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Mini Review

The Use of Ultrasonic Exposure to Improve the Drying Efficiency of Textile Materials

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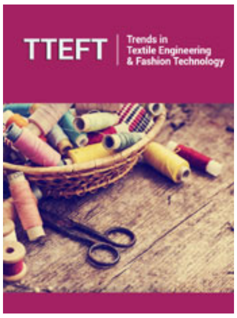

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Abstract

The article is dedicated to the development of technology for drying textile materials with heated air due to the impact of ultrasonic (US) oscillations. Studies are presented in which ultrasonic exposure is carried out both in a non-contact mode when drying textiles in drum-type dryers, and in a contact mode with the direct introduction of ultrasonic vibrations into dried fabrics, for example, during their production. The results obtained indicate the possibility of reducing the drying time from 5% to 28%, depending on the type of tissue, with non-contact ultrasonic exposure and up to 30% with contact introduction of ultrasonic vibrations. This allows us to recommend ultrasonic treatment as an effective and promising way to intensify the drying process of tissues in their production and daily use.

Keywords: Drying process; Ultrasonic intensification; Textile materials; Contact exposure; Non-contact exposure

Introduction

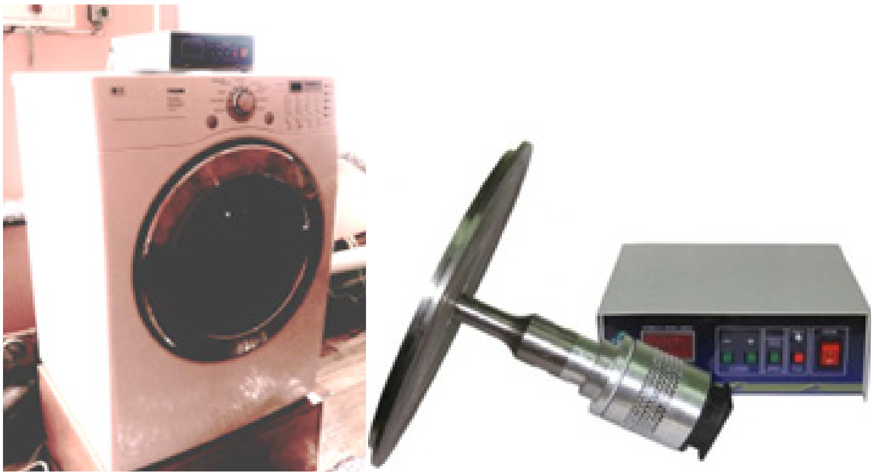
Drying of textile materials is a key step in the manufacture of various textile materials and an important aspect of their daily use. The quality of the drying process (duration and temperature of the process implementation) determines both the characteristics of the manufactured fabrics and the service life of textile products during everyday use. Many studies have been presented suggesting to increasing the drying efficiency of textile materials by exposure to ultrasonic oscillations in addition to heated drying air [1,2]. At the same time, ultrasonic action is capable of intensifying the process of drying materials due to microflows, Rayleigh type acoustic flows, mechanical action, thermal action, pressure changes at the surface of the material, dispersion [3], etc. The exposure of ultrasonic vibrations on textile materials can be carried out both non-contact (i.e., ultrasonic vibrations affect the material being dried through a gas gap, which is most effectively implemented in drying drums, for example, household dryers) and contact (the emitter is in direct contact with the material being dried, in multi-section dryers during the production of textiles). The following are the results of studies showing the effectiveness of the use of ultrasonic exposure for both cases.

Experimental section

To conduct research on ultrasonic non-contact drying, a solid-state emitter is used in the form of a flexural oscillating disk with piezoelectric excitation [4]. Such an emitter was installed in the rear wall of the LG drum dryer, model DLE5577W (Figure 1). The emitter diameter is 250mm, the operating frequency is 22kHz, the sound pressure level in the drying volume is up to 160dB. Drying experiments were carried out for three types of textile materials: cotton fabric, polyester and synthetic fluff (in the form of balls with a diameter of 2-3mm placed in a cotton bag). Two types of experiments were carried out:

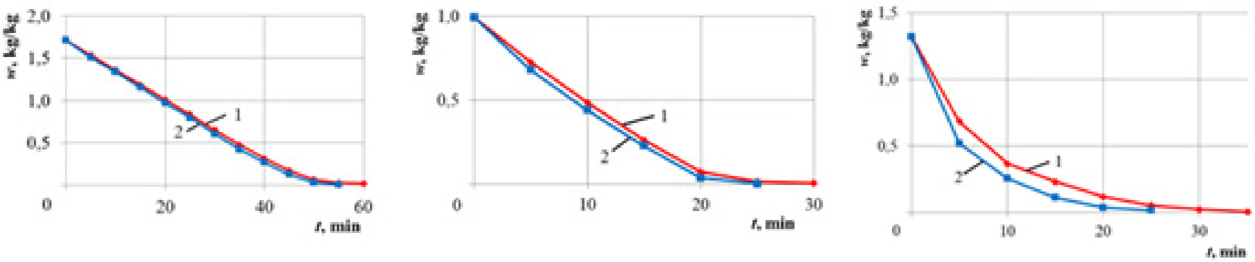
A. supply of heated air with a temperature of 70 °C without ultrasonic exposure.

B. supply of heated air at a temperature of 70 °C with ultrasonic exposure. Figure 2 shows the drying schedules for textile materials.



(a) (b)

Figure 1: Photograph of a drum dryer with an ultrasonic apparatus.
a) Drum ultrasonic dryer.
b) Emitter for exposure to ultrasonic oscillations.



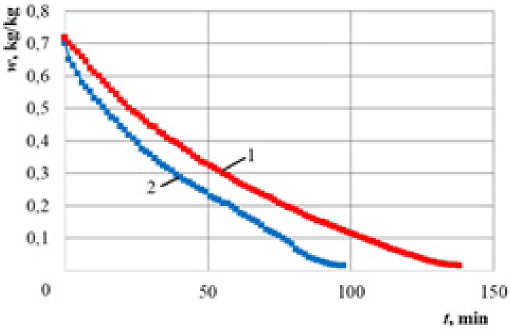
a) b) c)

Figure 2: Curves for drying textiles
a) cotton fabric dry weight 1.96kg.
b) polyester dry weight 1.41kg.
c) synthetic fluff dry weight 0.59kg.
1-convective drying without US; 2-convective drying with US.

According to the drying curves, it is possible to identify a reduction in the process time with ultrasonic exposure compared to only convective drying for cotton fabric - 5%, polyester - 15%, synthetic fluff - 28%. The results obtained showed that the effect of ultrasonic treatment is higher for lighter tissues. For polyester and synthetic fluff, the reduction in drying time was from 15% to 28%, respectively. While for a heavier cotton fabric, the reduction in drying time due to the use of ultrasonic exposure did not exceed 5%. In turn, for denser fabrics, it is expedient to carry out ultrasonic exposure in the contact mode, for example, in drying machines during the production of such fabrics. A model of a drying machine with a fabric broaching was made (the rewinding speed can be adjusted, and the fabric mass is automatically recorded by strain gauges), shown in Figure 3a. During the movement of tissue from one coil to another, a contact ultrasonic effect occurs [5]. The oscillation frequency of the working tool is 20kHz, the oscillation amplitude is about 70μm, and the size of the contact area is 110x20mm.

A thick woolen fabric with a thickness of 2mm and a porosity of 50% was chosen as the drying object. The fabric was cut into a strip 8000mm long and 100mm thick. Velocity of the movement of fabric is 17m/min. The drying graphs for wool fabrics for various types of drying are shown in Figure 3b. It follows from the presented graphs that even at a high velocity of fabric traction, ultrasonic treatment reduces the drying process time by up to 30%. This makes it possible to recommend ultrasonic treatment as an effective and promising method of drying tissues not only during production, but also during everyday use.

a)



b)

Figure 3: Photo of experimental stand and drying curves.
a) experimental stand.
b) drying graphs.
1-convective drying (50 oC) without US; 2-convective drying (50 oC) with ultrasonic.

Conclusion

The conducted experiments showed that ultrasonic exposure is an effective way to reduce the drying time. In this case, ultrasonic exposure can be carried out both in contact and non-contact modes. This makes it possible to recommend ultrasonic treatment as an effective and promising method of drying tissues not only during production, but also during everyday use. This is confirmed by the fact that non-contact ultrasonic exposure reduces the drying time from 5% to 28% depending on the type of tissue and contact exposure up to 30% compared to tissue drying with heated air.

Acknowledgement

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