> ɒɑo^`ɑ7

KP Sheet is a stampable sheet made of glass fber (GF) and polypropylene (PP), and has a distinctive characteristic of expansion in thickness. To realize light weight and high stiffness in automotive headliners, the GF content and arrangement in the thickness direction were studied with the aim of increasing expansivity. Although expansivity increases with GF content and the elastic slope is enhanced by the resulting increase in sheet thickness, the maximum elastic slope reaches saturation at a GF content of 50 mass% or more. Therefore, the GF arrangement in the thickness direction is controlled to improve GF spring back, resulting in a 30% improvement in expansivity at the same unit weight. A newly-developed ultra-light product (UL grade) realizes a high elastic slope of 7.2 N/mm at a web unit weight of 800 g/m^2, while also displaying excellent moldability and dimensional stability equal to those of normal grade KP Sheet, enabling further weight reduction.

.ⁱ Fkɑolar`ɑflk

To improve marketplace competitiveness, automobiles are equipped with a full range of convenience and safety devices such as car navigation systems, back view monitors, and air bags. On the other hand, as means of reducing environmental loads, weight reduction in automotive parts and improved engine fuel consumption are also under study. Against this background, fber reinforced composites, which possess high specifc strength and specifc stiffness, have drawn attention as materials responding to the need for weight reduction.

K-Plasheet, which is a member of the JFE Steel Group, produces and sells fber reinforced composites for press forming use (stampable sheet "KP Sheet") made of glass fber (GF) and polypropylene (PP). They have won an excellent evaluation from customers for their light weight, formability, and low coeffcient of thermal expansion. Since 1997, they have been widely adopted in automotive interior parts, and particularly as headliner materials, as shown in **Melɑl .**.

Broadly classifed, three types of headliner mate-

y osdsir -on ee pi e yfh ma jc ℵ dirf ak ic ɥ

(3) thermoplastic foam.[1,2)]

The features required to headliner materials include (1) low release of harmful chemicals and foul odors in the process of molding headliner parts from material in order to improve the workplace environment, (2) high handling stiffness during installation in the auto assembly process, (3) light weight and minimal dimensional change in parts in environmental atmospheres, high durability, and high sound absorption, and (4) good recyclability when the automobile is scrapped.

Because KP Sheet is made of PP, no harmful chemicals or foul odors are released in the molding process, and as reheating is possible, it also has recyclability. As shown in Photo 1, when KP Sheet is molded to produce a headliner, its microstructure forms a porous structure in which PP fixes the intersection points between glass fibers. Dimensional change in the product is slight because GF suppresses shape change due to molding shrinkage and environmental heat loads, and durability is excellent. In addition, the product is also sound absorbent, which is a distinctive feature of its porous structure.[3)]

This paper presents the results of a study of stiffness improvement in the development of a new type of KP Sheet with lighter weight and enhanced stiffness, and introduces UL grade (ultra-light grade), which was newly developed based on the study results.

2. Features of KP Sheet and Design of Lightweight Material

2.1 Production Method

KP Sheet for automotive headliners, as shown in **Fig. 1**, has a laminated structure consisting of an olefin film, which is applied on one side of a stampable sheet and is used in attaching the surface texture and securing non-permeability, and a PET scrim applied to the reverse side. The KP Sheet production process comcausing PP to concentrate around the glass fibers and at GF intersection points. Even if the KP Sheet is compressed into a certain thickness during stamping, only a small part of the PP coalesces. The larger part remains distributed around the GF and at GF intersections in the same dispersed distribution.

Since unit weight (per unit of area) and thickness are considered to contribute to rigidity, a model of an expansion-molded material consisting mainly of GF was used, as shown in **Cfd+ 0**. Assuming that GF is uniformly distributed in an arbitrary cross-section, and therefore the number of glass fibers per unit of cross-sectional area is also uniform, the second moment of area can be expressed by the following equation:

$$I \quad w \cdot A \cdot n \cdot h^3 / 12 \quad \cdots\cdots (1)$$

where,

w : Width (mm)

h : Thickness (mm)

A : Cross-sectional area of GF (mm^2)

N : Number of glass fibers in arbitrary cross-section

Using the unit weight and GF content of the expansion-molded material, the value of $A \cdot n$ can be expressed as follows:

$$A \cdot n \quad (GC / h) / \quad \cdots\cdots (2)$$

where,

G : Unit weight of expansion-molded material (g/mm^2)

C : GF content (mass%)

: Density of glass (g/mm^2)

For a given GF content, the strength of the GF intersections bonded by PP is constant, irrespective of the compression ratio (molded thickness/expanded thickness). In other words, assuming the elastic modulus of the GF intersections is constant, EI is proportional to the second moment of area (I h (conomi&

pressure of 0.3 MPa for 15 s at 205°C with an olefn flm laminated on one side of the web and a PET scrim on the other. The pressed material was cooled and solidifed to produce sheets.

In addition, web with a controlled GF arrangement was pressed to sheets using web produced by papermaking at K-Plasheet.

0+/ Mobm^o^qflk lc Bum^kaba Pebbqp

The expanded sheets were prepared by two methods. The frst was a free-expansion method in which the KP Sheet was placed on a Tefon sheet and heated to 200°C in& a f[illegible] , weight (thicko i d ! idt dt

unit weights. The numerical values in the figure are for the molded thickness. When compared at the same unit weight, the developed material shows a 50% improvement in elastic slope in comparison with the normal grade. Conversely, at the same elastic slope, a 20% weight reduction is possible. Thus, the developed UL grade is an outstanding material for either improving the stiffness performance of parts or for reducing part weight.

2· @lk`irpflk

To meet requirements for light weight and high stiffness in automotive parts, JFE Steel and its subsidiary K-Plasheet succeeded in improving the stiffness of KP Sheet for automotive headliners by controlling the GF arrangement of the material and optimizing expansivity and PP distribution, and developed and commercialized a new ultra-light KP Sheet (UL grade) with improved stiffness. The developed material has the following outstanding features:

(1) In the UL grade, free expansion was improved by 30% in comparison with the normal grade. As a result, the second moment of area is increased and stiffness is improved by 50%.

(2) With the same stiffness, a 20% weight reduction is possible.

A product with excellent sound absorption is under study, taking advantage of the porosity which is a feature of the expanded material, and development of materials with further improved functions is planned.

Obcbobk`bp

1) Haque, E. et al. “Development of Low Density Glass Mat Thermoplastic Composites for Headliner Applications.” SAE Technical Paper Series. SAE 2000 World Cong. Detroit (USA). Paper No. 2000-01-1129, 2000.
2) Kubo, H. et al. “KPSHEET” Used as Automobiles’ Interior Parts and “KP BOARD” as an Alternate for Wood.” Kawasaki Steel Giho. vol. 29, no. 4, 1997, p. 228–230.
3) Fujimaki, M. et al. “Sound Absorption and Mechanical Properties of Porous Stampable Sheet.” Kawasaki Steel Giho. vol. 29, no. 4, 1997, p. 196–201.
4) Yoshitake, H. et al. Plastics Age. vol. 42, no. 9, 1996, p. 124.
5) Araki, Y. et al. “Development of Lightweight and High Stiffness “New KP-Sheet” for Automotive Headliners by Controlling of Glass Fiber Arrangement.” Pro. of the 7th Jan. Int. SAMPE Symp. Tokyo Big Sight (Japan), vol. 11, 2001, p. 407.