Annals of the Academy of Romanian Scientists
Series on Engineering Sciences
ISSN 2066 – 8570 Volume **8**, Number **1**/**2016**

REAL TIME QUALITY CONTROL OF THE HEATSET OFFSET PRINTING PROCESS

Răzvan-George RĂCHERU[1],
Emilia BĂLAN[2]

Rezumat. *Litografia offset este una din cele mai folosite metode de creare a materialelor tipărite. În comparație cu alte metode de imprimare, imprimarea offset este cea mai potrivită pentru a produce economic volume mari de imprimări de înaltă calitate, într-un mod care necesită puțină întreținere. Din cauza vitezei de lucru și a volumului mare de produse realizate pe mașina de tipar, trebuie să ne bazăm pe automatizare pentru a putea realiza controlul automat al mașinii și nu trebuie să ne bazăm doar pe ochiul tipografului. Atunci când se imprimă o imagine formată din mai multe culori, este necesar ca fiecare culoare să se imprime separat și trebuie asigurată suprapunerea perfectă a fiecărei. În cazul în care acest lucru nu se realizează, imaginea finită va arata neclară, încețoșată sau "în afara registrului". Prin urmare, utilizarea unui sistem automat de control al calității în timp real va avea ca rezultat o potrivire mai exactă a imprimării, o culoare mai consistentă pentru client și mai puține deșeuri.*

Abstract. *Offset lithography is one of the most common ways of creating printed materials. Compared to other printing methods, offset printing is best suited for economically producing large volumes of high quality prints in a manner that requires little maintenance. Because of the high speed and the high volume of the printing press, we have to rely on automation for press control and not just to the printer's eye. When printing an image that has more than one color, it is necessary to print each color separately and ensure each color overlaps the others precisely. If this is not done, the finished image will look fuzzy, blurred or "out of register". To help line the colors up correctly, a system of registration is necessary. Therefore, the use of an automated real time quality control system will result in a more consistent color for the customer and less waste for the printer.*

Keywords: Offset, quality control, printing, color management, colorimetry.

1. Introduction

Offset lithography is one of the most common ways of creating printed materials. Compared to other printing methods, offset printing is best suited for economically producing large volumes of high quality prints in a manner that requires little maintenance. Web offset is a form of offset printing in which a

[1]Eng., affiliation: Faculty of Engineering and Management of Technological Systems, Machine and Production Systems Department, University "Politehnica", Bucharest, Romania, (e-mail: razvanracheru@yahoo.com).
[2]Assoc. Prof., PhD Eng., Faculty of Engineering and Management of Technological Systems, Machine and Production Systems Department, University "Politehnica", Bucharest, Romania, (e-mail: emilia.balan59@yahoo.com).

continuous roll of paper is fed through the printing press. Pages are separated and cut to size after they have been printed. Web offset printing is used for high-volume publications such as mass-market books, magazines, newspapers, catalogs and brochures. There are two methods of web offset printing, known as heatset and coldset. In the heatset process, the ink is dried rapidly by forced-air heating. In the heatset web printing presses, print on the both sides simultaneously. The paper width can be between approximately 680 and 1460 centimeters. The paper is fed through the system at speeds ranging from approximately 1.5 to 15 meters per second.

In the offset printing process, the printing and non-printing areas of the plate are practically on one level. The printing areas of the printing plate are oleophilic/ink-accepting and water-repellent, that is, hydrophobic. The non-printing areas of the printing plate are hydrophilic, consequently oleophobic in behavior (Figure 1, [1]). This effect is created by physical phenomena at the contact surfaces.

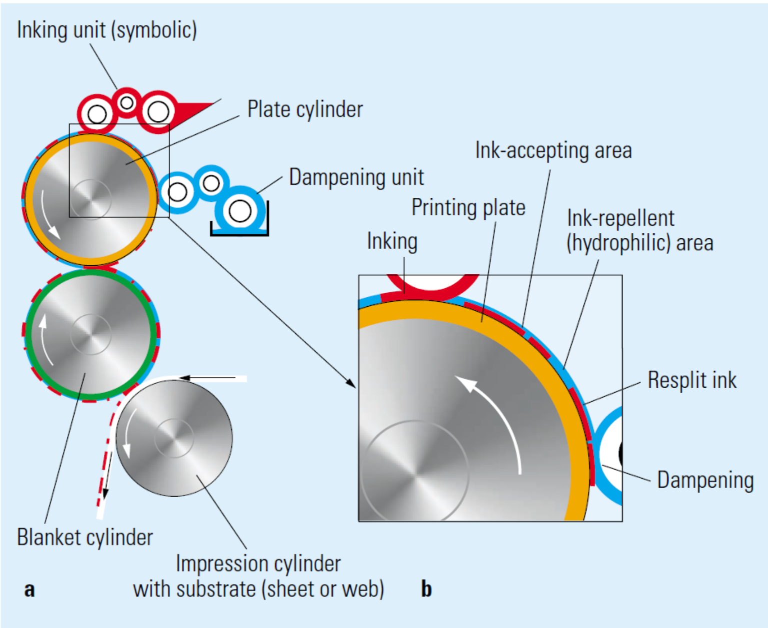


Fig. 1. Components of a printing unit.

Originally, the control functions of a web offset press only consisted of press drive commands that could be accommodated in a small switch panel at the folder. With increasing automation/motorization of most setting functions of the production plant, such as the side lay and circumferential register and the ink control, it became necessary to unite them in one central control console together with the accompanying operator control elements and displays. It was also useful to place the sample for inspection on a panel area so that the remote-controlled ink zones in the inking units could be allocated more quickly during ink feed adjustment. A web-offset press is usually equipped with one separate color control console for the upper (front) side and one for the lower (reverse) side of the web. This resulted in very long control consoles equipped with operator controls and displays (Figure 2). The transition to programmable control systems in the mid 1970's, as well as the trend towards relocating control units from the switch cabinets into the press, made it possible to centralize the control console functions. Visual display units with synoptic graphic displays were introduced to reduce the number of individual display elements, and a large number of switches and push buttons were replaced by "soft keys" or touch areas on the screens. [1]

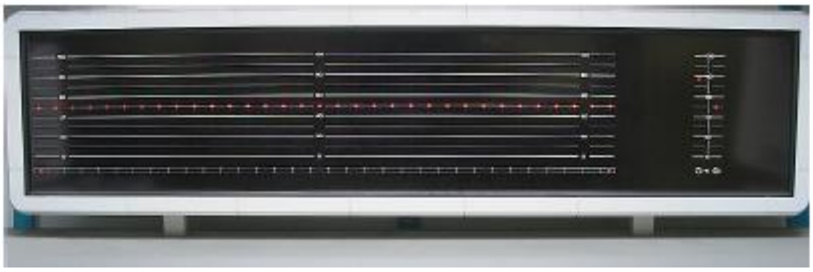


Fig. 2. Overview of color control display.

Measuring instruments are used for quantitative evaluation of the color quality. This is usually carried out with hand-held densitometers. The best measuring standard, however, is achieved with colorimetric scanning using a spectrophotometer. Automation variants range from off-line measuring systems where the sample sheet is evaluated outside the press to in-line measuring systems integrated in the press. Camera systems can record an image section in real-time for visual inspection. Very often, inline color register measuring and control systems are used. [2]

2. Marks and technology

We rely on automation today for mechanical press control. The early machines were using ink densitometers; spectrophotometers are used now and are more accurate. There are various alignment and calibration procedures that have been developed to ensure the repeatability of the devices used.

Two of the main factors that govern the quality of the printed product are the ink supply to the paper and the register, or how the individual color separations are printed on top of the other to give a multicolor image. In addition to the printer's eye, color measurement and control systems are used in order to setup the job quickly and also to monitor the production run. A number of test targets which are also called printer's marks are used. There are various ones in addition to finishing processes (trim, fold, score, punch, emboss, etc.) for different purposes.

It is imperative for the press operator to continuously monitor ink densities across the press paper roll to verify that the press is printing within prescribed tolerances - “by the numbers”, so to speak.

Identifying these metrics enable press crews to monitor press conditions and adjust ink key settings to correct for any variation as it occurs during the press run, resulting in more consistent color for the customer and less waste for the printer.

Fig. 3. Control color bar.

Color bars support density readings in several ink zones in addition to containing patches that allow for calculation of Tone Value Increase (TVI)/dot gain, print contrast, gray balance, doubling, ink film trapping, and slur.

Color bars are series of small ink patches (Figure 3) of different intensity ex.: 25%, 50%, 75%, and 100% (solid) for each plate which are read by machine to tell the variation from ideal. [7,8,12]

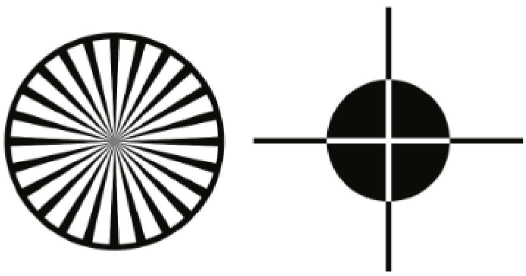


Fig. 4. Register marks.

Register marks (Figure 4) indicate how well the various plate images fall on top of each other. Misalignment of the printing plates is one of the basic problems with color.

The register has a crucial influence on print quality. The sharpness and cleanness of a four color print is greatly affected by the accuracy of the color register. Register refers to the accurate positioning of the printed image on the substrate in relation to the sheet edges or the web cut-off length. [7,8,12]

3. Inline control systems

Offset printing presses conventionally include ink fountains with zone width adjustments across the fountain for controlling ink feed in strip-like regions positioned side-by-side across the printed form. The adjusters can take various mechanical forms, but as a common feature, they typically control the ink film thickness in respective zonal widths across the fountain, and the ink film thickness as applied to the form controls the printed optical density of the form. In multicolor printing work, it is typical to individually control the film thicknesses of the individual colors which are superimposed, and the quality of the final printed result is determined by the control exercised over the film thicknesses of the individual ink films. [12]

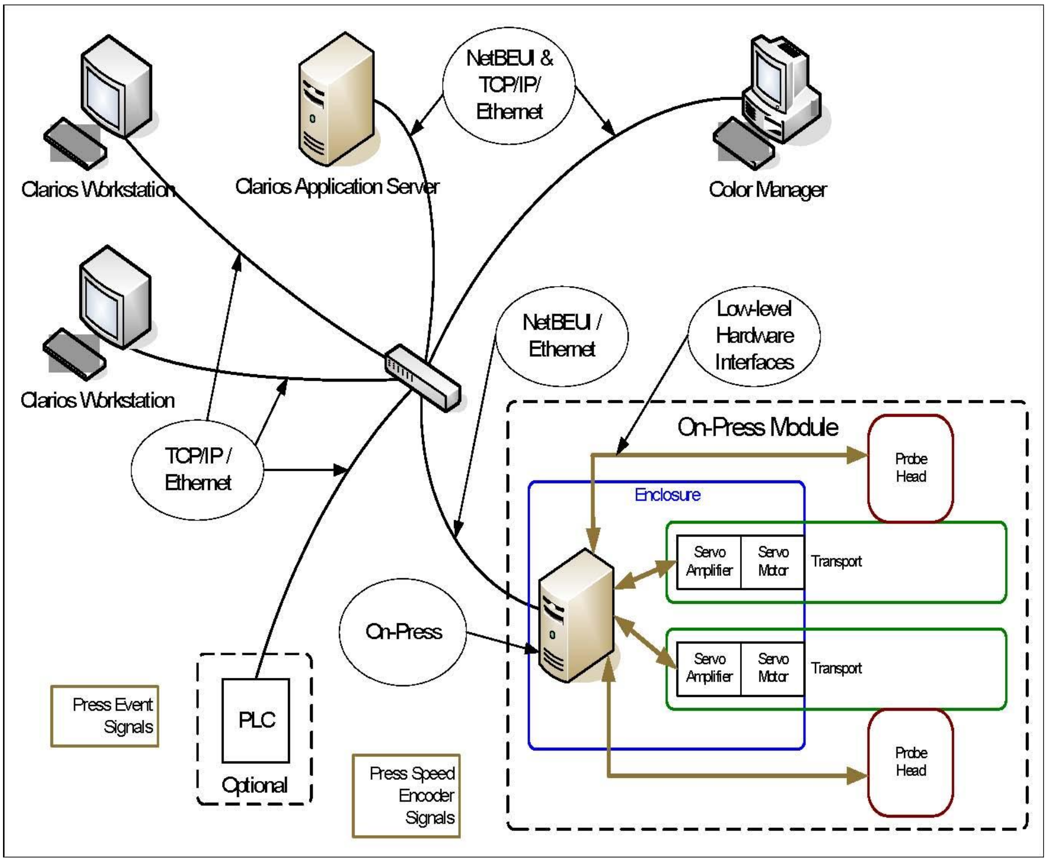


Fig. 5. The architecture of the Inline control system.

Printing plants capable of producing the highest quality product have evolved toward a high standard of automation wherein image scanners are utilized to scan the printed image and have automatic control systems coupled to the scanner for directly controlling ink adjustment on the press (Figure 5).

The Inline Density Control system (IDC) controls ink densities in commercial web presses on the basis of color marks in an ink control stripe which are scanned by high-quality camera systems and are subject to image analysis.

As the measurement modules are arranged across the width of the press, the entire measurement stripe is recorded for each color in one measurement process. The resulting high measurement frequency enables the printing process to be controlled dynamically by ink densities which are determined according to standards. Waste caused by ink fluctuations can therefore be reduced drastically.

An informative quality monitoring of the inking over the production run is enabled. The system is controlled via a separate touch sensitive monitor on the central control console as well as via the Color console itself.

The ink control stripe with the individual color marks and quality fields includes the integrated trigger mark for automatic detection of the measurement stripe on the print subject, requiring a total non-printing area of maximum 5 mm for the stripe (Figure 6).

A paper white measurement and the black balance occur permanently during the measurements; real density values are therefore determined.

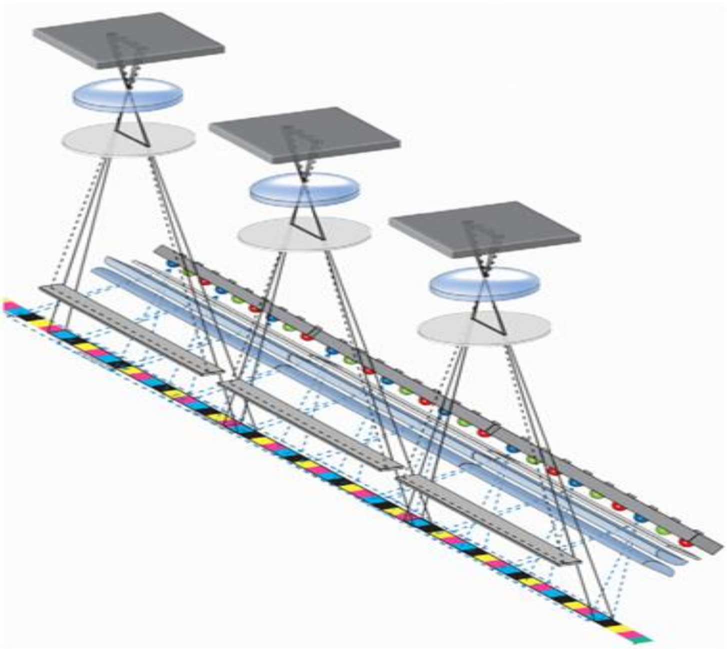


Fig. 6. IDC System.

The Clarios On-Press scanners measure density of points in the GMI (Inline control system) color bar for each surface running on the press. The measurements are sent from the On-Press computer to the system (the Clarios system includes a server application and one or more workstations, see Figure 5). The system compares the density readings to the target densities. The results appear on the workstation monitor that than sends key changes to the press console to bring color to the targets. After the press has had a chance to settle with the new ink levels, the On-Press scanners begin the process again to scan the GMI color bar (Figure 7).

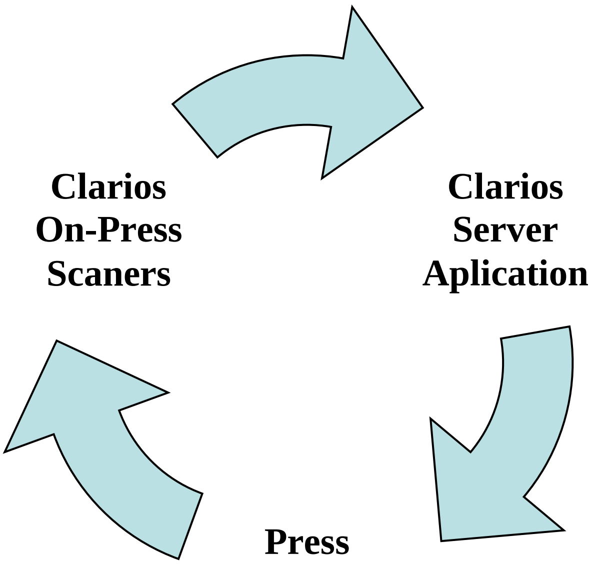


Fig. 7. Logical diagram of Inline control system.

4. Use of the automation in production

In order to ensure repeatable results in the production chain also in accordance with ISO 12467:2004 standard, and due to the high speed of the printing presses, the real time control systems of the printed products are a must.

When a new job is started, the information is uploaded from the central control station to the printing press. That information contains data about the paper width, folding type and ink zone description. The ink zone description is embedded in a JDF file, created for each exposed plate. JDF file (Job Definition Format) is promulgated by the prepress industry association CIP4 (the International Cooperation for the Integration of Processes in Prepress, Press and Postpress Organization, the successor of CIP3) as an open standard manner to accurately describe different steps throughout the print production process, from job planning to binding and finishing, so that different steps of the entire process can “talk” to each other.

Through adherence to JDF standards, almost any step of the print production process can be specified in these terms and interpreted accurately independently of specific software. The most common use of JDF definitions is with impositions, ink key presetting (CIP3/4), and some finishing operations like cutting and folding.

An example of CIP3 file is presented in Figure 8.

Data received from the CIP3 file are decoded, and the ink key presets appear on the operation panels. This means that with the ink zone opened to the right amount, the inking unit can be brought up to an almost ideal setting for production.

```
%!PS-Adobe-3.0
%%CIP3-File Version 2.1
% m_negativePrint:0
% m_mirrorPrint:0
% m_mediaClipRect:( 0, 17.28 )-( 3600, 2597.62 )
% m_plateRect:( 0, 0 )-( 3600, 2619.22 )
% m_appendNumSepsToFileName:0
% m_useOldPecomSpec:0
% m_deleteFilesAfterFTP:0
% m_sendFileUsingFTP:0
% m_imageHeightInPoints:3600
% m_imageWidthInPoints:2580.33
% m_rotateWithPreviewMatrix:0
% m_mirrorWithPreviewMatrix:1
% m_rotateCtpToPress:0
% m_replaceUnderscoresFromJobName:0
% m_useImpoNameForAdmJobName:1
% m_useSigNumInSheetNum:0
% m_bOutputJDF:0
% m_useImpoNameInFilename:1
% m_outputLowPageNumber:0
% m_truncateJobName:0
% m_writeMode:2
% m_outputType:0
CIP3BeginSheet
/CIP3AdmJobName (M1_89716_Superbrugsen_32p SIG001) def
/CIP3AdmJobCode (89716) def
/CIP3AdmMake (Creo) def
/CIP3AdmModel (Prinergy) def
/CIP3AdmCreationTime (Sat Apr 30 07:12:15 2016) def
/CIP3AdmSheetName (Sheet 1) def
/CIP3AdmPlateType (Lithoman_III) def
/CIP3AdmPSExtent [3600 2580.33] def
/CIP3AdmPlateTrf [1 0 0 1 0 17.28 ] def
/CIP3AdmPlateExtent [3600 2619.22] def
/CIP3AdmPressTrf [1 0 0 1 0 0 ] def
/CIP3AdmPressExtent [3600 2619.22] def
/CIP3AdmPaperTrf [1 0 0 1 0 -50.326 ] def
/CIP3AdmPaperExtent [3600 2522.83] def
/CIP3TransferFilmCurveData  [0.000 0.000 1.000 1.000 ] def
/CIP3TransferPlateCurveData [0.000 0.000 1.000 1.000 ] def
CIP3BeginFront
/CIP3AdmSeparationNames [ (Cyan) (Magenta) (Yellow) (Black) ] def
CIP3BeginPreviewImage
CIP3BeginSeparation
/CIP3PreviewImageComponents 1 def
```

Fig. 8. CIP3 file.

Also, when the job is uploaded from the central control unit, the target densities for each of the four process colors is uploaded (Figure 9). During the print run, the systems reads the color bar located on the paper. In this user interface the degree of area coverage of each ink zone is displayed (as a percentage) in the central window depending on the web side/printing unit and printing couple.

If the preset, lower or upper area coverage limit (actuator limit), depending on the press and inking unit, is reached in an ink zone, or a dynamic limit value is reached in comparison with the respective initial zone position (controller value), this is displayed by a flashing orange signal of the corresponding bar.

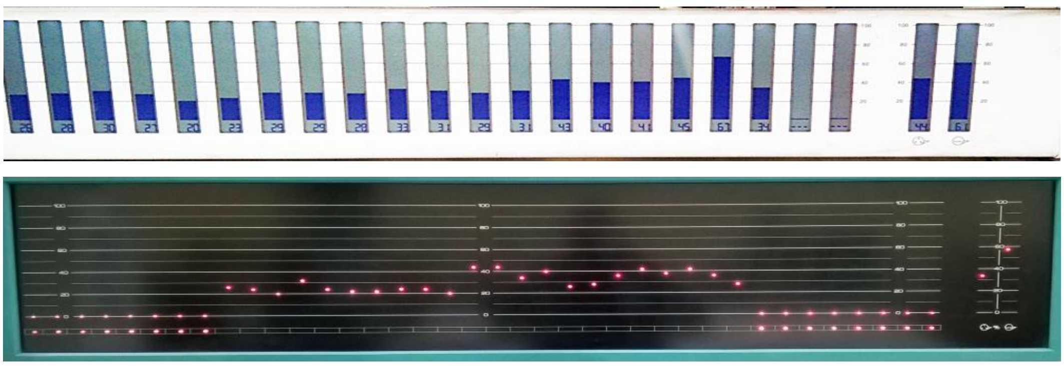
In addition, the actual values for the ink fountain roller and the dampener fountain roller, relative to the printing unit and printing couple, are displayed on the right edge of the screen (as a percentage). (This display corresponds to the display of the ink fountain roller and dampening fountain roller values on the Color console). When the control is activated, the area coverage on the Color console display are set to 50% display in all units.

When control is active, the ink zone keys can no longer be adjusted directly on the Color console due to controller priority.

If the adjusted state still requires a zonal ink correction, the set-point densities can now be adjusted in control mode by pressing the buttons for adjusting the ink zone keys. After adjustment of the set-point density, the controller attempts to adjust the new target value in the corresponding ink zone.

Each time the ink zone button is pressed on the Color console, the set-point density in this case changes by D 0.01 – i.e. to increase or decrease the set-point density in a specific ink zone by e.g. D 5/100, the appropriate ink zone adjustment button must be pressed five times.

The actual density for each of the color used in the process (cyan, magenta, yellow and black) is evaluated and then compared with the target density. If any deviations appear, a corrective measure is send to the inking unit in order to compensate the deviations from the target (Figure 10).



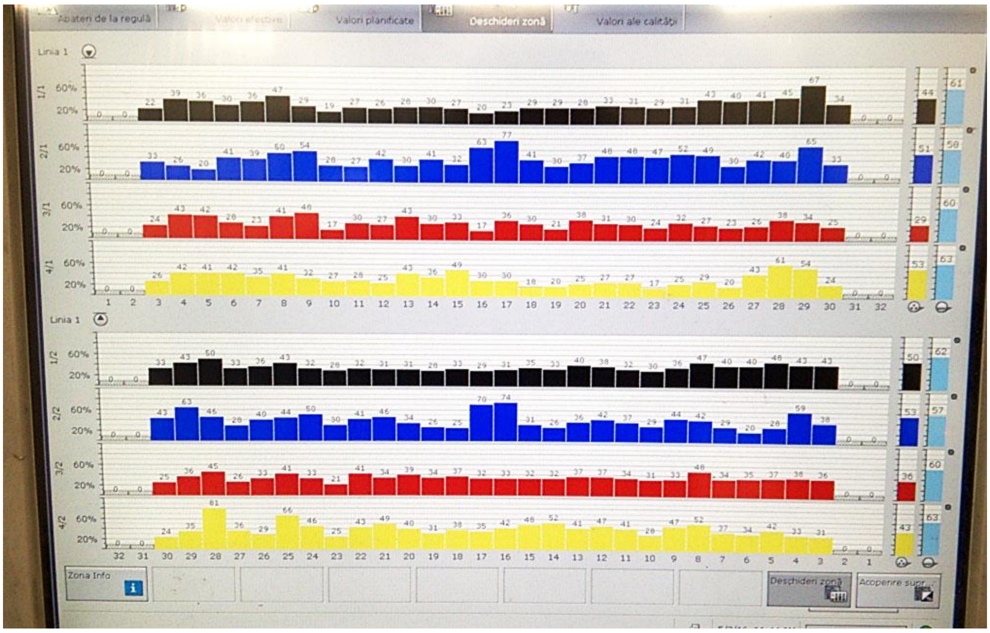


Fig. 9. Ink keys opening on different printing presses.
a – New digital visual system, b – Old LED graphical system, c – IDC Color Console.

The system also records the values of the whole production. Data is stored in the central console, and can be shown as a graphic, or as values (Figure 11). This can be very useful for quality assessment of the print run and also for accounting department in terms of ink consumption.

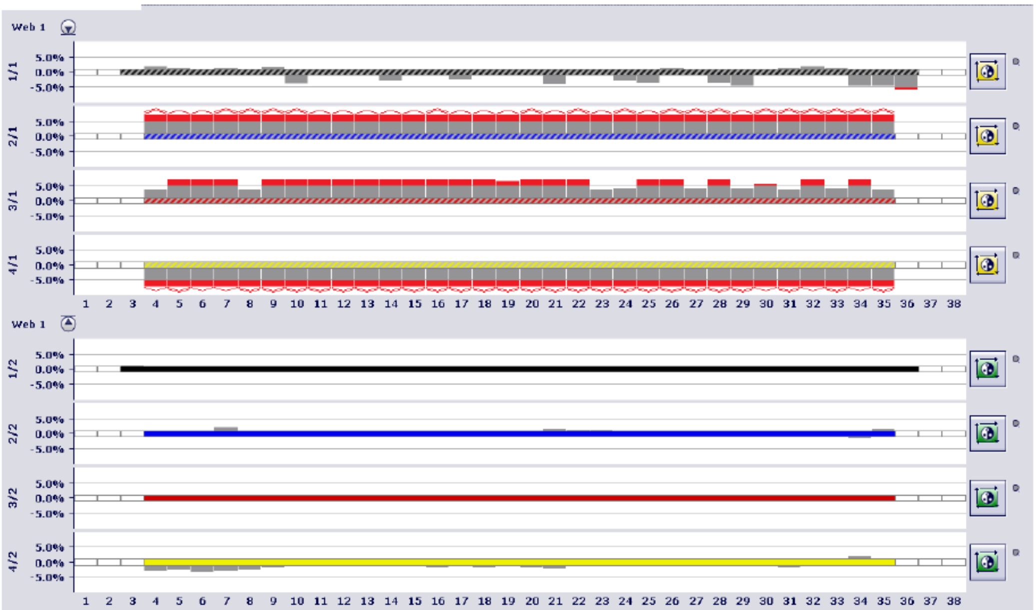
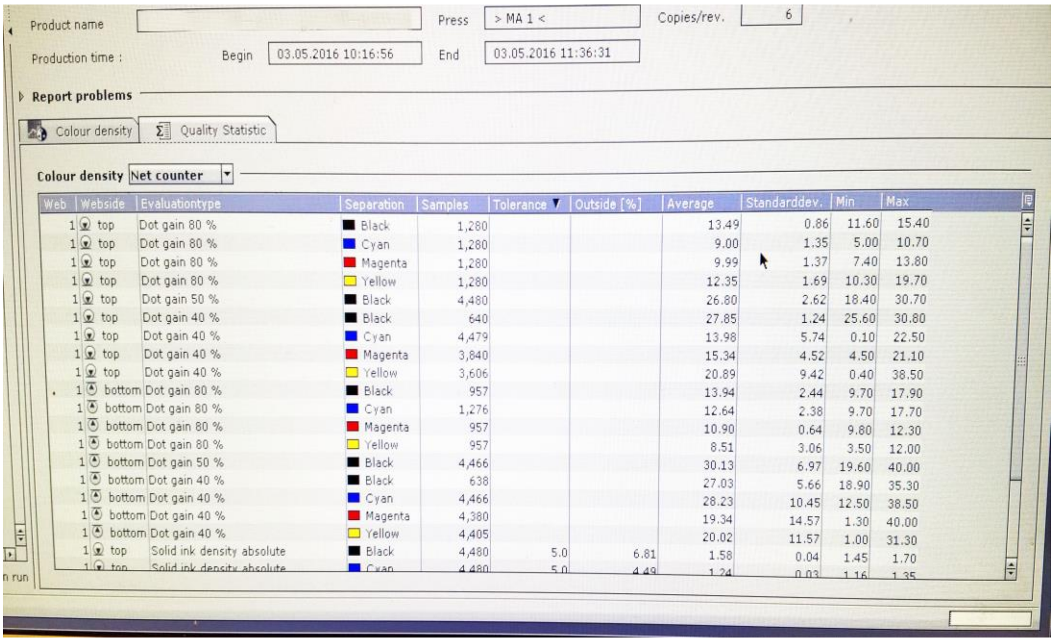


Fig. 10. Deviation readout on the control unit.



Product name | Press > MA 1 < | Copies/rev. 6

Production time : Begin 03.05.2016 10:16:56 | End 03.05.2016 11:36:31

Report problems

Colour density | Quality Statistic

Colour density Net counter

Web	Webside	Evaluationtype	Separation	Samples	Tolerance	Outside [%]	Average	Standarddev.	Min	Max
1	top	Dot gain 80 %	Black	1,280			13.49	0.86	11.60	15.40
1	top	Dot gain 80 %	Cyan	1,280			9.00	1.35	5.00	10.70
1	top	Dot gain 80 %	Magenta	1,280			9.99	1.37	7.40	13.80
1	top	Dot gain 80 %	Yellow	1,280			12.35	1.69	10.30	19.70
1	top	Dot gain 50 %	Black	4,480			26.80	2.62	18.40	30.70
1	top	Dot gain 40 %	Black	640			27.85	1.24	25.60	30.80
1	top	Dot gain 40 %	Cyan	4,479			13.98	5.74	0.10	22.50
1	top	Dot gain 40 %	Magenta	3,840			15.34	4.52	4.50	21.10
1	top	Dot gain 40 %	Yellow	3,606			20.89	9.42	0.40	38.50
1	bottom	Dot gain 80 %	Black	957			13.94	2.44	9.70	17.90
1	bottom	Dot gain 80 %	Cyan	1,276			12.64	2.38	9.70	17.70
1	bottom	Dot gain 80 %	Magenta	957			10.90	0.64	9.80	12.30
1	bottom	Dot gain 80 %	Yellow	957			8.51	3.06	3.50	12.00
1	bottom	Dot gain 50 %	Black	4,466			30.13	6.97	19.60	40.00
1	bottom	Dot gain 40 %	Black	638			27.03	5.66	18.90	35.30
1	bottom	Dot gain 40 %	Cyan	4,466			28.23	10.45	12.50	38.50
1	bottom	Dot gain 40 %	Magenta	4,380			19.34	14.57	1.30	40.00
1	bottom	Dot gain 40 %	Yellow	4,405			20.02	11.57	1.00	31.30
1	top	Solid ink density absolute	Black	4,480	5.0	6.81	1.58	0.04	1.45	1.70
1	top	Solid ink density absolute	Cyan	4,480	5.0	4.49	1.24	0.03	1.16	1.35

Fig. 11. Data as values recorded in the central console.

Conclusions

The inline color and register measurements depends on the quality requirements of the company. Quality assurance call for controls with simple press setting that can make quality assessment independent of the operator subjective point of view. It is known that the axial or side, peripheral or circumferential, and diagonal or skew register of a printing press may be controlled remotely from the press. But requiring the press operator to evaluate register marks and then to operate remote controls introduces the possibility of error and may limit the accuracy with which the register may be controlled. The efforts to shorten the job make-ready times, to minimize waste goes hand in hand with the requirements to simplify the press operations for the operator. The operator becomes more and more just an observer. Due to this, the productivity and the efficiency regarding resources increase. All the measured data is recorded for continuous improvement, press technical maintenance, supplier feedback and also in order to increase the customer satisfaction. Also the financial benefits relate to ROI by providing a preparation time of printing shortened by 20% and 5% less waste.

Acknowledgment

The author of this report would like to thank to the members of EDS Romania printing house.

R E F E R E N C E S

[1] Prof. Dr.-Ing. habil. Helmut Kipphan, *Handbook of print media*, Springer-Verlag Berlin Heidelberg, ISBN 3-540-67326-1, **2001**.

[2] http://www.fogra.org/en/fogra-standardization/standardization-pso/pso-e28093-the-process-standard-offset.html. (12.01.**2015**).

[3] A. Verikas, J. Lundström, M. Bacauskiene, A. Gelzinis, *Advances in computational intelligence-based print quality assessment and control in offset colour printing,* Expert Systems with Applications, Volume **38**, Issue 10, pp. 13441–13447, **2011**.

[4] J. Lundström, A. Verikas, *Assessing print quality by machine in offset colour printing,* Knowledge-Based Systems, Volume **37**, pp. 70–79, **2013**.

[5] J. Lundström, A. Verikas, E. Tullander, B. Larsson, *Assessing, exploring, and monitoring quality of offset colour prints, Measurement,* Volume **46**, Issue 4, pp. 1427–1441, **2013**.

[6] P. Urban, S. Stahl, E. Dörsam, *Chapter 5 – Image Display—Printing (Desktop, Commercial), Academic Press Library in Signal Processing,* Volume **4**, pp. 117–163, **2014**.

[7] Norm ISO 12647-2:2004 and ISO 12647-2:2004/Amd 1:**2007** Graphic technology - Process control for the production of half-tone color separations, proof and production prints - Part 2: Offset lithographic processes. Beuth publishing company, Berlin.

[8] Media Standard Printing **2008** - *Technical Guidelines for data, film, proof - and production print* (PDF file).

[9] Almutawa, S., & Moon, Y. B., *The development of a connectionist expert system for compensation of colour deviation in offset lithographic printing.* Artificial Intelligence in Engineering, **13** (4), pp. 427–434, **1999**.

[10] Jernström, K., Leppanen, T., & Purontaus, J., *Method and a device for controling the quality of print.* US Patent 0070006762, filed June 28, 2006, and issued January 11, **2007**.

[11] Xiaohan, Y., Södergård, C., & Ylä-Jääski, J., *On-line control of the colour printing quality by image processing.* In Proceedings of the IEEE Region 10 - Conference on computer, communication, control and power engineering, pp. 1039–1041, Beijing, China, **1993**.

[12] U. Schmitt, *Ugra/Fogra - CMYK media wedge instruction manual.* Fogra, Munich, **2008**.