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ScienceDirect

Procedia Engineering 152 (2016) 478 – 481

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Oil and Gas Engineering, OGE-2016

# Revisiting the quality control of ink layer

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**Abstract**

The quality of end production units of either packing or microelectronic industry depends on characteristics of a ground (ink) layer covering a polymer substrate. The complex procedure of automatic quality control of the ground coating in a "ground - substrate" system is offered. The algorithm for estimation of the ground layer quality control includes three stages: microgeometry parameters of substrate surface definition, analyzing of ground distribution on / in volume of substrate surface (coverage), adhesion strength for a "ground – substrate" system. For qualitative and quantitative estimation of ground coating parameters such criterions as a substrate roughness, layer or substrate coverage rate, and adhesion strength were used.



Peer-review under responsibility of the Omsk State Technical University

*Keywords:*control; automation; polymer films; adhesion; ground coating

## 1. Introduction

Ink or ground coating of polyethylene and polypropylene films is common in different manufacturing processes including packing and chips producing. The quality control of a ground coating is time-consuming procedure. Known ways of quality control automation of ground coating on different substrates for defects detection include the analysis of images, algorithms of objects recognizing with neutron grids application for image classification, and electron microscopy [1-4]. However, the adhesion strength as a quantitative parameter of a ground layer quality of a "ground –substrate" system is not illuminated.

There are some theories for adhesion estimation. Adhesion strength can be measured by different methods, both direct and indirect; the most of them being not quantitative.

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Peer-review under responsibility of the Omsk State Technical University
doi:10.1016/j.proeng.2016.07.627

The most important characteristics of polymer films are surface properties. Therefore during a coating technology development it is important to know the reason of adhesion junction destruction based on analyze of surface layers interface. Besides, it is important to evaluate the contact area value and predict adhesion strength.

In the study [5] the method of contact area and ground layer adhesion area estimation for porous substrate was offered.

The purpose of this study is the development of complex method of automatic quality control of ground coating on polymer substrate.

## 2. Study subject and research methods

Ground layers with carbon amorphous fillers were printed onto industrial produced polypropylene films (PP) from 3 different manufactures after corona treatment modification by flexographic methods.

For qualitative and quantitative estimation of ground coating parameters such criterions as a substrate roughness, layer or substrate coverage rate, and adhesion strength were used.

The method of ground layer quality control consists of 3 stages:

- the first stage is to define the microgeometry of surface structure using optical microscopy “MicroMeasure 3D Station” with the purpose to estimate geometric linear values and surface profile and topology;
- the second stage is to analyze the ground distribution on a surface structure using scanning electron microscopy (SEM) by field emission electron microscope JSM7500F (Jeol) in secondary electron detection mode at acceleration voltage 10kV, probe current $2 \cdot 10^{-9}$ A. Samples were Pt coated (about 10 nm thickness) in argon atmosphere to avoid surface charging and destruction under electron beam using magnetron type AutoFine Coater JFC-1600 (Jeol). Spatial resolution was at least 1.4 nm. The ground layer coverage evaluation was carried out according to [6];
- the third stage is the definition of a ‘ground-substrate’ system adhesion strength using adopted testing method for MicroScratchTester (CSEM). The adhesion strength parameter is a load force in the start moment of system destruction named critical load force.

## 3. Results and discussion

The results of polymer films microgeometry parameters are presented in Table 1 and in Figure 1.

Table 1. The correlation between adhesion strength of “ground-polymer substrate” system and substrate roughness and coverage values

| Substrate type | Roughness, Ra, μm | Adhesion strength, N/cm$^2$ | Calculated adhesion strength, N/cm$^2$ | Surface coverage, % |
|---|---|---|---|---|
| 1 | 0. 267±0.003 | 21. 3±0.02 | 23.1 | 98. 2±0.02 |
| 2 | 0.195±0.001 | 17.4±0.01 | 17. 2 | 97. 8±0.01 |
| 3 | 0.141±0.002 | 7.2±0.02 | 6.9 | 95. 1±0.04 |

As it was noted earlier [4], irregular or partial ground coating depends on defects and inhomogeneity of substrate surface (texture) which are often developed after a polymer surface modification (Fig.2 a, b). The information about the degree and the scale of inhomogeneity can be obtained by a typical 3D-surface image of test objects (Fig. 3). It is shown the geometry of surface is non-planar. There are separate bulges and cavities on a surface with dimensions in order $10^{-6}$- $10^{-9}$ m. This feature should be taken into account during printing process of polymer films.

Based on SEM-images (the second stage) it was confirmed that a full ground layer is concentrated on a polymer surface (Fig. 2 c).

During the third stage, such test modes were adopted according to features of polymer films:

- the starting load force 0.01N;
- the speed 9.63 mm/min;
- the length of a track 10 mm

There was correlation between roughness parameters of a printed film $R_a$, adhesion strength of a ground layer and coverage values (Table 1).