COMPARATIVE TEST OF USING COPPER AND SILICONE PRINTING PLATES FOR SURFACE GILDING AT HUNGARYAN BANKNOTE PRINTING COMPANY

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Abstract:

Nowadays, there are numerous print surface treatment procedures applied, but surface hot foil stamping is unduly given little attention, though it can have ornamental, informative and protective functions on the surface.

Even the appearance of security printing products needs to meet increasingly demanding expectations. For stamps, backsides being as smooth as possible are becoming more and more important while workmanship on the gilded front side should feature perfect quality.

Our research was conducted to improve the quality of the products intended to be manufactured, and therefore in the case of base materials selected in view of predefined criteria studies and comparisons were made in relation to the usability and application potentials of copper and silicone stamp forms.

Security products may be made solely with the use of specific base materials (print carriers, gold foil). Practical tests were carried out on the machines used for hot foil stamping.

Keywords:

surface hot foil stamping, security products, backside pressure

1 INTRODUCTION

Creating striking, outstanding and unique products is a basic expectation of modern marketing strategies. A way of achieving this goal is the use of print surface treatment. These days little attention is paid to surface gilding - one of the several surface treatment processes - although it decorates, provides information and offers protection to the surface as well.

When using gilding technology, the material and the graphics of the printing plate, the gilding foil and the surface, the gilding machine, the print temperature, the pressing time and the pressure all strongly influence each other. In general the printing plate is made of a metal alloy (copper), which sufficiently withstands pressure and heat. However, in order to provide good quality surface gilding, high compression is applied with the result of an expressed deformity in the back panel. To resolve this problem, a silicone plate designed exclusively for surface gilding could be applied [2].

2 DESCRIPTION OF THE GILDING MACHINES IN THE TEST

Gilding tests were conducted using three different types of gilding machines at Banknote Printing Company. Two of the machines in the test (the FOMM BU panel press and the BAIER gilding unit of the automatic Kugler machine) perform gilding from a flat to a flat surface, while the STEUER PZ 82-3 foil press machine performs gilding from a flat to a cylindrical surface.

During the test different heat settings were applied (92 °C - 195 °C) - determined by the material and the technical parameters of the machines - to prepare the gilding samples at the Banknote Printing Company at 50% relative humidity and at an operating temperature of 23°C ± 2.

3 COMPERATIVE TEST OF SILICONE AND COPPER PRINTING PLATES

A 7 mm thick copper alloy is used for the copper printing plate, which is combined with other substances to achieve the desired properties (hardness, expected material deformation, malleability). The copper printing plate is used for gilding, made of one layer by mechanical milling *(Figure 1)*.

The silicone printing plate *(Figure 2)* is made up of three silicone layers with different hardness. The silicone (similar to the processing of copper) is mixed with "polluting" materials in order to achieve the desired material properties. This will allow for predictable material deformation. Then the silicone printing plate is attached to an aluminium base by a special adhesive, making it suitable for gilding [3].

Figure 1: Copper printing plate

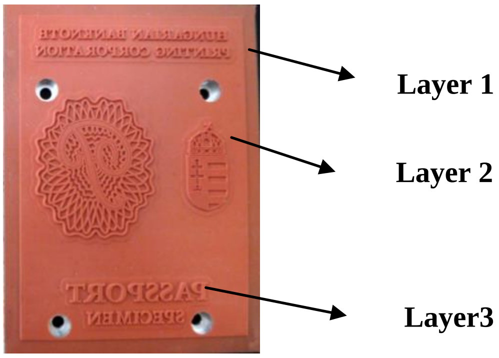


Figure 2: Silicone printing plate

3.1 Size variation of the tested printing plate parts

The printing plates were prepared for the test to contain texts with different letter sizes as well as line structures with various thicknesses. *(Figure 3)*.

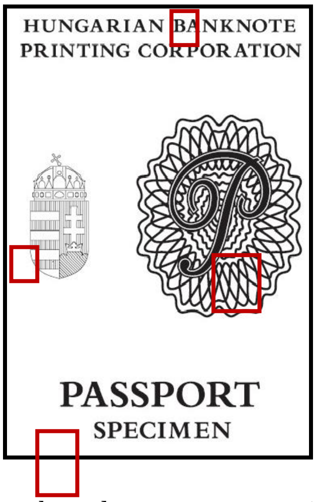


Figure 3: Location of the selected measurement points on the printing plates

Measurement points of the text parts on the surface of the printing plate are shown *in Figure 4 a)* and *b).*

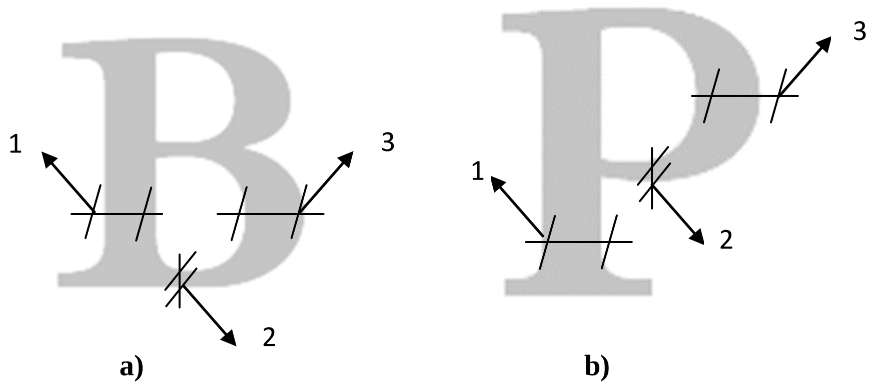


Figure 4: Illustration of measurement points on text printing plates.

A measurement point is located in the centre of the printing plate *(Figure 5.c)*, and *(Figure 5.d)*, for thin-line graphical elements. Similar to printing, thin-line elements are more difficult to handle in producing high quality, defect-free gilding.

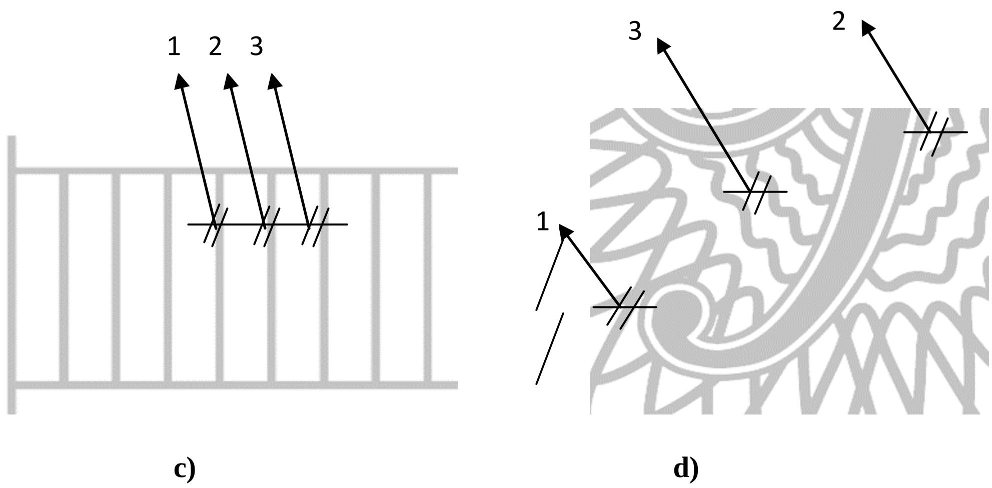


Figure 5: Illustration of measurement points c) a coat of arms and d) rosette printing plates

Selecting the measurement points for the gilding tests will provide important information on any distortion of gilded prints occurring during the use of printing plates.

3.2 Visual comparison of gilding samples printed with the use of various setting parameters
Gilding tests by semi-automatic gilding machines

Due to the structure of the copper and the silicone printing plates their heat absorption also differs, therefore different heat settings were used for gilding. Gilding tests were carried out at 120˚C and at 150˚C with the copper printing plate, and at 150˚C and at 195˚C with the silicone printing plate. Setting the test temperature for the copper printing plate was based on practical experience. These materials need a temperature of over 120°C to produce acceptable results. Due to the lack of practical experience with silicone printing plates, the maximum temperature setting (195˚C) was applied, determined by the technical parameters of the gilding machine. For the evaluation of the gilded samples a three-point scale was used *(Figure 6).*

1. highly incomplete, not recognizable print

2. small error, missing or overfilled parts, recognizable print

3. perfect print, appropriate quality

Figure 6: Quality phases of gilding

Evaluation of the gilded samples was based on the above pre-defined codes. Due to the lack of experience in determining gilding temperature when using silicone printing plates, preparatory tests were carried out at a lower temperature (120˚C). Based on the results of these tests the initial temperature setting of 150˚C was selected; at this temperature the print was recognizable.

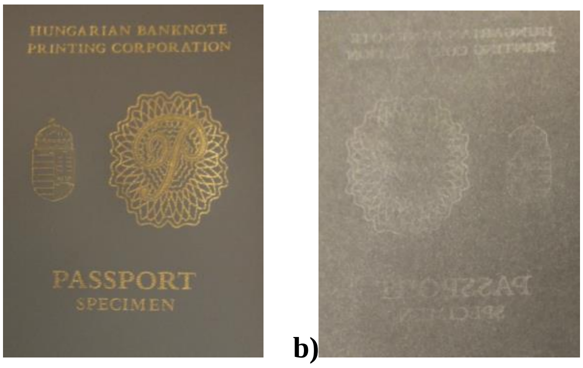
Gilding with the silicone printing plate was carried out at 150˚C and at 195˚C, printing on all the six selected substrates. The quality of gilding prints made with the silicone printing plate was evaluated using the three-point scale described above.

3.3 Gilding samples printed with the BAIER gilding unit

Based on practical experience, samples were gilded with the copper printing plate at 92˚C, and at 150˚C, so it can be compared to the semi-automatic gilding machine. Gilding tests with the silicone printing plate were also carried out at 150˚C and at 195˚C. Gilding was performed at the selected temperature, using 0.01s and 0.10s stamping time. Coding described above was used for the evaluation of the gilded samples. Visual examination was also performed on the six selected substrates printed using silicone printing plates [1].

3.4 Gilding samples with the STEUER PZ 82-3 hot foil stamping machine

The operating principle of the STEUER PZ 82-3 foil stamping machine is different from the two abovementioned machines (the semi-automatic and the BAIER unit) as it is able to gild from a flat to a cylindrical surface. The impression cylinder is made of steel. The operating temperature of the machine used for gilding using a copper printing plate is 170 °C, so this was set as the initial temperature for the gilding tests, at a speed of 1400 sheets/hour. The maximum temperature was determined by the technical parameters of the machine, and is 200˚C. Considering that this machine uses higher temperature for gilding as well, samples were printed at both temperature settings. The quality evaluation of gilding on substrates is classified by coding as described above.



a) **b)**

Figure 7: Gilded substrates showing strong deformity on the back. a) front, b) back

Substrates with highly structured surface and high surface roughness yield better print quality when using increased pressure, with the consequence of the appearance of a strong deformity on the back.

Gilding tests using the silicone printing plate were also performed for all six selected samples at 170˚C and 200˚C, at a speed of 1400 sheets/hour. Evaluation of gilding quality was performed according to the method described above. Regarding these substrates the print quality was not better at the higher (200˚C) temperature. The evaluation result is shown in a column chart *(Figure 8)*.

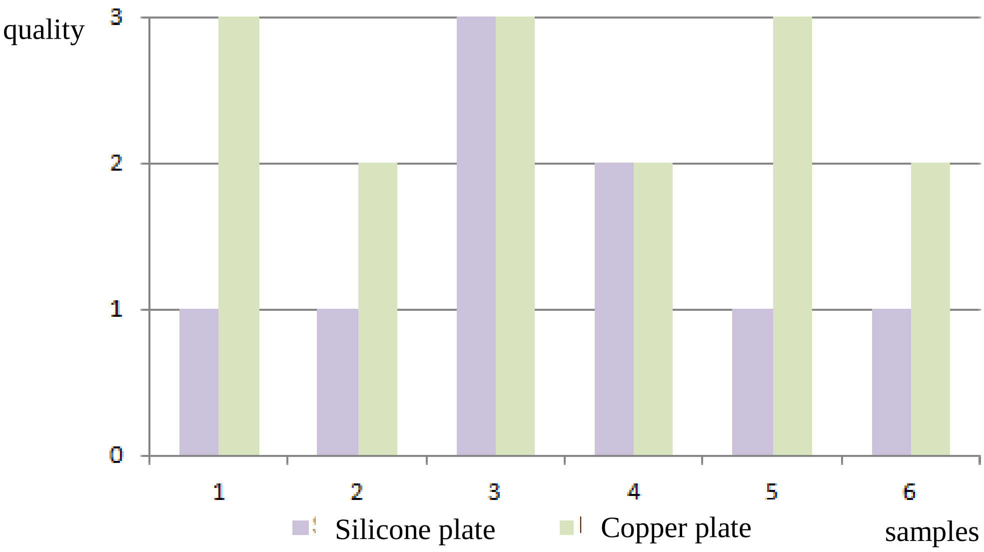
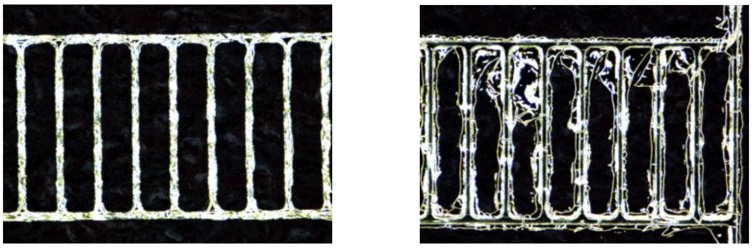


Figure 8: Quality rating of the gilded samples

In summary of the quality rating it can be stated that gilding printed by the copper printing plate in the case of samples 1, 2, 5 and 6 (stamp paper, matte coated paper, Grabiol PTL and Grabiol PTB) the quality of gilding is higher than the quality of samples printed by the silicone printing plate. Results of sample No. 4 (Grabiol Permi 06) offered the same quality for each printing plate. Sample No. 3 (Grabolit Extra substrate) provided acceptable gilding quality both by using the copper and the silicone printing plates, therefore this sample was selected to measure line distortion.

Measurement points selected for the Starrett AV 350+ 3D Multi Sensor 3D video microscopy test on the print match the points measured on the printing plates.

Due to the heat and pressure applied at gilding, the line thickness on the print image increases. In the case of the copper printing plate the line thickness value measured on prints was closest to the line thickness measured on the printing plate when the BAIER gilding unit was operating at 92˚C, and the STEUER PZ 82-3 foiling machine was operating at 170˚C. The core temperature of the STEUER PZ 82-3 gilding machine is 170˚C. Line thickness values closest to the printing plate values were measured at this temperature (letter "B", measurement point 2). Evaluation of the test results showed that the thickest line width was measured at the highest pressing temperature (150˚C or 200˚C) for all three gilding machines. This indicates that at high temperatures foils adhere to the substrate in a wider area because of the high heat transfer. The thickened lines will result in filling up, therefore the thin lines "merge". In the image created with the Starrett 3D video microscope at M/5 (83x magnification) it is clearly visible *(Figure 9)* that the print made at 92˚C has thin, sharp contours, while the same lines printed at 150˚C are significantly thickened.

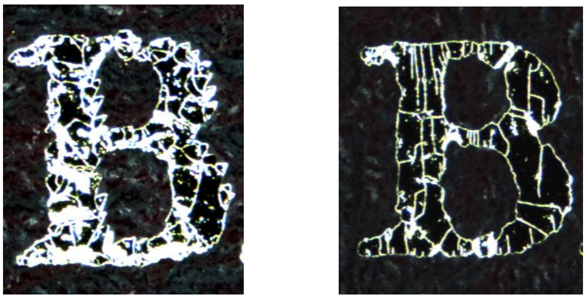


a) **b)**

Figure 9: Image made with a 3D microscope of a print of the BAIER gilding machine

a) at 92˚C b) at 150˚C

Line distortion was also measured using the microscope in the case of samples printed with silicone printing plates. Silicone printing plates are more flexible than copper printing plates, therefore pressure can only be increased moderately for adequate gilding, but it requires higher stamping heat, which is shown by the measured values. When lower heat settings were applied, the silicone plate could not transfer enough heat for the appropriate foil adhesion, so pressure had to be increased to achieve the desired result. Because of the flexibility of the plate, the increased pressure resulted in wider lines (larger line thickness values were measured). When comparing the print to the copper plate it is observed that measuring the letter "P" at measurement point 1 shows only a difference of 0.05 mm, while in the case of the silicone plate the measured difference was 0.50 mm, which is a one order of magnitude larger line thickness deviation. On 3D video microscope images it can also be observed that gilding made at low (92˚C) temperature using the silicone printing plate, line edges are "less defined" and tend to follow the surface patterns of the substrate. By increasing the gilding temperature, line edges became more and more defined, but no filling-in appeared in contrast to the copper printing plate *(Figure 10)*.



a) **b)**

Figure 10: Image made with a 3D microscope of a print of the BAIER gilding machine a) at 150˚C, b) at 195˚C

When gilding with the silicone printing plate is carried out at higher (195˚C) temperature, it can be observed that the foil becomes smoother and smoother, similarly to the case using the copper printing plate.

4 SUMMARY

During the gilding tests three different types of machines were used – a FOMM BU semi-automatic gilding machine, a BAIER gilding unit, and a Steuer PZ 82-3 foil press machine.

The gilding tests with the copper printing plate showed that by using any of the three machines, prints of relatively good quality can be created even at lower temperatures, but higher pressure is necessary. The gilding tests with the silicone printing plates were carried out at higher temperatures, because the heat transfer of silicone to foil is worse than that of copper. Gilding test results revealed that four out of the six samples showed better print results when using the copper printing plate, while in the case of samples 3 and 4, both printing plates created good print samples. When using the copper printing plate, back panel deformity was observed in each case, while this did not occur with the use of the silicone printing plate.

Line distortions were also monitored on prints. Lines on prints made with the copper printing plate thickened at higher temperatures, because applying higher heat made the foil adhere on a wider area. When using the silicone printing plate for gilding, the lower was the temperature, the thicker became the lines, in some cases up to 0.50 mm thicker than measured on the printing plate. Line thickening is indirectly related to temperature, since gilding is determined by the optimal setting of heat and compression. Since silicone is flexible, it gets distorted due to increased pressure, resulting in the thickening of the printed image.

As a continuation of the study we recommend the use of various gilding foils for the gilding of the selected substrate, as well as including gilding machines in the study that can provide a gilding temperature of over 195 °C.

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