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Simulation of Stretching Deformation of Films for Electronic Devices in Automotive Applications

Jihong Liu[1*], Akio Higaki[1], Nobuyuki Komatsu[1] and Satoru Takanezawa[1]

[1] Daikin Industries, Ltd., 1-1 Nishi-Hitotsuya, Settsu, Osaka 566-8585, Japan
jihong.liu@daikin.co.jp, https://www.daikin.com/

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Fluoropolymers have excellent weather resistance, heat resistance, electrical insulation properties, etc., and are used in a wide range of fields such as semicondutcors and automobiles [1]. Recently, it has been clarified that the electrical properties such as relative permittivity, volume resistivity and dielectric breakdown strength of the fluoropolymers are significantly improved by controlling their crystal structure with biaxial stretching [2]. As a result, biaxially stretched fluorine films are increasingly expected to be used in automobile-related electronic devices such as high-frequency substrate films, motor insulating papers, and film capacitors to improve their performances and reduce their sizes and weights. For example, the size of the film capacitors can be reduced to less than half with the fluorine films compared to polypropylene (PP) films. As automobiles become CASE (Connectivity, Autonomous, Sharing/Subscription, Electrification), various devices are required to be smaller and lighter. The downsizing of the film capacitors will greatly contribute to the miniaturization and performance improvement of the electronic devices for electric vehicles. However, it is difficult to continuously manufacture the fluorine films because kink bands and stretching tears are easily to occur during successive biaxial stretching with a tenter.

In this study, we proposed a simulation method for film transverse stretching based on the finite element method using the orthogonal anisotropy plastic model [3]. The simulation method can not only analyse the large stretching deformation up to the orientation hardening region, but also predict the kink band phenomenon that occurs during the film transverse stretching. The validity of the simulation method was confirmed by the film transverse stretching tests performed on the fluorine film sheets with different longitudinal stretching ratios. Using the simulation method, we clarified that the anisotropy index of the fluorine film sheets has a great influence on the presence or absence of the kink band phenomenon during the film transverse stretching. The anisotropy index of the film sheets after longitudinal stretching can be related to their orientation, and the two are approximately in a linear relationship for the fluorine film sheets. Moreover, we revealed the change in film stretching deformation due to difference in tenter shape. The main conclusions drawn by the simulations are as follows.

(1) The presence or absence of the kink band phenomenon during transverse stretching largely depends on the anisotropy of the film sheets after longitudinal stretching.
(2) The ratio of length to width of the stretching zone is desired to be 2.0 or more.
(3) The protective layer attached to the edge of the film sheet has the effect of preventing the film from tearing during the transverse stretching.

REFERENCES

[1] Ebnesajjad, S. *Introduction to Fluoropolymers: Materials, Technology, and Applications (Second Edition)*. William Andrew, (2020)

[2] Hazama, T., Komatsu, N., Yokotani, K., Tatemichi, M. and Higuchi, T. and Koga, K. Film. Pub. No. US 2020/0032014 A1 (2020)

[3] ANSYS Mechanical APDL 19.0 (2018)