PES FABRIC MODIFICATION WITH A CORONA DISCHARGE

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Paper presents results of experiments with polyethylene terephtalate (PET) focused on the applicability of atmospheric corona discharge for polyester fabric (PES) modification, mainly on the relation between corona discharge input power and the fabric's hydrophobicity and modification efficiency.
Modification effect strongly grew according to the discharge input power, but the growth was limited by the corona discharge conversion into the spark discharge. Modification effect aging expressed in the feathering spot size time changes sharply diminished in time. Results of corona discharge modification were compared with those of the RF discharge modification.
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1. INTRODUCTION

In the textile industry there is permanent search for new methods of technological optimisation and cost-effective production of fabrics. One of mostly used synthetic fabrics is PES based on PET, with still growing world production.

Since begin of the PET production single-minded effort was paid to the PET hydrophobicity improvement because of the PET low wettability, low adhesion, high oil impurities cohesion and undesirable electric discharge generation. The most reliable way how to change the wettability of the PET is the change of its surface chemical characteristics. The modification can be achieved [1] by different processes, e.g. by enzymatic hydrolysis, low pressure and atmospheric pressure plasma application, chemical grafting or excimer laser application [2].

The most extensive number of potential chemical reactions on the fabric's surface seems to be related with the plasma modification. The effect of the surface plasma modification depends on properties of used gas, because of methane, ethylene, ethanol participation in the graftage, oxide, tetrafloromethane (CF4) and ammonia can be used for sloughing, or noble gases as helium, neon, argon etc. effectivity as admixtures for better chemical processes initialization.

At present fabrics modification by low–pressure plasma is among most frequently investigated treatment methods. It seems to be more advantageous than classical chemical methods and offers distinctive advantages, especially easy modification process control (control parameters being e.g. plasma pressure, discharge input power, modification time and distance between electrode and modified fabric), for details see e.g. [3], [4], [5].

On the other hand the low–pressure plasma employment is mostly joined with higher financial expenses due to the necessity of the vacuum equipment application and batch processing. Necessary purchase of the complex equipment also significantly advances the final product price. The disadvantages of the low-pressure plasma employment might be removed with design of the continual modification system exploiting stable atmospheric plasma discharges. Due to relative simplicity of continual modification system exploiting stable atmospheric plasma discharges its operating expenses might be lower that that of the low-pressure equipment. That is why we focused on the applicability of atmospheric corona discharge for PES fabric modification. We studied the relation between the corona discharge input power and the fabric's hydrophobicity and modification effect aging expressed in the feathering spot size time changes. Results of measurements were compared with values obtained in radio–frequency (RF) and microwave (MW) low–pressure discharges.

2. EXPERIMENTS

For all experiments described in this paper the specimens made from the polyester fabric "Tesil12" were used. The specimens had to be properly cleaned before modification. The modification was performed in atmospheric corona discharge generated between grounded large plane brass electrode, diameter 45 mm and a electrode matrix (72 Ч 54) mm, a set of "single point" iron electrodes, each of cylindrical shape, diameter 0.7 mm and spike curvature radius about 25 μm, placed in vertices of rectangular square grid, dimensions of each square being (9 Ч 9) mm, hence the distance of electrodes was fixed at 9 mm. The electrodes were put into the open cylindrical vessel (diameter 15 cm, height 15 cm). During modification specimens were placed right on the large plane electrode. All experiments were performed in stationary air under atmospheric pressure and room temperature. Stabilized D.C. voltage (7,4-8,4) kV was applied to the electrodes, typical current values were (50-281) μA. The voltage setting limited spark discharge ignition. Modification time was 600 seconds.

Hydrophobicity was evaluated by means of the drop test [6], 20 μl of distilled water being the test liquid. After start of every experiment the feathering spot size was recorded with a camera until 10 minutes from the start. The area of the spot in the 300th second after start of the test was used as the standard for the evaluation. The experiment was stopped if the drop did not soak into the fabric after 10 minutes from the start.

3. RESULTS

Figure 1 represents the time dependence of the fabric moistened and feathering area with obvious difference of the fabric moistened and feathering area time evolution for supply voltage 7.7 kV and 8.1 kV. Almost linear shapes of 7.1 kV and 7.7 kV curves changed into the polynomial for 8.1 kV and 8.4kV ones. This change of shape might be connected with the rise of fabric modification degree or/and existence of fabric area "modification inhomogeneities" in case of less modified specimens.

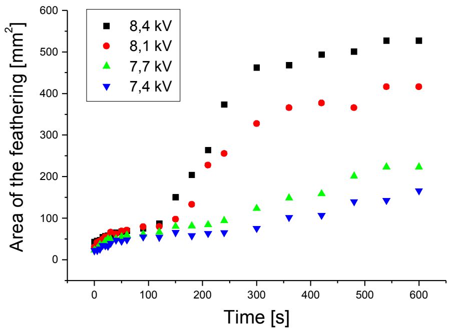

Fig. 1. Time dependence of the fabric moistened and feathering area

The corona discharge column had conical shape. Particles ionised in corona discharge modified the fabric in the close surroundings of their touch points with textile. Final shape of treated area was almost circular. The regions of ionised particle–fabric touch points were not completely joined together in case of low modification intensity and the test drop had to pour over unmodified zones. The time necessary for "unmodified zones overflowing" was relatively long and feathering area seemed to be almost straight time dependent. The modification "irregularities" might be corrected by optimising of the interelectode distance.

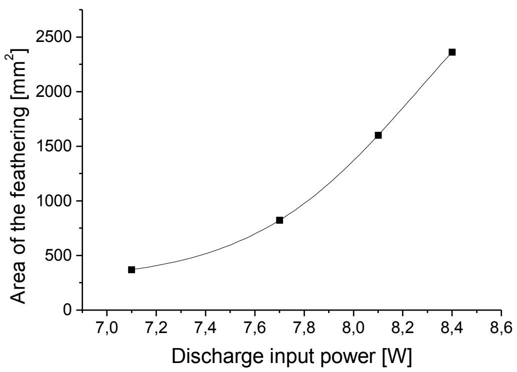

Fig. 2. Discharge input power dependence of moistened and feathering area

More effective modification expressed by the treated fabric area changes can be achieved by discharge input power rise (Fig. 2). For in experiment used input power values the feathering area–time dependence seemed to be exponential, hence small change of input power resulted in greater change of the hydrophobicity. PES fabric hydrophobicity changes were related with number and characteristics of ionised particles, too. Measurements in more intensive corona discharge were impossible due to the spark discharge ignition.

Corona PES fabric modification effect aging expressed in the feathering spot size time changes for different discharge input power is shown in Fig. 3.

The feathering spot size and hence modification effectivity had sharply diminished in time. The efficiency drop might be connected with transformation of created hydrophilous function groups on the fabric surface. The transformation might be caused by chemical reactions of created hydrophilous function surface groups with air components. Dipoles orientation might also change backwards in time returning into primary orientation. Four days after modification no important difference in hydrophobicity of modified and unmodified specimens was found.

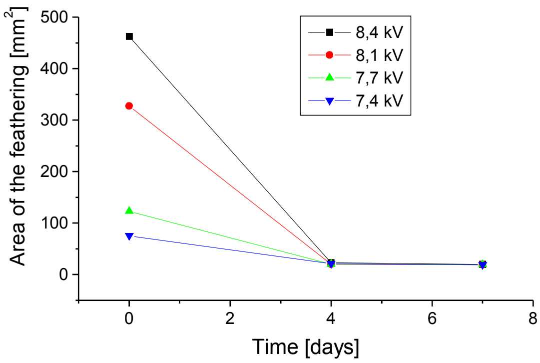

Fig.3. Atmospheric corona discharge PES fabric modification effect aging expressed in the feathering spot size time changes for different input power values

Results of corona discharge modification were compared with results of the RF discharge modification [7]. There were used specimens of the same PES fabric. The modification process seemed to be more efficient in case of RF discharges, but having in mind the costs of modification process the comparison is more difficult. For detailed comparison of both methods further experiments are necessary.

4. SUMMARY

The PES fabric was modified with atmospheric corona discharge. Modification effect strongly grew according to the discharge input power. The growth was limited by the corona discharge conversion into the spark discharge. There was performed a study of PES fabric modification effect aging expressed in the feathering spot size time changes. The modification efficiency had sharply diminished in time. There was found no important difference in hydrophobicity of modified and unmodified specimens four days after modification.

Results of corona discharge modification were compared with those of the RF discharge modification. The modification process seemed to be more efficient in case of RF discharges, but having in mind the costs of modification process the comparison is more difficult. For detailed comparison of both methods further experiments are necessary.

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МОДИФИКАЦИЯ ПОЛИЭФИРНЫХ МАТЕРИАЛОВ КОРОННЫМ РАЗРЯДОМ

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В работе представлены результаты экспериментов с полиэтилен-терфталатом (PET), целью которых было выяснение возможности применения атмосферного коронного разряда для модификации полиэфирного материалов (PES), главным образом, зависимости гидрофобности материалов и эффективности их модификации от потребляемой мощности коронного разряда.

Эффект модификации заметно возрастал с потребляемой мощностью, но это возрастание ограничивалось переходом коронного разряда в искровой разряд. Результаты модификации коронным разрядом сравниваются с результатами, полученными при использовании ВЧ разряда.

МОДИФІКАЦІЯ ПОЛІЕФІРНИХ МАТЕРІАЛІВ КОРОННИМ РОЗРЯДОМ

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В роботі подаються результати експериментів з поліетилен-терфталатом (PET), метою яких було виявлення можливості вживання атмосферного коронного розряду для модифікації поліефірного матеріалів (PES), головним чином, залежності гідрофобності матеріалів та ефективності їх модифікації від споживаної потужності коронного розряду.

Ефект модифікації помітно зростав з споживаною потужністю, проте цей зріст обмежувався переходом коронного розряду в іскровий. Результати модифікації коронним розрядом порівнюються з результатами, які були одержані з застосуванням ВЧ розряду.