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The Effect of Engraving Depth and Silicon Geometry on Pad Printing Efficiency

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Abstract – The fast-growing printing technologies play a significant role in increasing promotional and advertising activities in the manufacturing industry. Among these technologies, pad printing is a method in which the drawn image is transferred to the object directly. This method can be used in all other sectors in terms of permanence, production speed, and ease of use. To perform the pad printing process with a zero-defect policy, parameter optimization is vital. To obtain the desired efficiency, the main parameters affecting pad printing need to be enhanced and applied during the whole process such as engraving depth and silicon geometry. This work aims to observe the effects of the engraving depth and silicone geometry printing parameters on pad printing quality. With the optimized settings, the durability of the printing has been increased, the printing time performance has been improved and the error-free printing goal has been succeeded. The alterations made in engraving depth and silicone geometry were examined and the maximum printing efficiency and productivity are reached in our pad printing process.

Keywords *– Pad Printing, Engraving Depth, Silicon Geometry, Efficiency, Optimization*

I. INTRODUCTION

Printing techniques; requested colour, text, picture, shape, logo, etc. It is the name given to the whole of the methods used to print materials on any object. A variety of printing methods are used in many industries such as marketing and advertising, hobby products, photography, printing, and publishing.

The most commonly used printing techniques among these activities are offset printing, flexo printing, screen printing, intaglio printing, UV digital printing, and pad printing. Offset, Flexo, and Gravure printing in the printing industry; Screen printing in the textile industry; UV digital printing is used in the marketing and advertising industries.

Pad printing, which is one of these methods, is on small, large, curved, flat, and complex parts; It is frequently preferred in industries due to its ability to print on all kinds of materials such as metal, plastic, silicon, as well as short preparation times for the process and fast printing application times. In addition, its efficiency is higher than other printing types due to minimal faulty printing.

Pad printing: It is a printing technique made by using a cliché, printing pad, and printing ink. The piece called cliché is a sheet metal material. The pattern desired to be printed on the cliché is processed by carving or embossing on the metal sheet plate, thanks to the necessary equipment. After the paint in the paint reservoir on the cliché is transferred onto the cliché, the print pad transfers the pattern onto the product. As a result of this process, which must be repeated more than once for some surfaces, the part is pressed [1].

Frequently preferred in industries, it is important to use the pad printing method most efficiently. We use cycle time and print quantity parameters to measure efficiency in pad printing. Completing the printing in a single cycle instead of completing the printing on a part in 4 cycles will reduce the cycle time, increase the production quantity, and increase the efficiency of the process. The desired efficiency can be achieved by making changes in the factors affecting the efficiency of pad printing [2]. There are 2 main factors that affect efficiency:

- Cliché engraving depth
- Geometry of the Printing Pad

Engineers must optimize both factors taking into account the characteristics of the part to be printed and the desired motif.

Depending on the structure of the pattern to be embroidered on the product, if the cliché engraving depth parameter is increased or decreased in microns, the cycle time can be reduced as a positive result, or the pattern may be printed incorrectly as a negative result [3].

If the printing pad geometry parameter is not selected according to the product to be printed, the cycle time may increase, and the pattern may be formed incorrectly or not at all [3].

In this article, the barrel product, which is the most used in the industrial lock sector, produced with Zamak-5 raw material and has a complex geometry, is discussed. Since the housing product is used both indoors and outdoors, the process performed in pad printing is important because it also appeals to the visual. In this study, the effect of changing the parameters affecting the pad printing on the sleeve on the print quality and productivity was investigated.

II. FACTORS AFFECTING EFFICIENCY IN PAD PRINTING

II.I. Geometry of Print Pad (Silicone Geometry)

It is a pad printing element that transfers the desired pattern to the surface to be printed by absorbing the ink in the cavity on the cliché. One of the factors affecting the quality of the pattern on the product is this printing element.

In order to obtain high efficiency and quality in pad printing, the transfer between the cliché and the product must be trouble-free. For this reason, a silicone suitable for the desired pattern should be selected for the product and product to be printed. For example, it would be appropriate to use a round pad for a product with oval surfaces, and a print pad with a square structure for a product with a square surface.

For many years, gelatine, which is obtained by boiling the protein in the collagen substance found in animal bone and muscle connections, has been used as a silicone material for many years and is still used by ceramic, tile, watch manufacturers, etc. continues to be used in industries such as Today, quartz is used, which is obtained by placing organic groups instead of silicon molecules bonded to two oxygen atoms. This quartz structure is flexible and maintains its flexibility even at high temperatures. They do not react with water, do not decompose, and are waterproof. It does not insulate electricity and has high chemical resistance.

Although they are flexible, their hardness values should also be considered. While hardness values affect the lifetime of the silicone, it is also one of the factors that determine the quality of the work. When the hardness of the silicone pad increases, the desired pattern on the product becomes more visible. Silicone manufacturers determine their hardness according to Shore A (DIN53505) standards [4]. According to the structure of the silicone pad, 0 to 10 Shore A is selected so as not to damage the product to be printed.

Hardness ⬆ Silicone ⬆ Lifetime Quality ⬆

One of the most important factors affecting pad printing is silicon geometry. Although they all seem like curved geometry, the angles given from the center to the tip change according to the shape of the printed product. For example, if silicone is to be selected for a piece with a pointed inward groove, it would be appropriate to choose a more right-angled silicone. (Fig.1) For products with softer curves and not a pointed inner cavity, silicone with a low apex angle should be chosen. (Fig.1).

Fig.1. Pointed Silicone - Non-pointed Silicone [5]

Silicone size should also be 20%-40% larger than the printed product [6]. When this size is smaller than the printed product, the desired pattern may not be transferred in the full image, and when this size is large, there may be overflows in the desired pattern.

The most used silicon geometries are they are round-shaped, corner-shaped, and fishbelly-shaped silicones.

II.I.I. Round Geometry Silicones: Silicones with round geometry are one of the most used types. These silicones make the rolling movement on the product more comfortable than silicones in other geometries. The spreading movement of the ink on the product occurs evenly. The desired pattern can be transferred to the product at once and clearly [7].

II.I.II Rectangular Geometry Silicones: Square, rectangular, etc. may be in the form of They have a conicity in their centers so that they can make the rounding movement on the product [7].

II.I.III Fishbelly Silicones: It is one of the varieties that show similar features to the rectangular geometry but form a narrower type of surface that needs to be pressed. There is a conicity in the middle area so that they can make the rounding movement on the product [7].

Fig.2. Fishbelly Silicone - Rectangular Geometry Silicone - Round Geometry Silicone [5]

II.I.IV Special Geometry Silicones: Buffers in this geometry are generally used in products with complex geometry to be patterned. More than one silicon can be mounted together. Their cost is higher than silicones in other geometries.

As a result, to have an efficient production in pad printing.

- Round or conical silicones should be selected [6].
- It should be noted that it is wide-angle [6].
- The pattern should be 20%-40% larger than the size of the transferred product [6].

II.II. Engraving Depth

The cliché is one of the elements of pad printing machines. Clichés produced from emulsion-coated steel material are specially produced for each pattern to be printed. Generally, 3 types of clichés are used: thin steel clichés, Polymer Clichés, and Cylindrical Steel Clichés. Thin steel clichés, which we examined in our article, are very durable and provide the opportunity to print for a long time, so they are frequently preferred clichés.

To use thin steel clichés in printing; writing, shapes, and patterns should be processed by creating a hole on the plate. Abrasive chemicals are used while carving patterns on the plate. The printing life of Thin Steel Plates is between 100,000 and 250,000 cycles in closed chamber machines, and between 50,000-70,000 cycles in open chamber machines. Thickness dimensions of standard thin steel clichés vary between 0.30-0.50 mm [8].

Fig.3. Cliché

In pad printing machines, 2 different systems are used for ink absorption and printing. These are the open ink tank and the closed ink tank, which we mentioned above. In the open ink tank, the top of the ink tank is open. A pressure element called a "Doctor Blade" smears the paint from the reservoir and fills the cavity inside the cliché. In the covered ink chamber, the ink in a closed sliding chamber comes over the cliché and fills the ink into the cavity of the cliché, then while returning to its original position, it scrapes the excess paint and takes it back into the chamber. Closed chamber machines, which are also the method we will use in our article, can be used for longer periods with 100% efficiency due to the fact that the paint does not dry. In addition, it offers an ergonomic use as it does not spread the smell of paint around it.

Printing pads absorb the paint from these cavities on the cliché and print on the product. For this reason, the cliché's engraving depth changes the amount of ink and causes a change in the quality of the print. Mostly, the engraving depth of thin steel clichés varies between 20-40 microns [8]. Unnecessarily deep cavities may cause the ink to disperse on the product to be printed, while poor quality printing results in cases where the cliché cavities are low. For this reason, it is vital for the pad printing process to determine and apply the optimum engraving depth of cliché.

III. CASE STUDY

In this study, pad printing on the sleeve product used in the lock sector is discussed. By changing the silicon geometry and engraving depth parameters, the change of pressure on the product and its effect on yield were investigated.

To examine the effect of silicon geometry, 3 different types of silicon were used. The photos of the silicon geometries are as follows.

Fig.4. Fishbelly Silicone - Rectangular Silicone - Round Silicone

In order to examine the effect of cliché engraving depth, 3 different cliché types were used. The difference between these clichés is the hollow depth measurements. Cliché engraving depth micron values are 3 pieces: 28-30µ, 30-32µ, and 36-38µ.

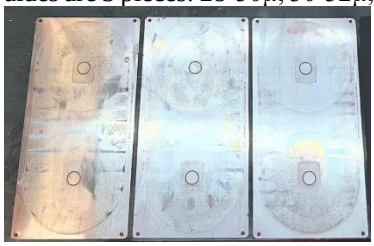

Fig.5. 28-30 µ, 30-32 µ, and 36-38 µ. Cliché

While examining the print qualities in the experiments, it was taken into account that a visually uninterrupted pattern was printed. A witness sample was used for visual control (Fig.6). It was reported as a result of the experiments that how many prints should be made until the print quality on the witness sample is uninterrupted and in the desired colour. In our experiments, a red circular pattern was printed on the housing product (Fig.6). By dividing the printed housing surface into 4 regions, the print quality in each region was examined one by one. These regions are named as A region, B region, C region, and D region (Fig.6).

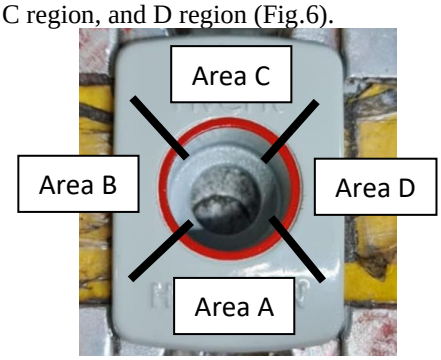

Fig.6. Witness Sample

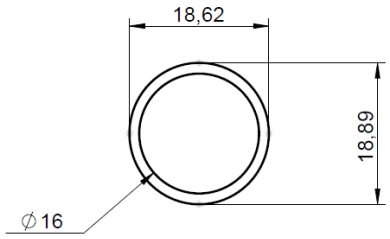

Fig.7. Pattern printed on the witness sample and its dimensions

III.I Experiment

Three different types of silicone were used in the experiments with the cliché at 28-30 micron degrees.

III.I.I Case of using Fishbelly Print Pad: In the first printing, ink was transferred only to regions A and C on the product surface, and it was seen that the ink could not be transferred in regions B and D. It was seen that the print coverage was insufficient, and the paint colour tone was not suitable. In the 2nd printing, it was seen that the paint coverage was insufficient in the A and C regions on the product surface, and the paint was transferred this time in the B and D regions, but the print coverage was insufficient. Appropriate colour tone not seen. In the 3rd printing, it was seen that the ink overflowed beyond the A and C regions of the product surface area, the print coverage was high, and the colour tone was appropriate. It was seen that the print coverage was insufficient, and the colour tone was not suitable for the B and D regions. In the 4th printing, it was seen that the ink overflowed beyond the A and C regions of the product surface area, the print coverage was high, and the colour tone was appropriate.

III.I.II Rectangular Print Pad: In the trials made with the cliché at 28-30 micron degrees, it was observed that the pattern was transferred to all parts of the product surface in the 1st printing, and it was observed that the print coverage was insufficient and the paint colour tone was not suitable. In the second printing, it was observed that the paint coverage on the product surface was still insufficient, and the colour tone was not suitable. 3. It has been observed that the paint coverage is insufficient on the paint product surface, but the colour tone is appropriate.4. In printing, the paint coverage is sufficient, and the colour tone is appropriate on the paint product surface.

III.I.III. Round Print Pad: In the trials made with the cliché at 28-30 micron degrees, it was observed that the pattern was transferred to all parts of the product surface in the 1st printing,

and it was observed that the print coverage was insufficient and the paint colour tone was not suitable. In the second printing, it was observed that the paint coverage on the product surface was still insufficient, and the colour tone was not suitable. 3. It has been observed that the paint coverage is insufficient on the paint product surface, but the colour tone is appropriate.4. In printing, the paint coverage is sufficient, and the colour tone is appropriate on the paint product surface.

III.II Experiment

In experiments with clichés with an engraving depth of 30-32 microns, pressure pads with fishbelly, rectangular, and round geometries were used, and it was observed that the same results were obtained with 28-30 micron experiments.

III.III Experiment

III.III.I Fishbelly Print Pad: In the experiments made with the cliché at 36-38 micron degrees, it was observed that the paint was transferred to the product surface in the 1st printing, but the print coverage was insufficient in all regions. In addition, it was observed that the paint colour tone was appropriate. In the 2nd printing, it was observed that the paint coverage was insufficient in the B and D regions on the product surface, but there was overflow in the A and C regions. In the 3rd printing, it was observed that the overflow area of the paint product surface area increased in the A and C regions, the print coverage was high, and the colour tone was appropriate, while the print coverage was sufficient, and the colour tone was appropriate in the B and D regions.

III.III.II Rectangular Print Pad: In the experiments made with the cliché at 36-38 micron degrees, it was observed that the pattern was successfully transferred to the product surface in the 1st printing, and the print coverage was sufficient. The colour tone of the paint is suitable. With a single print, the same quality of the print was obtained as the witness sample.

III.III Round Print Pad: In the experiments made with the cliché at 36-38 micron degrees, it was observed that the pattern was transferred to all surfaces of the product in the 1st printing, but the printing covering was insufficient. The paint colour tone is not suitable. In the second printing, it was observed that the paint coverage on the product surface was still insufficient, and the colour tone was not suitable. 3. It has been observed that the paint coverage is sufficient, and the colour tone is appropriate on the paint product surface in printing.

IV. RESULTS

The increase in efficiency is inversely proportional to the number of repetitions. As the number of repetitions increases, the efficiency decreases, and as the number of repetitions decreases, the efficiency increases. If we compare the yields with the number of repetitions above;

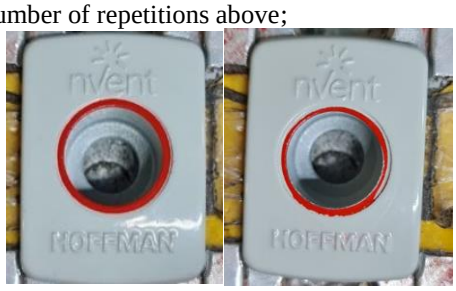

Fig.8. Proper printing Sample-improper printing sample

	Fishbelly Silicone	Rectangular Silicone	Round Silicone
28-30 Micron Depth Cliché	4 Repetitions	4 Repetitions	4 Repetitions
30-32 Micron Depth Cliché	4 Repetitions	4 Repetitions	4 Repetitions
36-38 Micron Depth Cliché	3 Repetitions	1 repetition	3 Repetitions

Table.1 Print Pad Repetitions

	Fishbelly Silicone	Rectangular Silicone	Round Silicone
28-30 Micron Depth Cliché	0%	0%	0%
30-32 Micron Depth Cliché	0%	0%	0%
36-38 Micron Depth Cliché	33.33%	100%	33.33%

Table.2 The Effect of Pad Printing Parameters on Yield

V. DISCUSSION

The study aims to examine the effect of engraving depth and pad geometry parameters on printing efficiency in pad printing machines. The criterion is based on print quality; the pattern desired to be printed is in the appropriate color tone, uninterrupted, and covers the entire printed surface. For this reason, the Witness sample was used for comparison and the number of pressures required for each input of the experiment was noted by making observations.

VI. CONCLUSION

Although multiple prints made with rectangular pad and round pad give the same quality results, the Fishbelly Pad does not give a quality print no matter how much the number of prints is increased. This is because the Fishbelly pad is not suitable for circular printing due to its geometry. In the prints taken with the fishbelly pad, overflows occur in some areas on the surface to be printed.

As a result, it was determined that the most suitable buffer geometry to be used for the housing product we used in the experiment was a rectangular buffer and a cliché with an engraving depth of 36-38 microns.

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