Analysis of problems using conventional and H-UV technology in the hybrid offset printing press

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Abstract
This study analyses the issues faced by the offset printing process on non-absorbent materials using UV offset printing technology on a hybrid printing press. In this case, the printing press is called hybrid when two technologies – conventional offset printing with oil-based inks or H-UV offset printing – are used at the same press alternatively, i.e., hybrid printing press is a machine that prints either oil-based or UV inks on all printing units.

The ink type can be changed by preparing the printing press for the technological transition from conventional to UV printing and vice versa. UV curing inks are generally convenient for printing packaging, labels and other products on a wide range of non-absorbent materials. The possibility offered by some offset printing equipment to print conventional and UV curing on the same printing press in succession could be very advantageous for companies in terms of equipment and labour costs. By acquiring such printing equipment, the companies expect to exploit UV printing technology in addition to conventional printing, print high-quality packaging, labels, and other products on non-absorbent materials, and process the production immediately after printing.

This paper presents the results of a study on the quality of prints printed on non-absorbent metallized cardboard using one of the UV technologies, specifically H-UV, on a hybrid offset press. The analyzed prints were printed after transitioning from conventional to H-UV printing process. The ink curing level and adhesion to the print were assessed utilizing rapid testing immediately after printing. In the event of defects in the curing and adhesion of the ink layer on the print surface, the ink rub resistance of the prints was further tested in the laboratory using a rub tester.

1. Introduction

Offset printing on non-absorbent surfaces such as metallized paper and cardboard, foils, etc., is known to cause problems related to ink drying, fixation on the printed material and adhesion to the substrate.

UV curing technologies and various improved modifications, such as LE-UV (Low Energy UV, Heidelberg), HR-UV (High Reactive UV, KBA), LEC-UV, RGMT LED-UV (Manroland), H-UV (Komori), etc., are well-known on the market and have been applied to improve the ink curing processes in offset printing machines.

Applying these UV curing technologies, UV inks are used, modified explicitly to the spectrum of radiation emitted by curing lamps. All UV curing technologies differ in the type of lamps, the wavelength range of the UV spectrum, the chemical composition of printing inks, the type and the number of acrylic oligomers, and photoinitiators (Abd El-Rahman, A. et al., 2021). Therefore, in conventional UV offset printing, the inks are cured by mercury vapour lamps, which are energy-intensive and emit ozone; LE-UV technology uses traditional UV lamps, which are not mercury doped as in the case of conventional UV, but iron doped, making the system more environmentally friendly; LED-UV uses light emitting diodes to initiate the curing process – it is the advanced version of the UV technology generating the wavelength at a light spectrum of 385-395 nm. LED-UV system uses even less energy than the iron-doped lamps of the LE-UV. In the case of H-UV technology, curing lamps affect the print surface within low-energy UV-A (315-380 nm) rays.

Since the composition of UV printing inks is different from oil-based inks, the process of their fixation onto the print also differs. During conventional offset printing, the inks dry due to their partial absorption, evaporation of the liquid phase (oils, solvents) and oxidative polymerization of the whole ink film. In UV technology, instantaneous ink layer curing occurs when photoinitiators trigger the formation of free radicals, and polymerization occurs due to the reaction of monomers and oligomers. It leads to the transformation of liquid inks into a solid film. Due to this method of ink fixation onto the print, UV technologies are convenient to use when printing on non-absorbent surfaces. Furthermore, H-UV like LED technology can be considered advantageous due to the reduced environmental impact: it is characterized by zero ozone emission due to the absence of shortwave UV radiation; H-UV curing lamps do not emit much heat.

Since the complete UV ink polymerization and curing is instantaneous, it allows for safe further processing of the prints. This is one of the key advantages compared to conventional offset and the reason manufacturers choose this technology. This advantage allows the product to be processed immediately after printing. Meanwhile, oil-based offset inks dry completely in 6 – 24 hours (Komori H-UV, the basics of this innovative offset technology, 2022).

It is known that the resistance of a layer of offset printing ink to rubbing and other mechanical effects is considered a fundamental property of printed products in terms of print quality. This property significantly determines the quality of packages, labels and other printed products. Ink rub resistance shows the ability of the printed surface to remain unaffected during post-press processing, transportation and use. The resistance of a layer of offset printing ink depends on several important factors, such as the paper's fundamental properties, the ink's composition, printing conditions and drying properties. The problems and perspectives of usage of the UV curing inks in sheetfed offset printing, the curing and the resistance of the ink layer to rubbing are analyzed and described (Oguz, M. et al., 2012; Preston, JS. et al., 2005, Rousu, S., et al., 2006). UV curing inks are also used in flexographic printing; digital printing devices for printing manufacturing, such as printing electronics, and 3D printing (Lu, Q et al., 2021); for reproducing Braille by UV ink-jet printing (Miloš, S. et al., 2021), etc.

Despite advantages, there are some UV ink-curing problems. One of the most common problems is poor adhesion of the inks when inks can be easily removed from the print using a simple adhesive tape test (Старченко, О.П., 2020; Standard Test Methods for Rating Adhesion by Tape Test, 2020). It means that ink is not fully cured or adhesion is poor due to other factors.

There may be several reasons for this, including inadequate exposure to radiation (low power of curing lamps, dirty reflectors, imperfect match of emission spectra of the lamp and sensitivity of the photoinitiator, etc.); ink is not suitable for the substrate; ink emulsification occurs due to an excessive amount of dampening solution; a too thick layer of the ink; lack of photoinitiators; too high speed of printing, etc. Sometimes, the ink film can remain sticky or wet to the touch. Even if the printed ink film appears dry but exhibits unsatisfactory rub and/or scratch resistance when abraded, it is not cured enough (UV Troubleshooting Guide, 2014).

2. Methodology and material

As mentioned before, conventional printing and UV curing inks can be used for offset printing in the same hybrid printing machine. This study was carried out on a Komori Lithrone LSX 629 + C hybrid printing press for conventional offset printing and printing products, mainly packaging, using H-UV technology. The transition from conventional oil-based inks to printing using UV inks and vice versa must comply with all technical and technological requirements. The printing press is designed to print using both conventional and unique H-UV technology, as well as sustainability aspects, namely, the fact that modified UV spectrum curing lamps ensure low energy consumption and instant drying of inks with lower emission of heating energy.
Although the quality of printing jobs was flawless on this printing press using conventional technology, the quality of H-UV printing on non-absorbent materials was low. In addition, it was observed that the use of hybrid capacities of the printing press is complicated: the transition from conventional offset printing to H-UV is time-consuming.
During the expertise, the following activities were carried out:

1. assessment of conventional offset printing and quality of the prints;
2. transition from conventional offset printing to H-UV printing according to the recommendations and under the guidance of the representatives of the equipment supplier;
3. assessment of H-UV printing and the quality of prints using express-tests with TESA 4104 adhesive tape of calibrated stickiness, designed for manual adhesion testing directly after printing (Старченко, О.П., 2020). The prints were tested by sticking and peeling off the tape on the print immediately after printing, 5 – 20 minutes after printing;
4. reverse transition from H-UV printing to the conventional one.

For printing, a print sheet sample with targeted image elements was prepared (press sheet – 360×510 mm, printed area – 330×490 mm) to evaluate the adhesion of inks covered on the metallized surface and the Opaque white colour strips (Fig. 1). Samples with various series of UV inks from different manufacturers and with a different number of colours were printed: 5 colour prints (Opaque White and CMYK) and 6 colour prints (Opaque White, CMYK and Pantone).

White 100		
No colour metalized surface Pantone 100	Pictures CMYK+Pantone	C100 M0 Y0 K0 metalized surface
No colour white ink base Pantone 100		C100 M0 Y0 K0 white ink base
C0 M100 Y0 K0 metalized surface		C0 M0 Y100 K0 metalized surface
C0 M100 Y0 K0 white ink base		C0 M0 Y100 K0 white ink base
C0 M0 Y0 K100 metalized surface		C100 M100 Y100 K0 metalized surface
C0 M0 Y0 K100 white ink base		C100 M100 Y100 K0 white ink base
C60 M60 Y60 K100 metalized surface		C30 M30 Y30 K100 metalized surface
C60 M60 Y60 K100 white ink base		C30 M30 Y30 K100 white ink base

Fig. 1. Targeted strips on the print sheet: CMYK (100 %) on the metallized surface (strips 1,3,5,7) and on the Opaque white (strips 2,4,6,8); Black (C, M, Y 60 % each, K 100 %), Black (C, M, Y 30 % each, K 100 %) on the metallized surface (strips 9, 10); Black (C, M, Y 30 % each, K 100 %) on the Opaque white (strip 11).

To ensure the quality of the printing process and the prints, several instrumental and visual quality assessment methods were used, including ambient temperature and relative humidity of the printing shop, parameters of the dampening solution (pH – 4,7 - 5,2, electrical conductivity without extra additives – 700 - 1600 mS, temperature – 9 - 10^0 C, the volume of alcohol – 3 - 5 %), etc. For each test, the density (C 1,4 ± 0,10, M 1,4 ± 0,10, Y 1,3 ± 0,10, K 1,7 ± 0,10) and CIELAB coordinates of colours were instrumentally monitored by PDC-SX Spectral Print Density Control System (compatible with ISO 12647-2) during both conventional and H-UV printing.

It is known that the preparation and maintenance of the printing press for the transition from conventional printing with oil-based inks to printing using UV inks has to comply with specific technological requirements for offset rubbers, printing ink rollers, printing forms, etc. As the transition from conventional to H-UV printing procedure has been initiated, the appropriate steps were taken: cleaning of the output device of the press (to the residues of the powder); washing of ink rollers of the printing press; change of the dampening solution; change of offset blankets (IMC Perfect Dot UV-LE.D, 1,95x770x760 mm); repetitive washing cycles of ink roller (to remove residues of the oil-based inks); repetitive application of K-Supply Roller Saturator paste (Art. No. KR915V0108), etc. The preparation of the printing press took 15 hours (the first preparation stage). Ensuring adequate technological process parameters and installing new Baldwin ozone-free metal halide system lamps (H-UV lamp LS29, IC 160W/cm, Art. No. Komori KG41220E06) prepared the press for printing.

Before printing with H-UV technology, the surface tension of the print material was measured using standard Dyne Test Pens corresponding to ISO 8296 (at least 38 dyn/cm). All H-UV printing tests were performed on the Metalprint Silk metallized cardboard with surface tension 40 dyn/cm). In all cases, the printing speed ranged from 9200 to 10000 prints per hour.

Conventional printing with oil-based inks on Aegle Pro (245 g/m2) cardboard was carried out at the beginning of the experiment. After the print run, the quality of the prints was assessed, and the printing press was prepared for the transition from conventional to H-UV printing. For this print run, Metalprint Silk MP/METP cardboard (from now on referred to as Metalprint Silk), laminated with a metallized film, with a total weight of 309 g/m^2 (280 g/m^2 cardboard, 29 g/m^2 metallized PET film) was used. In both cases, the exact layout of the print image was applied. H-UV printing was carried out using Siegwerk Sicura LOW NRGY Plast inks (from now on referred to as Siegwerk) following the manufacturers' recommendations. Six colours were used for printing: white in the first section, CMYK colour inks in the following areas, and Pantone inks in the sixth section. Other ink brands and their combinations, Toyo FD LED, Toka UV AD LED, and Janecke Schneemann JS Supra UV LED (from now on referred to as JS Supra UV LED), were also tested when printing in 5 colours (white and CMYK). For ink curing, two H-UV curing lamps (after section 1, section 6) were used for printing in five colours, and three H-UV lamps (after section 1, section 6 and in output) for printing in six colours. The prints were not additionally varnished to obtain a more accurate, unaffected by the varnish H-UV ink curing result.

The quality of the ink layer fixation on the print was rapidly assessed in the printing shop using manual adhesive tape tests immediately after printing, 5 – 10 min after printing, and 15 – 20 min after printing. A tape was applied evenly and with ease on the selected areas of the print and peeled off at a sharp angle.

As known, laboratory tests for rubbing effect can be carried out to assess ink adhesion strength on the print and ink layer adhesion to the material. The rub testing process is regulated by ISO standards (ISO 18947–1:2021). The ink rub resistance test can be done to optimize offset or other inks printability by employing additives or adjusting the printing process's parameters. The resistance of the ink layer to abrasion is also relevant for the printing of high-resolution elements in offset, digital or flexographic printing, as well as for printing on various types of paper and other printing materials (Gajadhur, M., 2014; Gajadhur, M., 2016; Gajadhur M., Ragulska M, 2020; Bijender, Mr., 2017).

The prints made with H-UV technology on the Metalprint Silk metallized cardboard were tested for rub resistance using the Ink Rub Tester Kinsgeo KJ-8310 JIS5701 (Guangdong, China). Before testing, the printed sheets were cut into smaller samples 60x260 mm. The first rubbing tests of the print fragments were carried out 24 hours after printing. Subsequently, the print fragments were rubbed after 30 days to determine whether a longer time interval affected the strength of the ink adhesion on the print. Initially, 24 hours after printing, the rubbing tests were performed with fewer cycles (200 and 500 cycles). For carrying out rubbing tests after 30 days, the number of cycles was increased to 1000. The rubbing speed was 85 cycles/min., and the weight was 1.81 kg. The fragments selected for rubbing were: CMYK colours (100 % each) on the metallized surface of the Metalprint Silk cardboard and fragments with CMYK colours (100 % each) on the metallized areas coated with Opaque white ink (Fig.1, strips 1-8); composite fragments consisting of Black 100 %, C, M and Y at 60 % each on the metallized surface with total ink coverage 280 % (Fig.1, strip 9); Black 100 %, C, M and Y at 30 % each with total ink coverage 190 % on the metallized surface (Fig.1, strip 10) and 290 % on areas coated with white ink (Fig.1, strip 11). Spectrophotometric analysis of the samples was also performed to compare the values of the colour changes before and after rubbing. The measurements were carried out using an X-Rite spectrophotometer model eXact 2 (measurement accuracy: ±0.01).

3. Results and discussion

The results of the conventional 5-colour (CMYK and Pantone) printing on the Komori Lithrone LSX 629 + C offset printing press on Aegle Pro cardboard, conducted in the first phase of the study, showed that conventional 5-colour offset printing machine runs smoothly; no technical or technological defects; the ink density is within limits; the quality of the prints is good, no defects are detected, the quality of the ink layer is good, no smearing, staining, ghosting or other defects. The inks do not rub off or smear on contact. The quality of the conventional offset printing was found to be good, with no technological or technical deficiencies in the operation of the equipment and the quality of the prints.

Five tests using H-UV inks from different manufacturers were carried out to evaluate the printing quality (Table 1). Toyo FD LED inks (Opaque white, CMYK, Pantone) were selected for the first test. Accordingly, two H-UV curing lamps were used after sections one and six. As the obtained result showed, the quality of the print was unsatisfactory. The inks easily peel off the cardboard surface using the adhesive tape test. This indicates insufficient adhesion of the ink layer to the surface of the metallized cardboard. The scratching test shows that when scratching with a fingernail, the ink layer easily chips off, the inks do not adhere to the metallized cardboard surface, and the fixation and bonding of the ink layer on the latter surface is insufficient. It can be concluded that the prints on the Metalprint Silk metallized cardboard using Toyo FD LED inks are of poor quality. It is worth noting that these inks are not available in the EU market and were used as an experiment only.

After this test, the printing press rollers were re-covered with K-Supply Roller Saturator paste and left overnight for 8 hours (the second preparation stage) to extract the remaining residues of oil-based inks. After repetitive washing cycles, a 5-colour test printing with Toyo FD LED Opaque White and Toka UV AD LED CMYK inks was done. The Toka CMYK inks were used for test printing only as they are not available in the EU market. Two H-UV drying lamps were used after section one and section six. These inks gave better results: using the adhesive tape test, the inks do not peel off. This shows that the adhesion of the ink layer to the metallized cardboard surface is sufficient. The scratching express-test results indicate that when scratching with the fingernail, the inks rub off from the cardboard surface but not so abundantly. Thus, the fixation and adhesion of the inks to the latter surface is moderate. It can be stated that the results of the quality assessment of the prints could be considered positive. Still, the inks used for the testing are unavailable in the EU market due to non-compliance with the requirements of the EU REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulation. These inks contain substances in the chemical formulation above the EU limits. Such substances are possibly to be photoinitiators, which, when present in higher than permissible concentrations, have a positive effect on the drying process when exposed to low-energy UV (A) radiation of the spectrum (wavelength 315 – 380 nm) and accelerate the polymerization of the ink layer.

The follow-up test was carried out with Siegwerk Opaque white, CMYK and Pantone inks following the recommendation of Komori suppliers. Three H-UV curing lamps after section one, section six and the varnishing section were used, and the obtained results showed that white ink did not properly adhere to the paper surface due to low adhesion, as scratching with a fingernail, the ink layer scratched off. The same result was obtained when using CMYK inks on the print areas printed on the white ink. In contrast, the adhesion of CMYK inks proved to be good on the metallized surface areas, which were not covered with white inks. It can be stated that the quality of prints of the test printing on metallized cardboard with Siegwerk inks and using three H-UV drying lamps was poor.

Having identified the defect caused by Siegwerk's Opaque white ink, the latter was replaced with Toyo Opaque white for the subsequent printing experiment. For printing, three H-UV drying lamps were used. Based on the results of this test, it can be stated that the combination of Toyo Opaque white and Siegwerk (CMYK and Pantone) inks did not give a quality result either: adhesion of all ink colours is good, except black on the metallized base (but not on white). This indicates that the effect of radiation is insufficient since black, due to its colouristic properties, is the most absorbent of all colours and prevents UV rays from passing through the layer and fully polymerizing it.

The last test printing was conducted with JS Supra UV LED (Opaque white, CMYK) inks using three H-UV drying lamps. Testing of the prints showed that the adhesion of white ink and all CMYK inks to white colour is insufficient, and inks peel off with the help of adhesive tape. Only CMYK inks adhered well to the metallized areas of cardboard. The ink layer peels off when scratching with the fingernail. JS Supra UV LED inks did not give a good result when printing on the metallized cardboard: the adhesion of white and CMYK inks, printed on a white colour, is low.

The summarized results of the tests carried out immediately after printing are presented in Table 1.

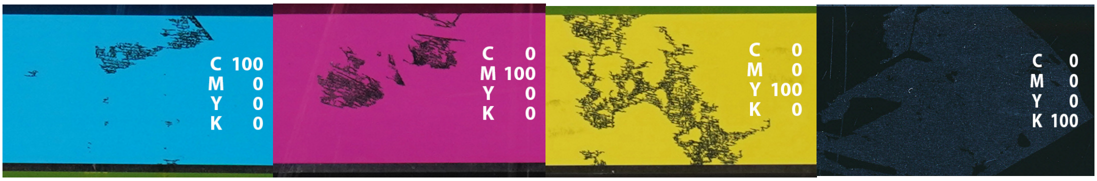

Fig.2. Assessment of the quality of prints using express-tests with TESA 4104 calibrated adhesive tape. Samples printed with Siegwerk inks (CMYK on a white colour)

Table 1. Results of Komori Lithrone LSX 629 + C H-UV printing tests on cardboard Metalprint Silk MP/METP (309 g/m^2)

No.	Printing inks/series, colour	Print speed, sheets/h	Number of H-UV curing lamps	Results of express evaluation of the print quality
1	Toyo FD LED - Opaque white, CMYK	9200	2	Negative: low adhesion of inks of all colours
2	Toyo FD LED - Opaque white, Toka - UV AD LED CMYK	9800	2	Partially positive, moderate adhesion of Opaque white inks, yet low CMYK
3	Siegwerk SICURA LOW NRGY Plast - Opaque white, CMYK, Pantone Reflex Blue	10000	3	Negative: low adhesion of white colour inks; low adhesion of CMYK inks printed on the white colour
4	Toyo - Opaque white, Siegwerk SICURA LOW NRGY Plast - CMYK	10000	3	Negative: low adhesion of black colour inks
5	JS Supra UV LED - Opaque white, CMYK	10000	3	Negative: low adhesion of white colour inks; low adhesion of CMYK inks printed on the white colour

Rub testing results. The prints on Metalprint Silk cardboard printed with Siegwerk inks were selected to test for rub resistance, as Siegwerk inks are commonly used in European countries. Six colour prints (Opaque White, CMYK, Pantone) were chosen for rub testing. The strips 1-11 (see Fig.1 and 2) were tested 24 hours after printing. Having done 200 and 500 rubbing cycles, the obtained result was visually evident: the inks of all colours rubbed off the prints, exposing the metallized cardboard's surface (Fig. 3).

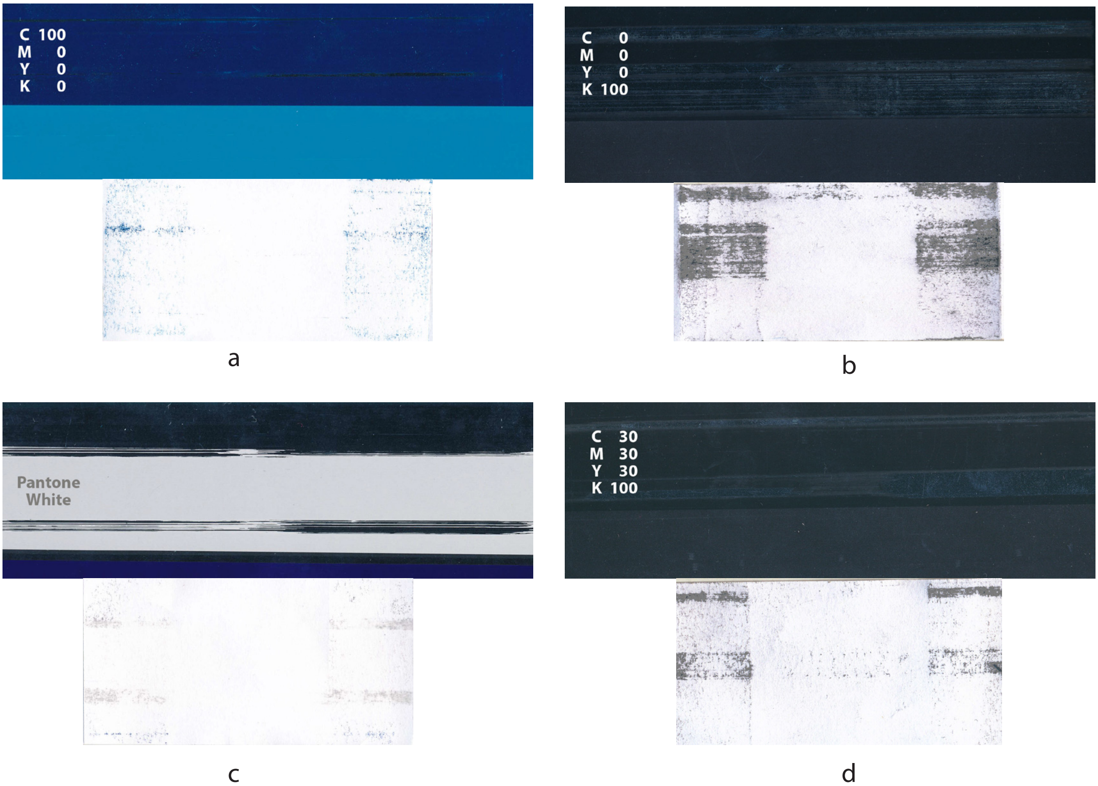

Fig. 3. Results of rubbing (200 cycles, 85 cycles/min, 1,81 kg), 24 hours after printing. Samples and receptors of Cyan 100 % (a), Black 100 % (b), White (c) and composite Black (C, M, Y at 30 % each, K 100%, d); Siegwerk SICURA LOW NRGY Plast ink

Having done rub tests of the samples with a rub tester, after 30 days (1000 rubbing cycles, speed 85 cycles/min, weight 1.81 kg), the results of spectrophotometric measurement show sufficient adhesion both to the surface of the metallized cardboard and the fragments of the surface covered with Opaque white ink (Fig. 4). The spectrophotometric measurements show an insignificant average in colour change ΔE_{00} on the samples (Table 2).

Table 2. Colour change averages ΔE_{00}, recorded by spectrophotometer eXact 2 on the print samples, 30 days after printing; Metalprint Silk MP/METP, 309 g/m^2 cardboard

Colour/surface	Cyan (strips 1, 2)	Magenta (strips 3, 4)	Yellow (strips 5, 6)	Black 1 (strips 7, 8)	Black 2 (strip 9)	Black 3 (strips 10, 11)	White
Metallized cardboard surface	1.14	0.88	1.33	1.18	0.92	0.39	1.04
Metallized cardboard surface covered with Opaque white	0.59	1.04	0.97	2.24	-	0.41	-
Receptor (white coated paper, 80 g/m^2)	0.53	0.46	0.44	0.56	0.26	0.25	0.45
*Black 1 (C0, M0, Y0, K100) *Black 2 (C60, M60, Y60, K100) *Black 3 (C30, M30, Y30, K100)							

a

b

Fig. 4. Results of ink rubbing (1000 cycles, 85 cycles/min, 1.8 kg), 30 days after printing. Samples and receptors of Cyan (a) and Magenta (b); Siegwerk SICURA LOW NRGY Plast ink

4. Conclusions

Having done the assessment of the technological process and its results of the Komori Lithrone LSX 629 + C hybrid printing press, the following was identified:

1. In the case of conventional printing on conventional materials, particularly Aegle Pro (245 g/m^2) cardboard using oil-based inks and following technological requirements, the prints are of high quality.
2. The transition from conventional printing with oil-based inks to H-UV printing with UV curing ink is complicated: the technological preparation according to the technical instructions (cleaning of the output device; washing of the ink rollers; change of the dampening solution; change of the offset rubbers; repetitive washing cycles of the ink rollers, etc.), which lasted for 23 hours (including both stages) and was carried out by three staff members, two qualified printing press operators and one printing-machine operator-instructor, representing the equipment suppliers.
3. In the course of the experiment, after the transition, the possibility of producing high-quality prints on non-absorbent surfaces using H-UV technology and UV curing inks available in the EU, as recommended by the equipment manufacturers, was not identified. The H-UV technology prints on the Metalprint Silk MP/METP (309 g/m^2) cardboard are of poor quality: inadequate adhesion on the surface and insufficient polymerization of the ink layer. The repetitive tests using different combinations of inks showed the following results: poor adhesion of the ink layer either in the entire area of the print (Table 1, Row 1), white colour and CMYK colours, printed on a white colour area (Table 1, Row 3 and 5), either in the areas of a black colour (Table 1, Row 4). In these areas, the inks peeled off when using an adhesive tape test and scratching with the fingernail. Partially satisfactory results were obtained with reasonably good adhesion using an adhesive tape. Still, partial delamination of the layer by nail scratching was observed only when the samples were printed using inks unavailable in the EU (Table 1, Row 2). An unsatisfactory result was achieved with any of the different ink combinations tested. Due to insufficient ink layer curing and adhesion, these prints are unsuitable for post-press processes immediately after printing or for a short time after printing.
4. The results of testing the prints in the laboratory after 24 hours using a rub tester (the prints printed with the Siegwerk SICURA LOW NRGY Plast inks as recommended by Komori) indicate insufficient rub resistance of the ink layer: even after 200 rubbing cycles, the ink rubs off the print and exposes the metallized surface of the cardboard (Fig. 3). The results of the rub resistance test after 30 days show a different result: the ink does not rub off from the print even after increasing the number of rubbing cycles to 1000 (Fig. 4). The average colour change ΔE_{00} recorded with the spectrophotometer X-Rite eXact 2 on the print samples and on the receptor ranges between 0.25 and 2.24 (Table 2), indicating a slight colour change within the tolerance limits.

Thus, in this case, the claim concerning the instantaneous polymerization and curing of UV inks under the influence of H-UV radiation on the Komori Lithrone LSX 629 + C hybrid offset press from the above-listed brands is not supported.

One of the possible causes can be inconsistency between the ink composition and the amount and intensity of H-UV radiation, too low concentration of the photoinitiators, which does not ensure the continuity of the polymerization process and leads to the too low formation of free radicals and /or premature termination of polymer chain growth (the lack of photoinitiators is indirectly indicated by the results of the scratching test carried out in the printing shop after printing). To justify the statements, further investigation of the chemical composition and physical properties of H-UV printing inks has to be carried out. Possible under-exposure to H-UV radiation due to too thick an ink layer can be rejected as the thickness of the ink layer is adjustable by setting standard density values.

As UV inks are chemically incompatible with oil-based printing inks, the technological incompatibility between conventional and H-UV technologies cannot be excluded. Conventional oil-based printing alters the condition of the offset printing unit (especially the ink rollers), and a transition to UV inks requires the removal of residual oil-based inks. As the study showed, this is exceptionally time-consuming, requires repeated washing cycles, and the use of many chemicals (pastes, saturators, detergents), and the residues can also damage the printing process. Thus, companies may face significant unproductive labour time to change ink type. The case study shows that using these printing presses for hybrid (conventional and H-UV in succession) printing is complicated.

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