THE ANALYSIS OF PARTICULARITIES AND POSSIBILITIES FOR ENSURING QUALITY IN FLEXO PRINTING

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Rezumat. *Pregătirea tipografilor specializați în tiparul flexo necesită timp îndelungat de practică la utilaj, cu costuri ridicate. Studiul a avut ca obiectiv principal reducerea timpului de pregătire prin câștigarea rapidă a informațiilor practice. Aplicarea lor corectă în procesul de tipărire conduce la obținerea unui produs de calitate. În cadrul lucrării au fost analizate următoarele aspecte: probleme în tipar – neconformități și defecte; calitatea tiparului – privită ca o obișnuință de a lucra corect și ordonat; calitatea în modul de lucru cu ștanțele; calitatea în procesul pre-press.*

Abstract. *Training printing workers in the use of flexography requires extensive time, as they are expected to gain knowledge on-site, through hands-on practice, resulting in high costs for the employer. This paper addresses the issue by providing practical information up front. Applying this information correctly during the printing process leads to a quality product. The study was created to analyse the following aspects: problems in printing - nonconformities and defects; quality of the print - seen as a habit of working neatly and correctly; quality when working with die cuts; quality in the prepress process.*

Key words: nonconformities, defects, quality instruments, flexographic printing, flexo guide.

1. Introduction

This paper will cover the problems that usually arise during flexo printing, including the print preparation stages and the printing itself, which the print worker must know how to approach correctly.

Every problem caused by imperfections in the printing process becomes a factor which modifies the quality of the final product.

For an easy analysis, the main elements were grouped into categories which are reflected in the print quality of the final product: the materials which were used, the printing assemblies of the machine and the printing quality control instruments - all used by the print worker starting from the print preparation stage. They were all analysed by taking into account the nonconformities and visible flaws arising from either known or unknown causes.

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Using graphical quality control instruments [1] during the flexo printing process: the Pareto Chart or the 20/80 principle [2-3], the Ishikawa Diagram or the cause-and-effect diagram [4] and using statistic files during the production process, all of these with the aim of determining the main nonconformities and defects which must be prevented in order to downsize production losses.

In the same context, the repercussions of nonconformities and defects of known origin were defined in relation to those of unknown origin and the necessary factors for getting an accurate assessment have been identified.

In order for the analysis to encompass even the slightest printing influences, the Pareto analyses were used alongside the Ishikawa Diagram. This completes the Pareto Chart, by allowing even the smallest problems to be “visible” in a cause-and-effect analysis.

How the objective was completed: we used data from production for the quality analysis of the elements involved in the printing process, by firstly applying the Pareto Chart to every category of nonconformities and defects which occurred during the printing process. Later, the Pareto Chart was used again to analyse the influence of every type of defects on the entire technological flow, and we determined which of the nonconformities and defect categories demand fixing priority from the print workers in order to minimise production losses: the category of those with known causes and/or the category of those with apparently unknown causes.

2. Current status

The analysis of the nonconformities and defects which appear on the flexo prints was carried out while considering the following factors: graphics, raw material, printing plates, doctor blade, inks, die cuts and, of course, the human factor.

These are the nonconformities and defects that were studied: printing skips, print impression with flashes of drops, lacquer with unstable gloss when in contact with light, asymmetrical movement of the graphics in relation to the printing direction, longitudinally and transversely, the reaction between Opaque White and Black.

3. Nonconformities and defects visible in print with unknown causes

3.1. Printing skips

On the print impression, the skips appear as transversal areas with variable ink densities and with a frequent and irregular repetition (Fig. 1).

In order to establish the possible causes, these were successively ruled out: homogenising the ink when mixed; using a new double adhesive; checking the rolling contact bearings.

This last step is where problems arose therefore all the rolling contact bearings on all the engaging elements have been changed: ductor cylinder, anilox and sleeve axle. As a result, the print was visibly improved (Fig. 2), namely the density of the ink stream was reduced and the number to occurrences diminished.

After awhile, the skips reappeared during the printing process, only this time they had a different frequency and visual intensity. The printing assembly was removed and the cogwheels were cleaned, greased and then reassembled. The skips were not eliminated, but merely softened (Fig. 3), so the printing assembly was checked again.

It was determined that the sponge that protected the gears against ink spattering was worn out. The old protective sponge was replaced with a new one. The resulting print was visibly better (Fig. 4), so much so that, at low speeds, the skips disappeared completely.

The print quality stayed the same for awhile, after which the skips reappeared, finer and in a randomised sequence. Further tests showed that, at lower printing speeds, this phenomenon is not visible.

This printing defect continues to be investigated.

Fig. 1. Stronger skips, with an irregular repetition.

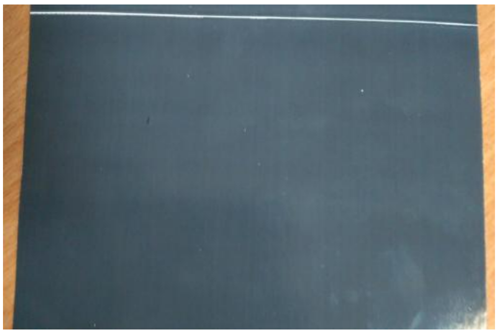


Fig. 2. After changing the rolling contact bearings, the skips have a reduced repetition.

Fig. 3. Printing skips after cleaning the cogwheels.

Fig. 4. The print after changing the protection sponge.

3.2. Print impression with flashes of drops

On the print impression there are visible flashes of drops that interceded in print, but then vanished from the printing base, without any of the elements from the doctor blade - anilox - sleeve control circuit having been modified during the printing process and without the machine having been stopped (Fig. 5 and Fig. 6). It is worth noting that the ink was mixed correctly before being put into the tank. The causes which led to the apparition of this defect are still being investigated.

3.3. Lacquer with unstable gloss when in contact with light

The printing base is a foil with a metallic sub-layer, whose colour was topped with a matte lacquer. After exposing the roll to light for a certain period of time, the foiled turned glossy.

Fig. 5. Print with flashes, most likely ink drops - Product 1.

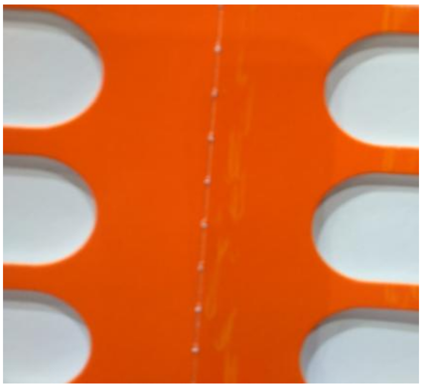


Fig. 6. Print with flashes, most likely ink drops - Product 2.

Fig.7. Lacquer with unstable gloss:
a. The matte sample exposed to light is glossy; **b.** Non-lacquered sample; **c.** Sample which was re-lacquered matte.

Fig. 8. The Reflex Blue shifted alongside the print length:
a. the first repetition; **b.** the second repetition; **c.** the third repetition.

The interior side has conserved the matte quality of the foil.

The manufacturer of the lacquer studied this phenomenon and the only reasonable explanation at that time was that the amount (2.88 g/m^2) of lacquer that was laid down by the anilox [5] was too low to create the gloss. This theory was invalidated because the product had been printed numerous times, and each time the lacquering was done using the same amount of anilox.

Fig. 7a shows the matte lacquered sample which became glossy after being exposed to light; Fig. 7b shows the sample without lacquer, with a gloss coming from the foil and the ink that were used; Fig. 7c shows the sample after being re-lacquered matte.

As a temporary fix during production, the manufacturer replaced the problematic lacquer and the foil was re-lacquered matte.

3.4. Asymmetrical movement of the graphics in relation to the printing direction, longitudinally and transversely

The study was extended to cover a product that had three repetitions longitudinally to the printing direction and eight transversally to the printing direction.

Fig. 8 shows how the print impression of the Reflex Blue printing plate exhibits graphical elements which have progressively moved longitudinally, like: Fig. 8a shows that the first repetition is good, Fig. 8b shows the second repetition which already exhibits a slight movement and Fig. 8c shows the third repetition with a shift of ~ 0.2 mm.

Transversally to the printing direction, the following has been noted: during the technical adjustment process, one edge of the print exhibits good group colour control, while on the opposite end the group colours have all shifted. It was also noted that, on the edges of the printing plate, the cross-shaped fitting markers are all superimposed in a way on one end, while at the other end they have shifted.

Figures 9 and 10 show images seen under a microscope with the cross-shaped fitting markers left and right to the ends of the printing plates for two products which are symbolically named 1 and 2.

Product 1 (Fig. 9) has the cross-shaped fitting markers showing the start of the printing plate on the upper side and the cross-shaped fitting markers showing the end of the printing plate on the lower side. The printing process starts with the upper repetition, followed by the lower repetition. A shift by ~ 0.2 mm is noticeable for the Reflex Blue printing plate.

Product 2 (Fig. 10) exhibits the same chaotic shift of the Reflex Blue printing plate. Cyan and Magenta can be seen as they too have shifted at both ends of the printing plate, but not by that much - only between 0.05 and 0.10 mm.

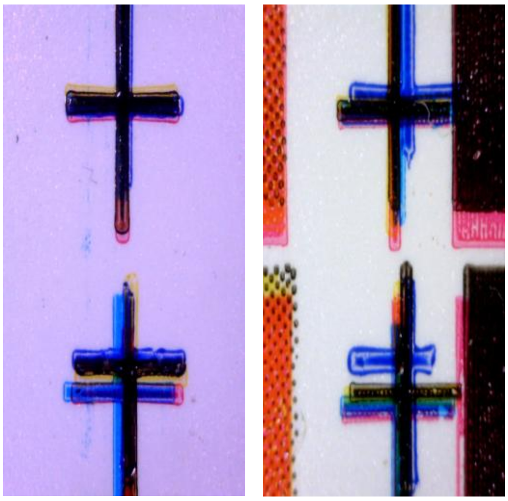


Fig. 9. Product 1: The left side cross-shaped fitting markers and the right side.

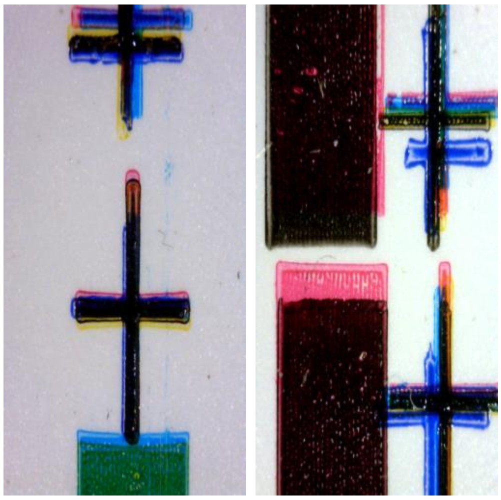


Fig. 10. Product 2: The left side cross-shaped fitting markers and the right side.

The printing plates were measured: the thickness and the height of the type alignment are, respectively, within the accepted limits and they do not offer a valid explanation for the shifts that can be observed under a microscope.

A flawed assembly was presumed next, but this hypothesis was eliminated due to the fact that the printing plates were mounted on sleeves with the help of a device monitored with optical readers. Taking into account the fact that the same printing plates assembly was used and, furthermore, that the printing plates were sent into production having the same graphical characteristics, another hypothesis was formed: that the cause of the flaw could have been here.

The issue is still being investigated. At the moment, the performance of a new set of printing plates is being tested, in order to rule out the option of the printing plates having deteriorated in time. The production constraints for the printing plates have been maintained.

3.5. The reaction between Opaque White and Black

The reaction between Opaque White and Black has been evaluated using colour printing graphics on a transparent self-adhesive BOPP printing base, with Opaque White being the first colour to be laid down. Immediately after coming out of the printing assembly, black maintains its colour intensity, but after only 3-4 seconds the intensity lowers dramatically.

A chemical reaction between the components of the two inks could be at fault. The exact chemical composition of the two inks has been requested from the manufacturer.

4. Graphical quality control instruments. Quality evaluation using the Pareto Chart

The Pareto Chart helps identifying those problems (defects/nonconformities) which generate 80% of the losses [3]. It is a bar chart which horizontally shows the values of the studied issues in a decreasing sequence, and which vertically shows two axes: the one on the left indicates the frequency of defect occurrences, and the one on the right indicates the percentage cumulated frequency values.

In order to evaluate the quality using the Pareto Chart, data was collected from the production archive as follows: ranging from June 2016 to March 2017, pertaining to a single machine and three shifts of printing workers. The data were grouped into defect categories as they were mentioned in chapter 2. The values for each month were taken into account, then added up for the entire period.

Individual types of nonconformities and defects resulted from the following analyses of the flexographic printing process:

4.1. Analysis of the influence that the raw material has on the flexographic printing process

Over the studied time interval, six types of problems regarding the raw material were identified: the lack of adherence to ink, folded material inside the roll, weak tensioning, lack of corona treatment, wrapping shift of the material on the end axle roll - shifted roll, material torn in the machine during printing.

Fig. 11 shows that 80% of the problems were caused by the raw material being torn in the machine and by the shifted roll (wrapped material shifted on the roll).

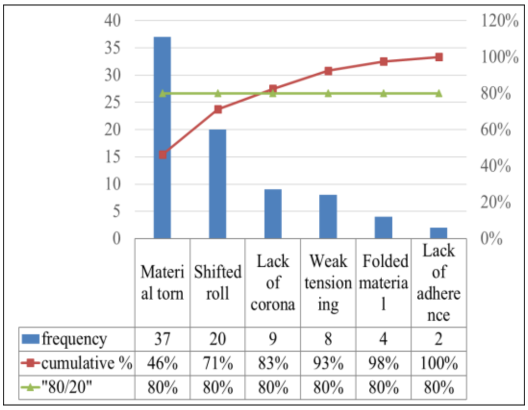


Fig. 11. Analysis of the influence that the raw material has on the flexographic printing process.

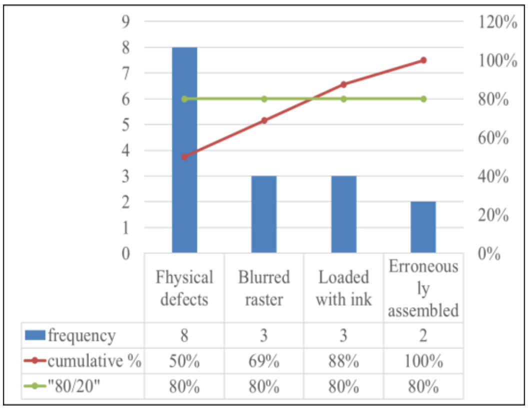


Fig. 12. Analysis of the influence that printing plates quality has on the flexographic printing process.

4.2. Analysis of the influence that the printing plates quality has on the flexographic printing process

The printing plates showed: physical defects visible only during imprinting, blurred raster, printing plate loaded with ink because of the destroyed raster, printing plate which was erroneously assembled - the case of the similar graphics with an incorrect marking of the printing plate for the archive (Fig. 12).

80% of the problems were caused by physical defects that are undetectable to the naked eye and by flawed rasterisation.

4.3. Analysis of the influence that the print quality has on the flexographic printing process

The acquired data show printing defects with apparently unknown causes: skips on the print impression, the asymmetrical movement of the graphics in relation to the printing direction, lacquer with unstable gloss when in contact with light and print with flashes of drops.

Fig. 13 shows that 80% of the problems were caused by the first two unknown causes.

4.4. Analysis of the influence that the number of ink and lacquer tests has on the flexographic printing process

The optimal printing rhythm is influenced by the large number of ink tests, but also by the reaction of the lacquer when in contact with the imprinted surface. 80% of the problems were caused by the large number of Pantone tests (Fig. 14).

4.5. Analysis of the influence that the die cutting quality has on the flexographic printing process

During printing, the die cuts can create the following nonconformities and defects: they snatch labels, cut the liner, tear the material, don’t cut due to breakage, shift on the magnetic cylinder, accumulate adhesive around the cutting blades, or they block the die cutting assembly.

Over the studied time interval, 80% of the losses were due to the die cuts which snatch labels, cut the liner and tear the material (Fig. 15).

4.6. Analysis of the influence of machine elements that are directly involved in the flexographic printing process

Some components of the machine directly interfere in the technological process and can slow down the printing by interrupting it. Over the studied time interval, the printing was interrupted due to the following causes: deterioration of the hose that links the charging pumps to the ink tanks, changed doctor blades, nip-rolls failure [6], cleaning and/or changing the UV drying lamps, power outage in the industrial area, alarm triggered by the die cut sensor, assemblies which came out of printing.

80% of the downtime was caused by the pump hose, the doctor blades and the nip-rolls failures (Fig. 16).

4.7. Evaluation of the flexographic printing process quality

In order to analyse the quality of the printing process, the Pareto Chart was used while considering the main groups of elements involved in the process: inks and lacquer, printing defects, machine elements, raw material defects, nonconformities generated by the die cut, defects generated by the printing plates.

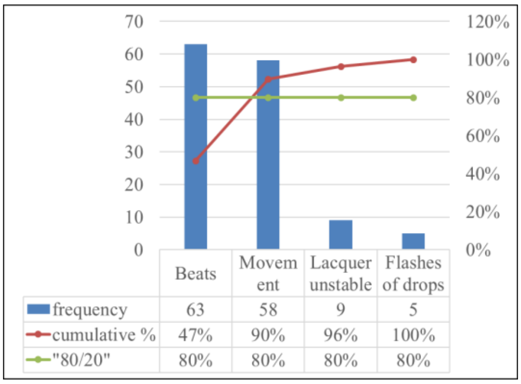


Fig. 13. Analysis of the influence that the print quality has on the flexographic printing process.

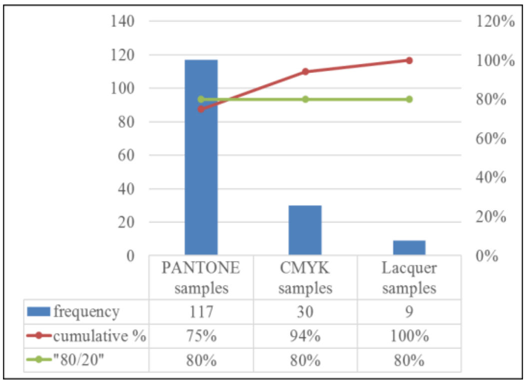


Fig. 14. Analysis of the influence that the number of ink and lacquer tests has on the flexographic printing process.

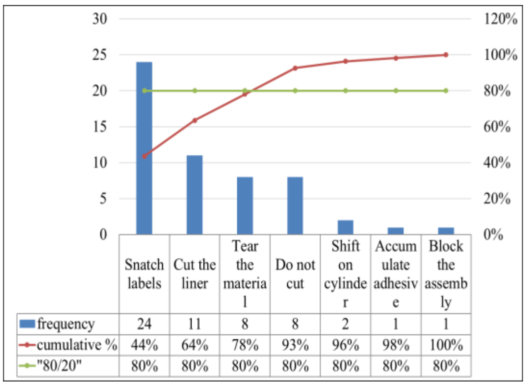


Fig. 15. Analysis of the influence that the die cutting quality has on the flexographic printing process.

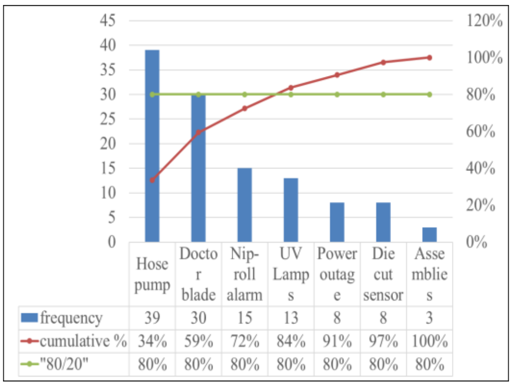
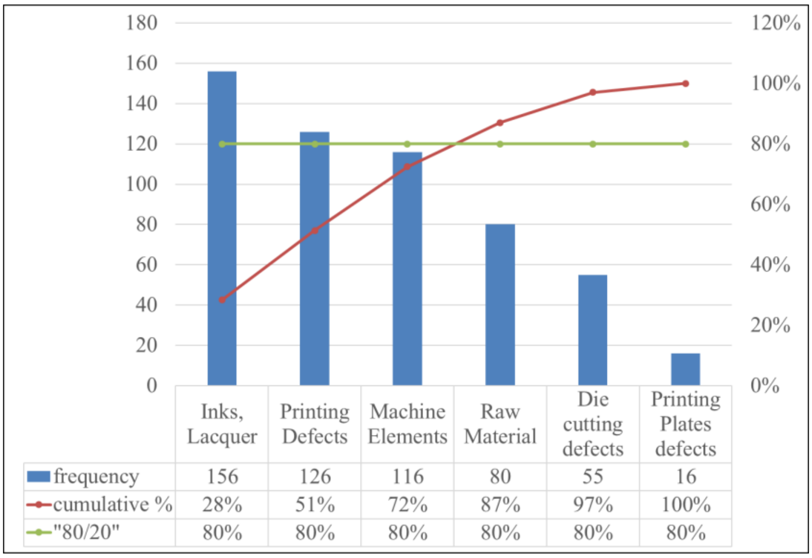
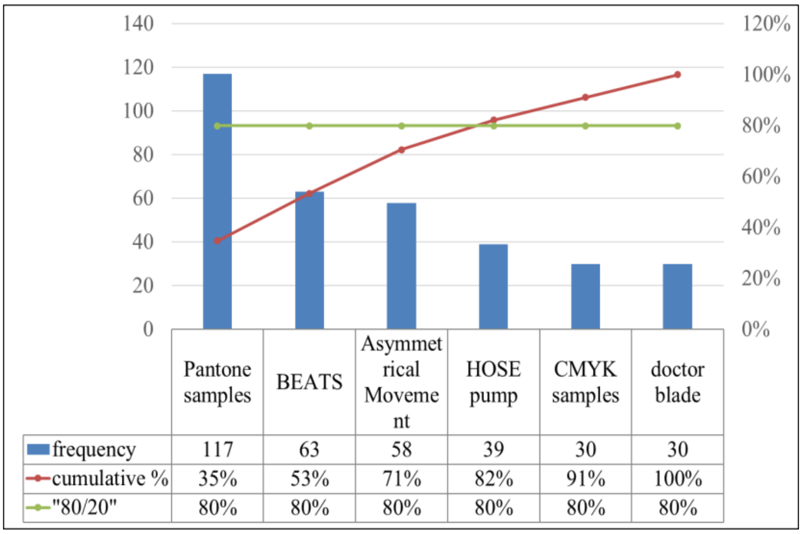


Fig. 16. Analysis of the influence of machine elements that are directly involved in the flexographic printing process.



	Inks, Lacquer	Printing Defects	Machine Elements	Raw Material	Die cutting defects	Printing Plates defects
frequency	156	126	116	80	55	16
cumulative %	28%	51%	72%	87%	97%	100%
"80/20"	80%	80%	80%	80%	80%	80%

Fig. 17. Evaluation of the flexographic printing process quality.



	Pantone samples	BEATS	Asymmet rical Moveme nt	HOSE pump	CMYK samples	doctor blade
frequency	117	63	58	39	30	30
cumulative %	35%	53%	71%	82%	91%	100%
"80/20"	80%	80%	80%	80%	80%	80%

Fig. 18. Analysis of the influence that the ink groups components, printing and machine defects have on flexo.

Over the studied time interval (Fig. 17), 80% of the problems were generated by inks and lacquer, printing defects, machine elements. This information can be a special case, considering that the data which were used did not encompass all the elements involved in flexographic printing.

Over the upcoming months, statistic files [7] will be introduced in production to record data.

4.8. Analysis of the influence that ink groups components and printing and machine defects have on the flexographic printing process

The extreme situation when all the three elements presented at point 4.7 can appear simultaneously during print was analysed. These generated 80% of the losses. The following situation was also analysed: when lots of inks and lacquer tests are necessary, when defects occur frequently on the print impression and when machine elements break down often leading to the interruption/slowing down of the machine.

In this case, the print events over-saturation Pareto Chart (Fig. 18) shows that the greatest losses can be generated by the following elements, listed in a descending order by value:

a) print interruption for Pantone tests;
b) printing skips - on the print impression, the skips show up as transversal areas with variable ink densities and frequent and irregular repetitions;
c) asymmetrical movement of the graphics in relation to the printing direction;
d) defects of the hose that links the charging pumps to the ink tanks.

5. Quality assurance

The print interruption for Pantone tests can be remedied in the future by using a correct colour management system. And the hose that links the charging pumps to the ink tanks can be replaced in time through proper machine maintenance. However, two other elements are part of the "unexpected" category during the technological printing process. Having unknown origins, they can cause strong effects when it comes to production losses, therefore necessitating urgent intervention to minimise the effects.

At the same time, studying them as novel process phenomena is valuable in the sense that, if they appear again, the solution is already at hand. For this reason, this study will be pursued even further after collecting the statistic files for production data and drafting the Ishikawa Diagram.

The quality analysis of flexographic printing will follow, considering the following: the quality of the printing plates, the quality of the ink and special ink, the quality of lamination and lacquering.

5.1. The quality of the printing plates

The quality of the printing plates through: polymeric material, the quality of printing plate manufacturing, the ruling of the printing plate correlated with the graphics and the type of anilox available; the particular case of High Density printing plates execution with the following observations: the printed images are clearer, with great hue variation, fine details and good contrast; the half-tone dots are more stable at smaller percentages, i.e. 1% - 2%; this leads to fine, uninterrupted gradients; good ink transfer with easily-obtainable high colour densities.

Next, the study will focus on whether the printing plate suppliers implement UV after-treatment methods [8] of the printing plates in their workflow and whether this leads to a significant improvement of the fine print elements.

5.2. The quality of the ink

The ink quality must be continuously supervised irrespective of the manufacturer's brand, because of the previous chemical interaction described in chapter 3.5. Fig. 19a shows the exact moment when the printing base stops being in direct contact with the printing plate. After only a few seconds, the intensity of the Black ink starts to decrease (Fig. 19b).

Paper [9] details the ways of measuring the print quality, which for flexo can be structured as follows: measuring with a spectrophotometer; special "spot" colours which can be compared against Pantone swatches or measured with the ΔE chromatic numerical difference.

5.3. The quality of lamination and lacquering

The lamination quality was determined by observing: the quality of the imprint on the printing base, the type of printing base, the quality of the printing base, the quality of the adjustment (the ensemble: printing worker - colour group - the type of printing plates assembly - register mark - pressure/guiding elements) and the quality of the special finishing operations.

The printing base - the way it behaves while inside the machine and the way the printing is approached while considering the final destination of the finite product.

Fig. 19. Reaction between Opaque White and Black:
a. Observe the barcode: the Black ink is intense.
b. After only a few seconds, the intensity of the Black ink decreases.

The behaviour of mono- and multi-layer LDPE foils used for packaging aggressive materials (coal) was also analysed [10] in relation to the stability of the print applied under the influence of light and temperature - factors which spark the accelerated ageing of the foils.

5.4. The quality of the finishing operations

The quality of the product finishing operations: cutting the finished rolls, folding and pasting.

5.5. Die cutting in flexo typography

A die cut which is mounted onto the magnetic cylinder can determine the tearing of the printing base. This is why the die cut quality check also includes mounting the die cutting assembly onto the magnetic cylinder.

5.6. Prepress quality

Prepress quality is ensured by: image processing, chromatic separation, printing plate mounting (in accordance with print stages and with the features and performance of the machine) and graphic proof according to the original.

The effects in the printing process were: making the preparations for printing more quickly, an enhanced precision when adjusting the assemblies and a quality print.

Conclusions

The study was centred on successive Pareto analysis, used to uncover solutions for problems which arise during the flexographic printing process. Production data was gathered from a single machine and from three shifts of printing workers, spanning a time interval of 10 months. The data were used to analyse the relative frequency of nonconformities and defects arising in the following assemblies directly involved in the printing process: raw material, printing plates, the print itself, inks and lacquers, die cutting, machine elements.

Resulting information: the quality evaluation of the flexographic printing process lead to the conclusion that 80% of the problems were caused by the following groups: inks and lacquers, printing defects and elements belonging to the machine.

The importance of this information: the Pareto analysis of the elements forming these groups showed that the nonconformities and defects with unknown causes are those which generate important production losses. Eliminating those using quick, radical measures is justified even if this involves high immediate costs.

Monitoring the flexographic printing process also revealed vulnerable reference frames, which have to be considered and controlled in order to continuously ensure the quality. Among these: using only quality materials; checking and ensuring the quality of the prepress processes; monitoring the conformity when preparing the equipment that go to print; ensuring print quality through chromatic conformity and a correct superimposition; ensuring the quality of the finishing operations: die cutting, lacquering, lamination, etc.

Acknowledgements

The authors wish to express their gratitude to the SEEN PRINT typography of Cluj-Napoca for the support offered for this paper.

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