Characterization of nano-fiber web structures using a morphological image processing

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Abstract An image processing algorithm has been developed in order to analyze the nanofiber web images obtained from a high magnification microscope. It has been known that precise pore detection on thick webs is extremely difficult mainly due to lack of light uniformity, difficulty of fine focusing and translucency of nanofiber web. The pore detection algorithm developed has been found to show excellent performance in characterizing the porous structure, thus being a promising tool for on-line quality control system under mass production. Since the images obtained from an optical microscope represent only web surface, a scale factor has been introduced to estimate the web structure as a whole. Resulting web structures have been compared to those by mercury porosimetry, especially in pore size distribution. It has been shown that those two structures have a strong correlation, indicating that scaling of a single layer web structure can be an effective way of estimating the structure of thick fiber webs.

Introduction The algorithms reported in the variety of fields such as geology, metallurgy, ceramics, and membrane science, precise pore detection have difficulty in detecting the pores with irregular shapes under non-uniform illumination. Applications in textiles have been limited to the transparent web samples with relatively simple fiber structure [1, 2]. More specifically, pores in real fiber webs are hardly detected by a simple algorithm due to low boundary sharpness and irregular fiber shape. In the study, a new image processing algorithm is introduced for overcoming the limitation.

Experimental

1) Materials

PAN dissolved in DMF was flash-electrospun at several different process conditions in Table 1.

Table 1. Web processing condition

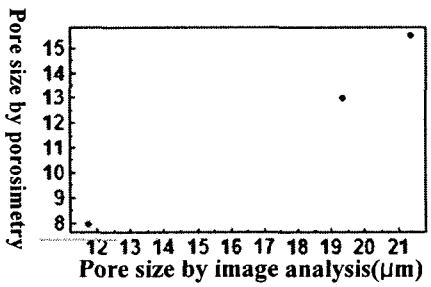
	Concent-ration. (wt %)	Pressure (kgf/cm)	Voltage (kV)	Air Pressure (kgf/cm)
1	40	3	30	0.2
2	40	4	40	0
3	45	3	50	0

2) Experimental apparatus

A high magnification microscope, Hyrox CX-10C with Olympus LMPlanFI objective lens and Sony XC-55 CCD camera, was employed for non-contact measurement. The images acquired were transferred to the processing computer through the FlashBus frame grabber. The Keyence LT-8110 laser sensor was used for thickness measurement.

Results The images have been further analyzed by a morphological processing of edge detection, dilation, inversion, skeletonization, labeling and pixel counting. The resulting pore size distribution has been compared to those from the mercury porosimetry after being multiplied by the scale factor predetermined. Figure1 shows correlation between the pore-size by image analysis and by mercury porosimetry.

Figure 1. the correlation between the resulting pore sizes by image analysis and porosimetry



Conclusions

It has been found that pores in thick nanofiber webs could be successfully estimated by way of scaling the surface layer pores at certain focal depth.

References

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