Foam structure of Microcellular controlled by process conditions and material design

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Abstract

We investigated the foaming control factors of microcellular process in terms of forming conditions and material design, and this paper describes the foam morphology of the samples prepared on various processing conditions and materials for mainly PP.
If we choose the optimum condition carefully, the foam size can be controlled about 30 μm and the distribution of cell size is uniform.

Introduction

The Mucell Technology which produces the small cell size foam by using supercritical fluid such as CO_2 and N_2 is expected to obtain good physical properties, good dimensional stability, good flowability and reducing warpage. The cell size is one of the important factors to control the physical properties, the surface appearance and very much influenced by process conditions and materials.
By optimization of a processing condition and a material design, MuCell technology gives potentialities of forming a homogeneous and microcell-structure. For example, long chain branching PP with special additives give better cell size uniformity and smaller cell size compared with general PP. Further, the addition of foam nucleus and using core back process are control factors. Microcellullar has good merits such as dimensional stability and reducing warpage and shrinkage, especially for glass fiber filled materials with random dispersion fibers observed by using this technology.
There are very few reports which describe the cell size control factors for injection moldings. This research is to obtain the main factors of the cell size control for injection molding in terms of process conditions and materials. We chose the polypropylene which is difficult to obtain the small cell size.

Experimental

MuCell machine J180ELⅢ(180ton,JSW) was used. The material was Idemitsu Polypropylene (MI 3) and supercritical fluid was N_2. The process conditions were listed in Fig.1 as control factors of cell size. The electron microscope JSM-6100 (Nihon Denshi) was used to observe the cell morphology.

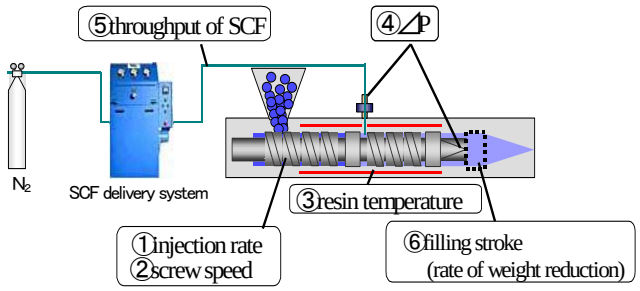


Fig.1 Various molding factors in MuCell process

Results & Conclusions

Using supercritical nitrogen (N_2), we investigated polypropylene foaming by MuCell process in order to grasp the most influential molding factors for minute foaming with design of experiment. It was

$$y=\alpha_{00}+\alpha_{01}x_1+\alpha_{02}x_2+\alpha_{03}x_3+\alpha_{04}x_4+\alpha_{05}x_5+\alpha_{06}x_6 +\alpha_{11}x_1^2+\alpha_{22}x_2^2+\alpha_{33}x_3^2+\alpha_{44}x_4^2+\alpha_{55}x_5^2+\alpha_{66}x_6^2 +\alpha_{12}x_1x_2+\alpha_{13}x_1x_3+\alpha_{14}x_1x_4+\alpha_{15}x_1x_5+\alpha_{16}x_1x_6 +\alpha_{23}x_2x_3+\alpha_{24}x_2x_4+\alpha_{25}x_2x_5+\alpha_{26}x_2x_6 +\alpha_{34}x_3x_4+\alpha_{35}x_3x_5+\alpha_{36}x_3x_6 +\alpha_{45}x_4x_5+\alpha_{46}x_4x_6 +\alpha_{56}x_5x_6+\varepsilon \quad (8)$$

y ; index of foaming morphology
x_n ; molding factors
ε ; error
α ; contribution rate

found that the most influential molding factors for MuCell process were the Δ P(the differential pressure between injection pressure of supercritical N_2 to cylinder and back pressure of screw), throughput of supercritical N_2 to injection molding machine from supercritical fluid delivery system and resin temperature (Fig.2 & 3, Table1). Consequently, the average diameter of foaming cell was achieved 30 μ m for foamed polypropylene which is generally difficult to control the cell size (Fig.4&5). In terms of

material, nucleating agent is also important factor for reducing the cell size.

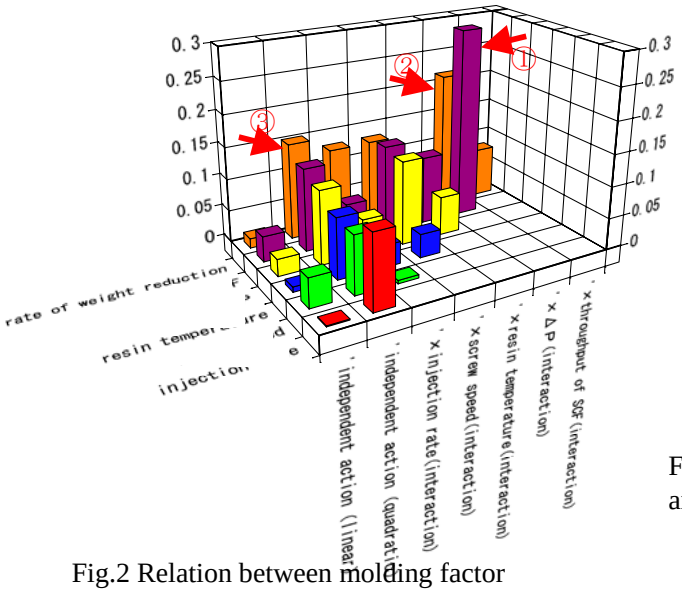
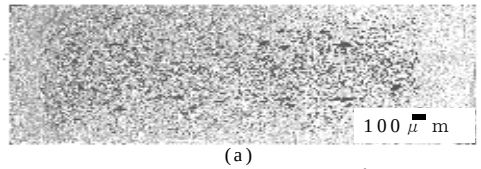
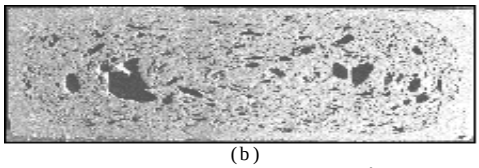


Fig.2 Relation between molding factor and contribution rate

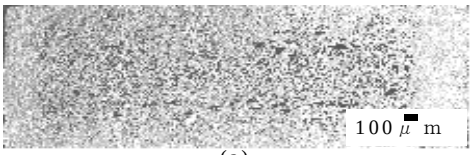


(a)
Resin temperature 235℃

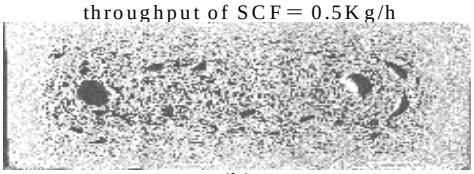


(b)
Resin temperature 200℃

Fig.4 SEM micrographs of polypropylene foaming at various temperatures



(a)
ΔP＝3 MPa、
throughput of SCF＝0.5Kg/h



(b)
ΔP＝2 MPa、
throughput of SCF＝0.25Kg/h

Fig.5 SEM micrographs of polypropylene foaming by various SCF condition

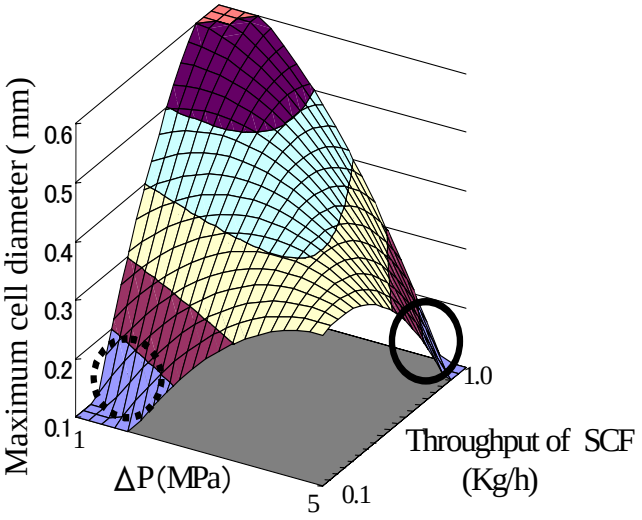


Fig.3 Relationship among maximum cell diameter, ΔP and SCF throughput

Indexs of foaming morphology and contribution rate		Order of contirubution 1	2	3
	Maximam cell diamater	ΔP・Throughput of SCF	ΔP・Rate of weight reduction	Rate of weight reduction
	Contribution rate	0.298	0.214	0.150
	Rate of area	Injection rate・Resin temperature	ΔP・Rate of weight reduction	ΔP・Throughput of SCF
	Contribution rate	4.13	3.79	3.25
	Distribution2	Resin temperature・Rate of weight reducution	ΔP・Throughput of SCF	Injection rate
	Contribution rate	0.258	0.228	0.196

Table 1 Relation between molding factors and foaming morphology

References

1. T.Kanai : Seikeikako 02,115(2002)
2. H.Miyazaki : Seikeikako 02,117(2002)
3. M.Ohshima : Japan Society of Polymer Processing 52th Seminar,1(2002)