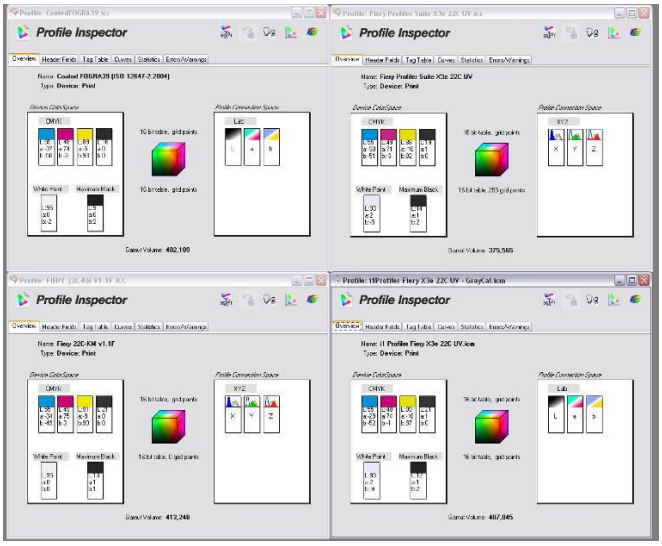

Fig.5 - *Comparison of the basic parameters of the studied color profiles (factory-bottom left; i1Profiler - bottom right; Fiery Color Profiler - top right) versus standard offset profile Fogra 39 (top left)*

The largest color gamut of 413284 colors is achieved with the factory generic ICC profile; the profile created with the i1Profiler software has a gamut of 407045 colors and the profile created with the Fiery Color Profiler software has a color gamut of 375565 colors. The factory profile of the printer with 413284 colors has the largest range of the three profiles tested and shows that when the printer was new, its color rendering capabilities exceeded those of offset printing. It should be remembered that since then 13 years have passed and the components of the printer have been replaced several times, and that the toners currently used are not original.

Therefore, it is necessary to generate a current individualized color profile describing the current status of the printer. Another important aspect is the white point of the profiles. With the factory profile and the offset profile, the white point is almost neutral and does not indicate the presence of brighteners in the paper. For both generated profiles, there is a strong shift in blue to the color of the paper (white point LAB coordinate b). This is a sign of eventual inconsistencies in color rendering at a later stage because the spectrophotometer used has reported fluorescence on the paper and its effect is recorded in the generated profile but color prints may exhibit visual differences because the human eye has adaptation mechanisms to the white level, while the profile will calculate all available colors in the print image based on a bluish (not offset white) reference base. The color gamut of the i1Profiler generated profile is slightly larger than that of the offset profile, and suggests that it may possibly be used as a hardproofing device. In the following figures, other important parameters determining this suitability will be analyzed. Figure 6 shows a comparison of the color generation curves in the profiles studied using an absolute colorimetric rendering intent. For the smallest brightness (0% on the X axis), the different inking strategies and the important TAC (total area coverage) parameter in percent can be seen. The neutrality degree of the color rendering of the generated profiles (top and bottom right) is good, as shown by the color tone shift circle indicator, but it is not ideal as in the offset profile (top left). This is again an indicator of the inherent instability of printing of toner-based electrostatic printers compared to classic offset printing. The improvement of the darkest achievable black color of the generated with i1Profiler profile versus the factory profile is noticeable - another benefit of printer profiling. A comparison of the colors of the printer's toner inks was made versus standard offset inks, and the corresponding color differences were also calculated. The studied printer has much smaller color difference than other models tested by the author, and excellent printer behavior can be expected as a hardproofing device.

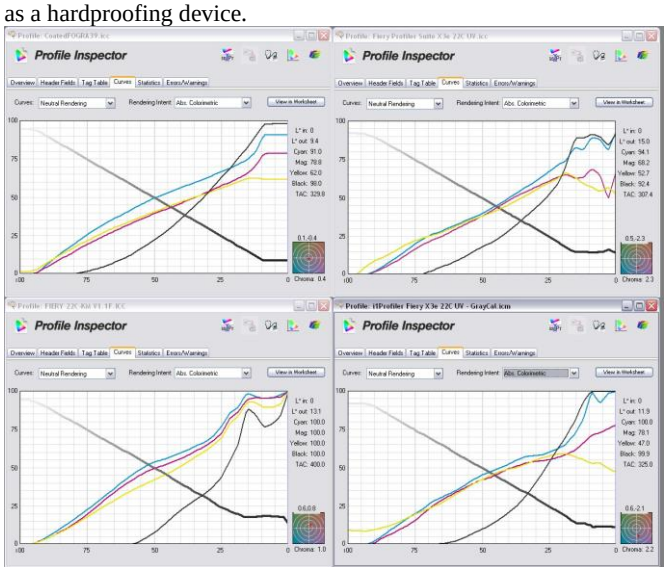

Fig.6 *- Comparison of the profiles neutral color generation curves rendering*

Figures 7 and 8 show the analysis of the neutral color rendering of the generated profiles by converting 100 gray levels defined in the LAB color space and converted to gray colors as they would be printed by the printer if it used this profile. At the right of the figure, a graphical representation of the color error is made along with the corresponding numerical values. The improved neutral color rendering of the generated profile with i1Profiler is noticeable, partly due to the AutoGray procedure. This will greatly improve the color quality of the printer. It should be noted that the two tested profiles have a much better neutral color transmission compared to non-color servers equipped printers tested. It can be concluded that the research printer is of a higher quality class. After evaluating the neutrality of the profiles, an assessment of their overall color gamut is also made.

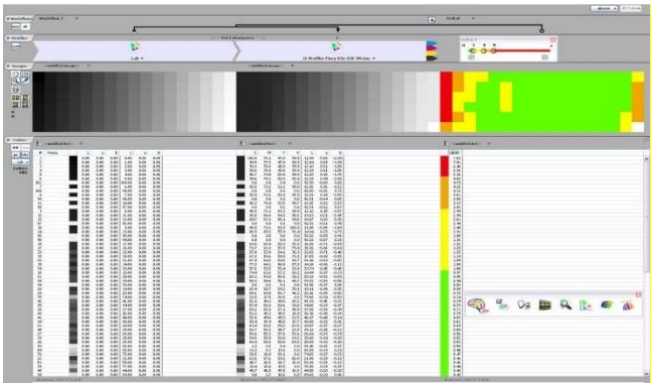

Fig.7 *- Neutral color rendering evaluation through generated individualized profile with i1Profiler software*

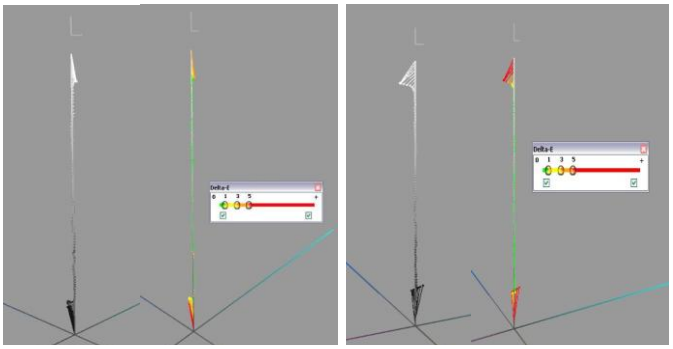

Fig.8 *– Grayscale color rendering errors in the LAB color space of generated with i1Profiler (left) and Fiery Color Profiler (right) profiles*

It is compared to the gamut of standard defined offset printing space to visualize in 3D the suitability of a researched printer as a hardproofing device. The color gamut of the i1Profiler profile is shown graphically in figure 9 along with a standard offset profile gamut superimposed on top of it. It shows slight deviations from the reference one mainly in the yellow and less in the magenta hue areas. This may be due to a change in the toner used, as well as the wear of the yellow color printing mechanism. There are also differences in white points due to the bleached paper used. The black color differences are small. It can be concluded that the generated profile has a good color rendering abilities and a sufficiently large color gamut and can be used for unofficial offset printing simulation, but it will not be able to color manage the printer as a hardproofing device and will not be able to withstand Fogra certification for hardproofs.

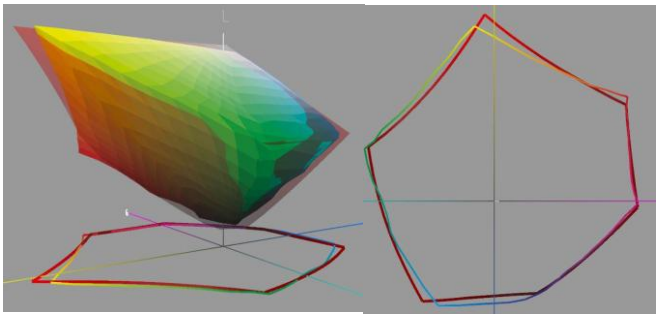

Fig.9 *– 3D Comparison of i1Profiler generated profile color gamut and standard offset profile gamut (shown entirely in red)*

Figure 10 shows the Fiery Color Profiler profile color gamut with a standard offset color gamut superimposed on top of it in 3D LAB color space. It covers almost the whole gamut of the offset profile, with deviations mainly in the yellow area. The reason most likely is the wear of the yellow printing unit or differences in the used

yellow toner compared to the original one. It can be expected that the generated profile will have a good color rendering in its own right, as well as when used for offset printing simulations, but the printer will fail to successfully pass certification as a hardproofing device according to the Fogra procedure.

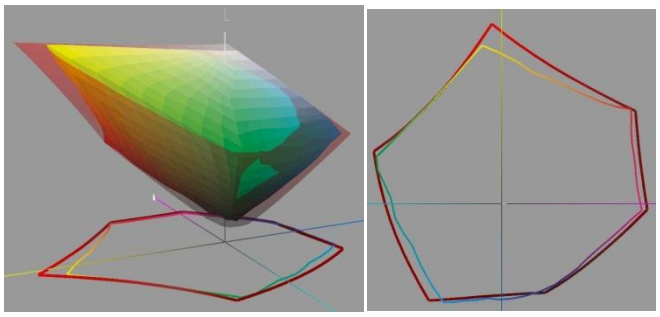

***Fig.10** - Comparison of the Fiery Color Profiler generated profile gamut and a standard offset profile gamut on top of it in 3D LAB color space (colored entirely in red)*

Figures 11 and 12 illustrate graphically the generation of primary and secondary colors (CMY and RGB) using the two generated printer profiles as a comparison of an standard offset profile on the graphs. The results show that the printer has a good generation of primary and secondary colors, and they are closer in rendering colors to that of a standard offset printing profile.

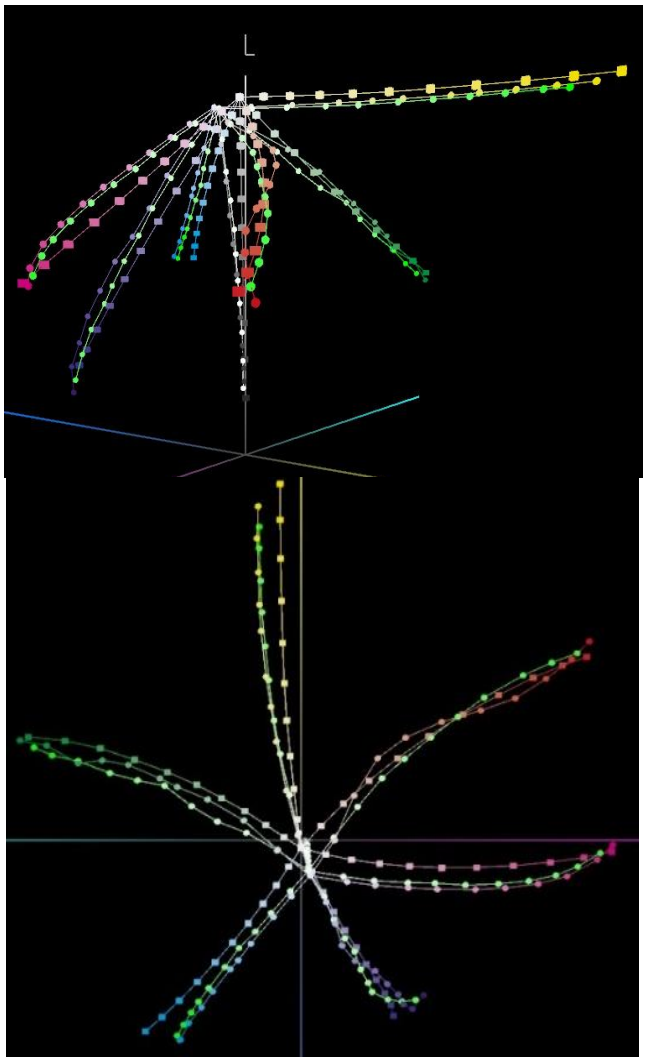

***Fig.11 and 12** - Primary and secondary colors of i1Profiler generated profile (spheres); Fiery Color Profiler profile (green spheres) and offset profile Fogra 39 (cubes)*

6. Results and discussion

In the presented study two software packages are used to generate individualized profiles in order to get a more complete picture of the printing behavior of the tested printer. Also a method of generating two profiles with and without UV content and subsequent averaging of the measured colors for achieving greater color accuracy is used. Also a procedure for optimizing the gray balance of the generated profiles is used. The neutrality of color rendering of profiles has been investigated as well. The profiles color gamuts are compared to that of a standard offset profile. Graphics are also generated for the generation of primary and secondary colors of the profiles. The results of the study clearly show a significant improvement in the color gamut, the neutrality and the generation of the main colors of the printer using individualized color profiles versus a factory color profile. There is also almost complete overlapping of the color gamut of the properly set-up and individually profiled printer with that of standard offset printing condition. In this way, the printer can be used successfully both as an unofficial hardproofing device and for full-color digital printing with a high degree of reliability of the printed materials against its original originals. It should be noted that the identified color weaknesses in some hue areas are due to the age of the printer and the author can reasonably claim that when the model was new, after applying the procedure described here, it would have been a full substitute for offset printing press in qualitative aspect.

7. Conclusion

The results obtained using previously published adjustment and calibration method of the researched printer and the profiling procedure described here with optimizations and improvements to the generated profiles prove the benefits of using color management in today's digital printing versus the use of only factory settings of the printers. The presented material also contributes to the improvement of print production quality in digital printing houses.

8. References

1. “Изследване на влиянието на хардуерни растерови процесори (RIP) върху качеството на цветен печат на полиграфски цветопробни системи“, ТУ-София проект № 171ПР0012-06, 2017г.