Dielectric Properties Study of Thin Polymer Film Layers Used in LEP

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Abstract

Indigo's technology is based on Liquid Electro Photography (LEP). In this process an electrostatic latent image is first produced on the Photo Imaging Plate (PIP) and then ink is transferred to PIP. Afterward the ink is transferred to the intermediate transfer media, i.e. blanket and finally to the printing media (substrate). The electro ink is transferred mainly due to electrical fields (forces). In this process different types of polymeric coatings are used on the intermediate transfer media (blanket) and the electrical ink transfer depends strongly on these polymers electrical properties. In this work we present a technique for measuring electrical properties of different types of polymeric material coatings at different conditions. This unique set-up enables working under a wide range of physical parameters: temperatures, pressures, electrical voltages and frequencies. A theoretical study of the impedance behavior and equivalent electrical circle has been developed. The analysis shows good matching between experimental and theoretical results. This technique allows better understanding of development of new polymeric materials and determining process working points, especially temperature and electrical voltages.

Introduction

In the HP Indigo printing process small color particles that are suspended in imaging oil are transferred from the ink tank to the media passing through a number of stations as shown in Figure 1. First, an electrostatic latent image is produced on the PIP. Then, the ink is transferred to the PIP by a highly charged development roller applicator (Binary Ink Developer (BID)). Then the inked image is transferred to the blanket drum by electrical forces. At the end ink is transferred from the blanket cylinder to the media via pressure. A very important aspect in this process is the full ink transfer from the PIP to the blanket under pressure and electrical forces that are applied on the ink particles. Likewise the Indigo blanket transfers 100% of the ink to the substrate and is then ready to collect new ink from the PIP. The electric field at the PIP-blanket conjunction must be high enough to pull the ink from the PIP to the blanket and small enough not to discharge the ink through the interface [0].

The typical structure of Indigo's blankets is illustrated in Figure 2. The blanket is a multilayer-compound body, of which the main layers are a compressible layer, a conducting layer, and a top layer. All these layers are made from polymeric materials, of which the electrical parameters determine the electric field acting on the ink particles at the transfer from the PIP to the blanket. Because these layers are polymeric, their impedance characteristic depends on: pressure, frequency, electric field and temperature [0]. For that purpose, dielectric spectroscopy technique that includes these parameters is needed. In this paper we demonstrate a method for measuring the impedance and dielectric constants of blankets polymeric layers under Indigo's press conditions (pressure, frequency and temperature).

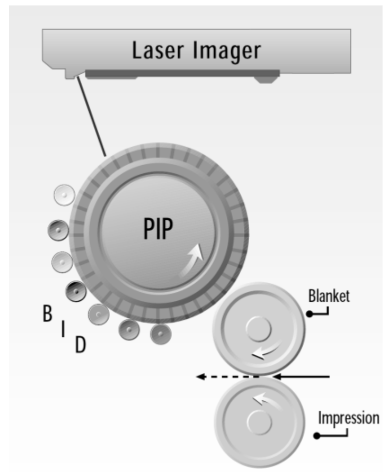

Figure 1: *Indigo's process illustration*

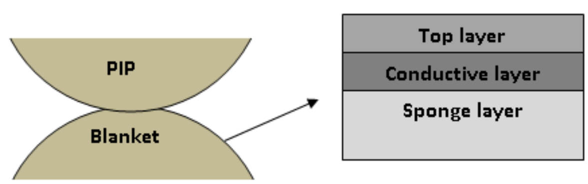

Figure 2: *schematic illustration of PIP/Blanket contact nip and blanket layers*

Experimental method

Samples of blanket top layer have been laminated between two Al electrodes. The sample thickness was ~0.1 [mm] and area of ~12 $[mm]^2$. The schematic set-up of the measurements is shown in Figure 3.

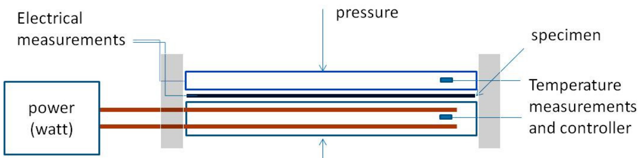

***Figure 3**: PIP/Blanket electrical properties measurements set-up: a power source heat the sample to a desirable temperature.*

The specimen is lying under a hot plate that heats it up to a desirable temperature, which is controlled and measured within the hot plate and above the sample. The sample is put under a constant pressure along its length. The schematic diagram of the experimental sample measurement circuit is shown in Figure 4a. An alternating voltage is applied on the specimen to measure its electrical properties under high voltage conditions. A Trek AC/DC generator (model 615-3) is used as an amplifier to a Keithley signal generator (model 3390). The measurements were done between a wide range of parameters corresponding to the process parameters: Temperature: 25 – 150°C, Pressure: 0 – 2 MPa, Voltage: 0 – 10 kV (ac + dc bias), and Frequencies: 0.01 – 10,000Hz.

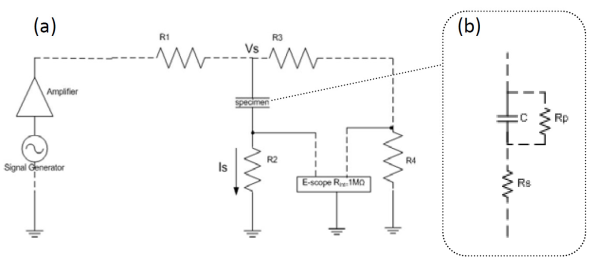

Figure 4: (a) Electrical circuit used to measure specimen electrical properties. (b) An electrical circuit suggested to be equivalent to the sample electrical characterization. The voltage applied on the specimen (by an external High Voltage Power Supply or/and amplifier) can reach up to 10kV, and frequencies can be varied from 0.01 up to 10kHz.

Results

Figure 5 shows the dependence of phase (left) and impedance (right) on the frequency. The suggested equivalent circuit for the top layer is a capacitor (C) in parallel with a resistor (Rp), which are both in series with another resistor (Rs) (see Figure 4b) [0]. The results show that for typical blanket top layer Rs is negligible. We found a good agreement between measurements and the model results. Red rectangles are the measured phase/impedance and the blue line is the model fitting results. As shown in Figure 6, the top layer resistivity is found to be strongly dependent on temperature, decreasing from ~ 20 GΩ·cm at room temperature down to 0.2 GΩ·cm at 100°C (see Figure 6a). The dielectric constant stays stable with temperature and it is found to be approximately ~16 at 100°C (Figure 6b).

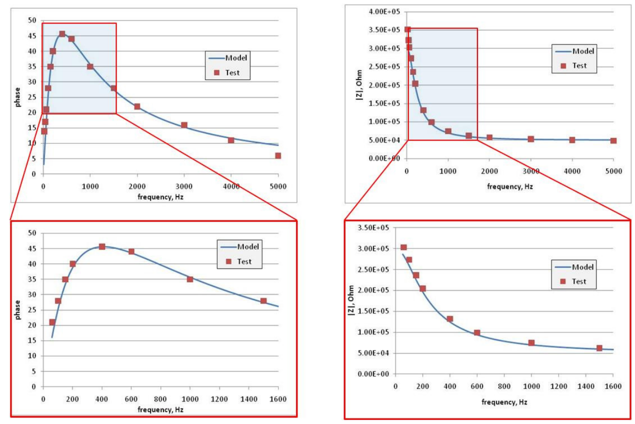

***Figure 5**: Typical dependence of blanket top layer electrical impedance (right) and phase (left) at 80°C on frequency. Lower figures are zoom-in at lower frequencies.*

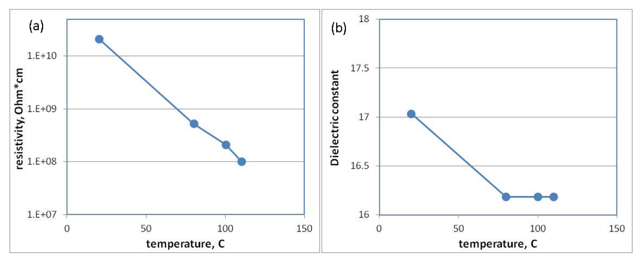

***Figure 6**: the dependence of blanket top layer dielectric constant (right) and resistivity (left) on temperature.*

Summary

Impedance measurements of polymeric samples under press condition have been study. The blanket top layer electrical behavior found to be equivalent to a capacitor in parallel with a resistor. Typical top layer resistivity and dielectric constant were extracted. We found a good fitting between experimental and analytical model. This electrical properties study can be used for simulate ink transfer from PIP to blanket behavior and can help in blanket future development.

Literature Cited

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