# The effect of printing inks on both hardness and thickness of flexographic plates produced digitally versus flexographic plates produced by 3D printing technology "applied by Fused deposing modeling technology "

**Prof. George Nubar Semonian**
**Faculty of applied arts-Printing, publishing and packaging department -Helwan University-Egypt.**
**george.nubar@acu.edu.eg**
**Assist. Lect. Suzan Mohamed Farahat Hassan**
**Faculty of applied arts-Printing, publishing and packaging department -Helwan University-Egypt**
**suzanfarahat2030.SW@gmail.com**

## Abstract:

One of the most important challenges facing the flexographic plate manufacturers and by extension in the field of flexographic surface prepress is the stability of the rate of change in the physical and chemical properties of the flexographic surface, whether during the photo-engraving process and the subsequent processes of developing drying, and, final exposure, then the printing process and what it faces from other challenges, which are friction power resulting from the continuous contact between the anilox cylinder and the flexographic surface, and then transferring the inked image to the surface of the material continuously during the printing run in the presence of impression cylinder.

The characteristics of the printing ink components is considered one of the most important factors affecting hardness and thickness of the flexographic surface, whether the type of ink has a solvent based or water based, or even of the type of inks with ultraviolet dryness. Each of these types has a direct effect on the physical behavior of the thickness and hardness of the flexographic surface during Print Production.

The research aims to develop a guideline for the rate of change of thickness and hardness of the printing flexographic plate with 3d-printing techniques "by applying the fused deposition modeling technique" by comparing it with the flexographic plates produced by digital methods. The study followed the descriptive, analytical and experimental method and found a convergence in the rate of change for both the hardness and thickness of the flexographic plates produced digitally and the flexographic plates produced by the technique of 3D printing "by applying the fused deposition modeling technique" Over the course of twelve hours, in the case of water-based inks and UV-treated inks, while in the case of solvent-based inks of the type of nitrocellulose inks, the rate of change was higher in both types of flexographic surfaces, whether digital or produced by 3D printing technology, in addition to the splitting of the polymer layer in the flexographic plate produced by 3D printing from the polyester backing film after eight hours of testing.

## Key words:

The printing flexographic plate -Hardness-thickness- solvent based ink- water based ink – uv ink

DOI: 10.21608/MJAF.2021.62782.2213

## Introduction:

One of the most important challenges facing workers in the manufacture of flexographic plates and workers in the field of flexographic plate equipment is the stability of the rate of change in the physical and chemical properties of the flexographic plate, whether during the photo-engraving process and the subsequent processes of exposure and drying, post exposure, then the printing process and what it faces from other challenges, which are forces of friction resulting from continuous contact between the anilox cylinder and the flexographic plate , and then transferring the inked image to the surface of the material continuously during the printing run in the presence of the impression cylinder. One of the most important physical characteristics of interest by printers that rely on flexographic plates is the extent to which the printing plate is able to maintain the lowest rate of change in thickness and hardness during printing processes in order to achieve the main elements of any production process, namely achieving the largest amount of production while maintaining the required quality level at the lowest possible economical cost. The properties of the printed ink are considered among the most important factors affecting the hardness and thickness of the flexographic plate, whether the type of ink has a solvent or water base, or even of the type of inks with ultraviolet curing. Each of these types has a direct effect on the physical behavior of the thickness and hardness of the flexographic plate during a print production.

**Research problem:**

The rate of hardness and thickness of flexographic surfaces changes upon continuous exposure to printing inks, whether solvent-based, water-based, or UV-curing inks for long periods, which consequently affects the quality of the printed production.

**Research Significance:**

Measuring the rate of change of hardness and thickness in each of the digital flexographic plates versus the flexographic plates produced by 3D printing technology "by applying the fused deposition modeling technique" in the presence of the most used printing inks in the field of printing and packaging.

**Research Objective:**

Developing a guide for the rate of change of thickness and hardness of flexographic plates printed with 3D printing technology "by applying the fused deposition modeling technique" by comparing them with their analogs from the flexographic plates produced by digital methods.

**Hypothesis:**

The research assumes that:

- Changing the hardness and thickness of flexographic plates, whether digitally produced or produced by 3D printing technology in the presence of water-based inks
- Changing the hardness and thickness of flexographic plates, whether digitally produced or produced by 3D printing technology in the presence of solvent based inks

• Changing the hardness and thickness of the flexographic plates, whether digitally produced or produced
by 3D printing technology, in the presence of UV-curing inks.

**Methodology:**
This research follows the descriptive, analytical and experimental method.

**First: The theoretical framework:**

**plate hardness:**

There are some technical considerations and tests to ensure the quality and accuracy of the used printed plates, the most important of which is the measurement of hardness and its resistance to solvents, inks and other standard tests.

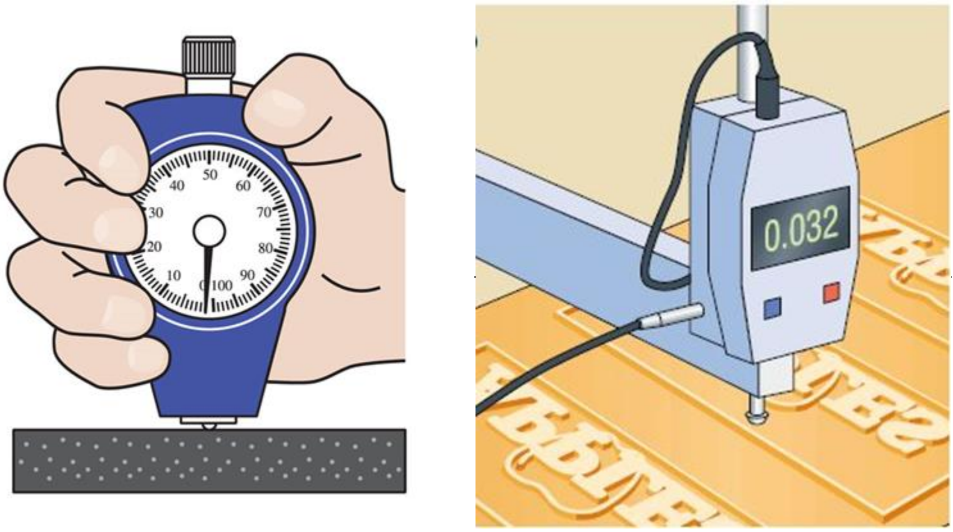


**Figure (1) shows the different shapes of the durometer used to measure the hardness of flexible materials**
**https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQMqsBQc84dN3V2tjUiZYz1H4lzbvAXnUk03g&usqp=CAU**

The hardness is measured by the ratio of the strength of the elastic surface of the piston pressure, ranging from 0 (the most elastic) to 100 (the hardest). The hardness is measured by unit (Shore), the more elastic materials get to occupy the slice (Shore A), while the hardest materials measure (Shore D). For example, in the case of flexible plates if the surface hardness is 45A for a thickness ranging between (0.045-0.100) inch, temperature factor is one of the factors affecting the hardness measurement of flexible surfaces, especially photopolymer colors. The higher the temperature of the material, the higher the reading indicates the elasticity of the printed surface. Second item: plate thickness: The thickness of the printed surface is one of the most important criteria that must be controlled and measured due to its effect on the rate of the print pressure during printing, and the permissible convergence rate reaches 12 microns in high-quality printed plates, and to measure the thickness of the printed plate, it is measured using a micrometer device for flexible materials. In the case of flexographic plates, it can be measured with high-precision devices to monitor any change, no matter how small, in the thickness of the printed surface. The micrometer used in measuring the thickness of raw materials has many shapes and is divided into: analog indicators and digital indicators.

**Printing Inks:**

Flexographic ink is one of the main elements within the printing process as it is the color translator of the details formed on the print plate and responsible for its transfer on the surface of the material, and the used ink should meet the requirements for final operation, in terms of physical properties that enable the formation of ink, and the size of ink particles and their behavior during printing. In addition to achieving the basic elements of the efficiency of the printing ink, whether in terms of hardness, sharpness, color strength and stability of the material printed on it, we cannot overlook the relationship and nature of the flexographic ink with the nature of the surface material. Classification of flexographic inks according to the old systems is water-based inks, solvent-based inks, and UV-curing inks. On the other hand, inks can be classified according to their components, which start with resin, which is responsible for determining the printability, rheology, viscosity and adhesion strength, and the second component, which is the solvent, is responsible for determining the extent of ink's ability to flow and transfer from ink reservoir cylinder to anilox cylinder and from there to the surface of the material, the third component is additives, which are responsible for improving the luster rate or increasing opacity, as well as improving heat, moisture and resistance properties.

**Experiment description:**

Prepare four samples of flexographic plates: Three of them were produced with traditional digital processing techniques for flexographic plate for companies that already produce flexographic plates , namely "lucky-flint-assahi", and the fourth sample was produced by 3D printing technology, specifically FDM technique "fused deposing modeling" inside glass containers, which are sealed with a weight of 10 g of water-based ink while maintaining a direct contact between the photopolymer layer of the flexographic plate and the ink film . The rate of change of thickness and hardness of each sample is measured over a period of twelve hours and the readings are recorded as shown in figure (2), and figure (3).

**Operating conditions:**

Temperature: 22 ° - humidity level: 30%. Ink type: IKATE water-based ink - Thinning ratio: 10% Ink viscosity: 36 seconds with Zhan cup 2

**Devices and tools:**

- Sealed glass containers of water-based ink with 10% dilution
- A durometer
- A device for measuring surface thickness of micrometer
- Digital Balance, Zhan cup 2 ink viscosity measuring instrument

## Results:

The measurement results for thickness are shown in the following figure, where the vertical axis is in millimeters and the horizontal axis represents the number of hours.

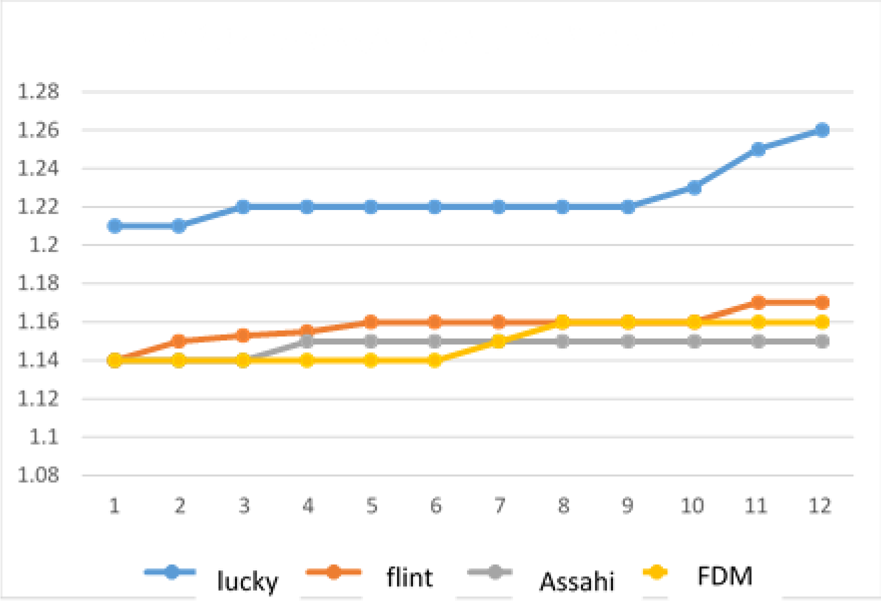


**Figure (2) shows a graphical representation of the average readings of the thickness in the water-based inks resistance test**

The measurement results for Hardness are shown in the following figure, where the vertical axis is in Shore A unit, and the horizontal axis represents the number of hours.

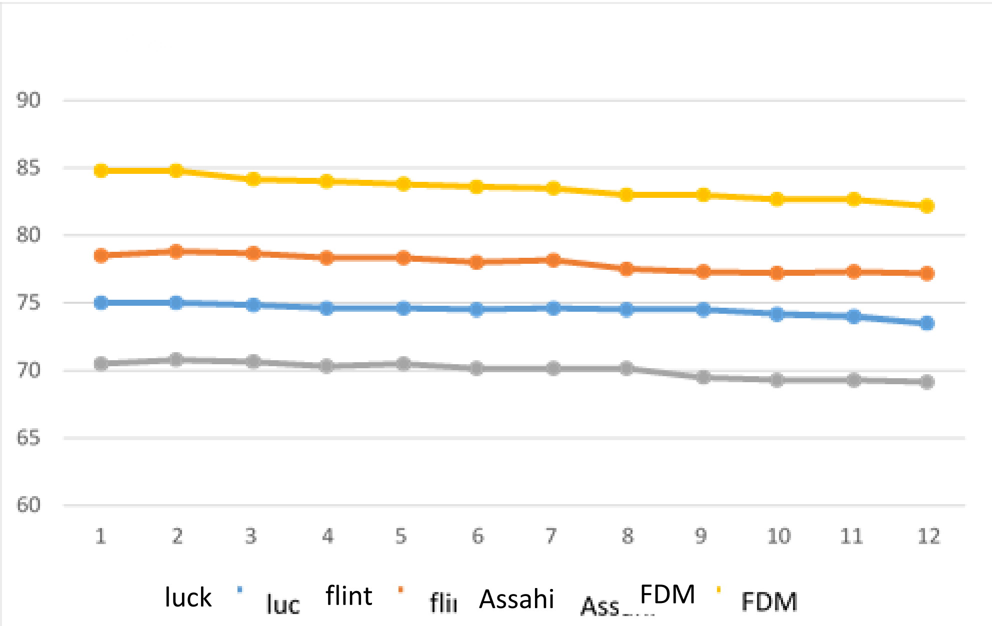


**Figure (3) shows a graphic representation of the average hardness readings in a water-based inks resistance test**

**Second: In the case of solvent-based inks, "nitrocellulose inks":**

**Experiment description:**

Set four samples of the flexographic plates: Three of them were produced by the techniques of traditional digital processing of flexographic surfaces and the fourth sample was produced by 3D printing technology, specifically FDM "filament deposing modeling" inside sealed glass containers with a weight of 10 g of ink, the solvent of the base with maintaining direct contact between the photopolymer layer of the flexographic surface and the ink film. The rate of change of thickness and hardness of each sample is measured over a period of twelve hours and the readings are recorded as shown in figure No. (4) and figure No. (5).

**Operating conditions:**

Temperature: 22 ° - humidity level: 30%. Ink Type: IKATE Solvent Based Ink
Dilution: 20% Solvent type: 15% ethanol alcohol - 5% ethyl alcohol
Ink viscosity: 30 seconds with Zhan cup 2

**Devices and tools:**

• Sealed glass containers with solvent based ink with 20% dilution • A durometer
• A device for measuring surface thickness of micrometer
• Digital Balance, Zhan cup 2 ink viscosity measuring instrument

**Results:**

The measurement results for thickness are shown in the following figure, where the vertical axis is in millimeters and the horizontal axis represents the number of hours.

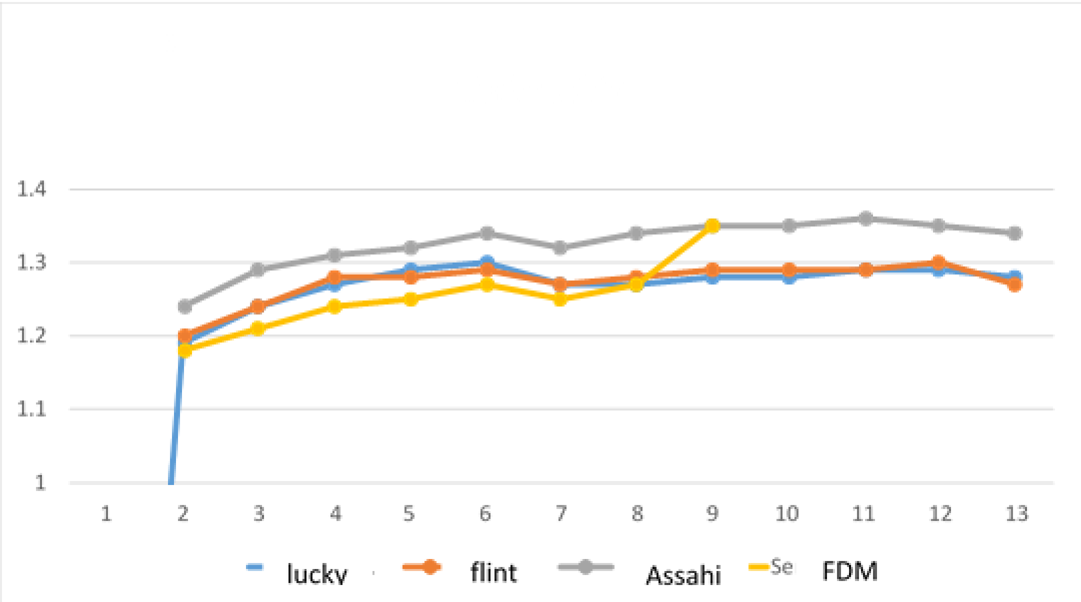


**Figure (4) shows a graphical representation of the mean readings of thickness in the solvent-based ink resistance test Nitrocellulose Inks**

The measurement results for hardness are shown in the following figure, where the vertical axis is in Shore A unit and the horizontal axis represents the number of hours.

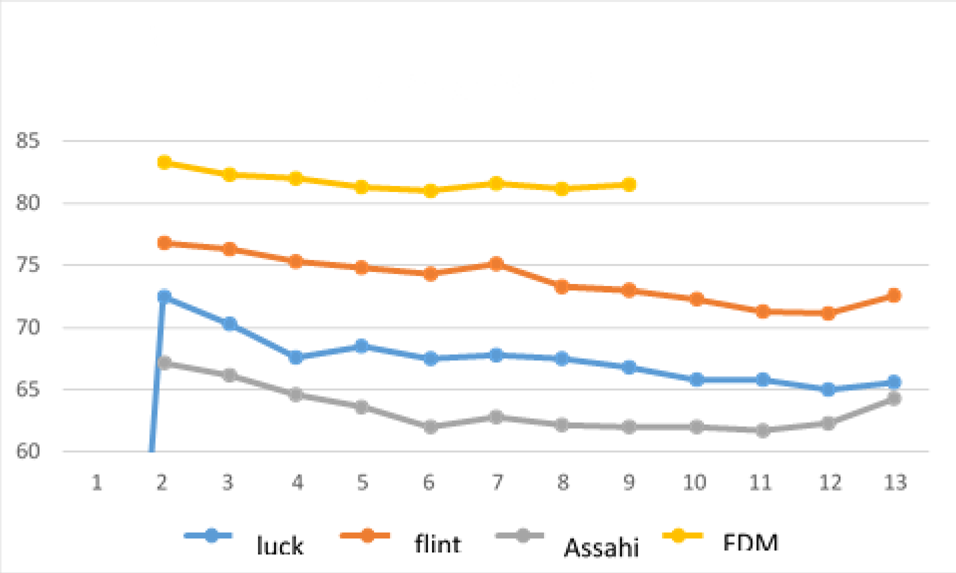


**Figure (5) shows a graphic representation of the average hardness readings in the solvent-based ink resistance test Nitrocellulose Inks**

**Third: In the case of inks treated with ultraviolet curing:**

**Experiment description:**

Set four samples of flexographic plates: three of them were produced with the traditional digital preparation techniques for flexographic plates, and the fourth sample was produced by 3D printing technology, specifically FDM "filament deposing modeling" inside sealed glass containers with a weight of 10 gm of ultraviolet curing ink ,while maintaining a direct contact between the photopolymer layer of the flexographic plate and the ink film, the rate of change of thickness and hardness of each sample is measured over a period of twelve hours and the readings are recorded as shown in figure No. (6) and figure No. (7).

**Operating conditions:**

Temperature: 22 ° - humidity level: 30%. Ink Type: Solvent Based Ink - Dilution: 20% Solvent type: toluene alcohol Ink viscosity: 70 seconds with Zhan cup 3

**Devices and tools used:**

• Sealed glass containers with UV ink with 20% reduction • A durometer
• A device for measuring surface thickness of micrometer • Digital Balance

## Results:

- The measurement results for thickness are shown in the following figure, where the vertical axis is in millimeters and the horizontal axis represents the number of hours.

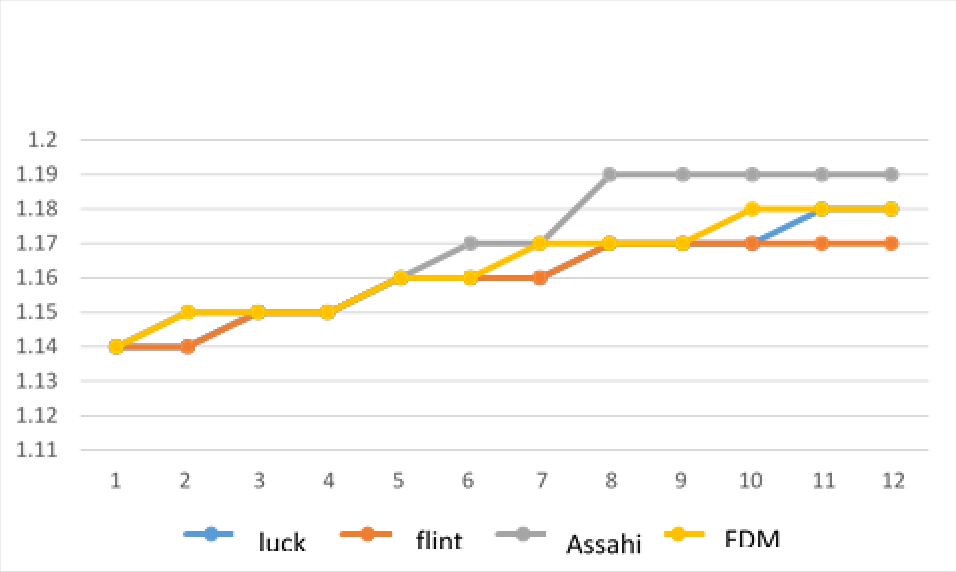


**Figure (6) shows a graphical representation of the average of the thickness readings in the UV-curing inks resistance test**

- The measurement results for Hardness are shown in the following figure, where the vertical axis is in Shore A unit and the horizontal axis represents the number of hours**.**

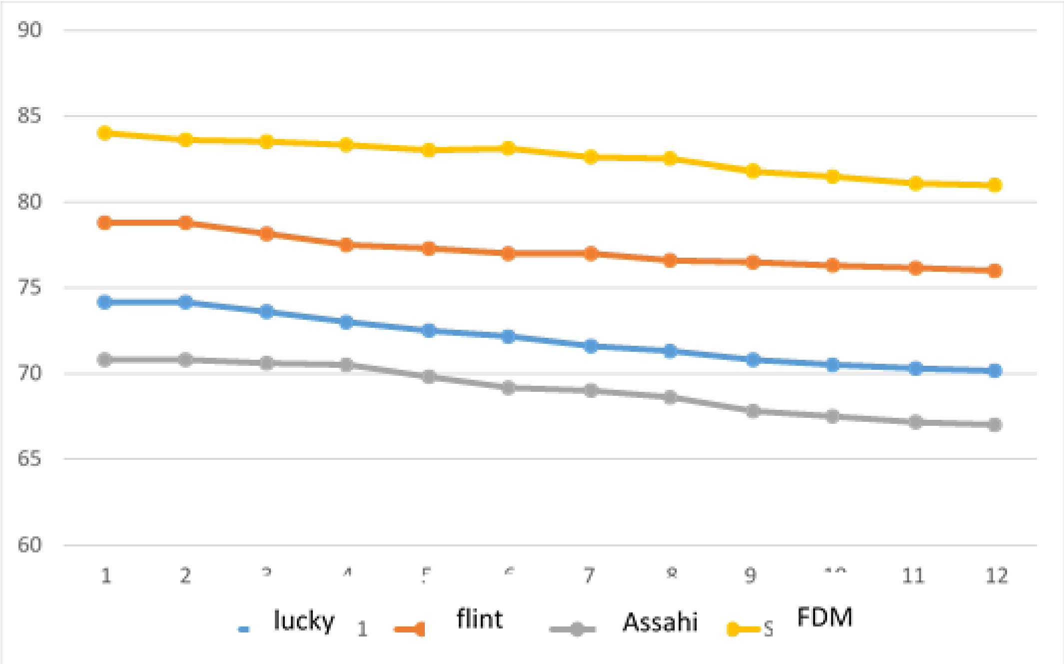


**Figure (7) shows a graphic representation of the average hardness reading in the resistance test of UV-treated inks**

## **Recommendations**:

• It is recommended to use the flexographic plate produced with 3D printing technique "by applying
fused deposition modeling technique." When using water-based inks, as the rate of variation in both
hardness and thickness is the permissible limit for the flexographic plates produced by the digital method.

• It is recommended to use the flexographic plate produced with 3D printing technique "by applying fused deposition modeling technique." When using UV-curing inks, as the rate of variation in both hardness and thickness is within the permissible limit for the flexographic plates produced by the digital method.

• It is recommended to search for solvent-based inks whose rate of interaction is lower with the flexographic plate produced with 3D printing technique "by applying" fused deposition modeling "to reach the permissible limit in changing the hardness and thickness and thus maintaining the stability of the print production.

## References:

**Foreign books:**

- R.H. Leach, R.J. Pierce, E.P. Hickman, M.J. Mackenzie and H.G. Smith: the printing inks manual, publisher: Springer, (2007)

**Websites:**

- https://www.diva-portal.org/smash/get/diva2:5784/FULLTEXT01.pdf
RETRIVED : 21-5-2020 -5 PM
- https://encryptedtbn0.gstatic.com/images?q=tbn:ANd9GcQMqsBQc84dN3V2tjUiZYz1H4lzbvAXnUk03g&usqp=CAU RETRIVED : 13 -5-2019 -8 PM
- https://5.imimg.com/data5/FL/KY/SJ/SELLER-24599016/40734-8620906-500x500.jpg
RETRIVED : 2 -9-2019 -7 PM
- https://www.msi-viking.com/assets/images/510-141_2019.jpg
- https://www.researchgate.net/publication/339046660_Effect_of_the_Common_Solvents_on_UV-Modified_Photopolymer_and_EPDM_Flexographic_Printing_Plates_and_Printed_Ink_Films
-RETRIVED : 20-12-2020 -12 AM
- https://www.researchgate.net/publication/265084813_Deformation_of_Flexographic_Printing_Plates RETRIVED : 21-5-2020 -5 PM
- https://www.testingmachines.com/apps/admin/www/images/products/49-56-digital-micrometer.jpg
RETRIVED : 13 -5-2019 -1 PM