Performance Chemicals

Successful Performance Chemicals of Sanyo Chemical Group 123

# Skin Material for Automobile Interiors

Elastomers Research Dept.
Unit Manager
Takanori Yamamoto

Interiors of automobiles are made of many parts. The instrument panel, in particular, is an interior part that is most familiar to us when driving an automobile, as it stores electronic devices as well as the air bags that protect the occupants.
The instrument panels of automobiles are classified into 2 types, which are soft instrument panels and hard instrument panels. As shown in **Fig. 1**, a soft instrument panel has a 3-layer structure in which the space between the internal base material and the external skin material with soft feeling is filled with urethane foam, etc. Meanwhile, a hard instrument panel has a one-layer structure which is formed by injection molding polypropylene, etc., and is hard to the touch in general. Soft instrument panels can be further classified into slush molded type and vacuum formed type by the method of skin material molding. Since instrument panels with higher design properties can be manufactured freely with skin material that is formed by slush molding than the skin material formed by vacuum forming, slush molding has been adopted in various vehicle models.
This article describes an overview of skin materials for soft instrument panels prepared by slush molding method, and introduces 'THERPUS LF,' our company's urethane bead material which can achieve weight reduction with film thickness reduction.

## Slush molding method

As shown in **Fig. 2**, slush molding method consists of 5 processes, which are [1] Heating of the die, [2] Setting the box injected with bead-shaped resin powder of approximately 100–200-μm diameter and the die, [3] Rotating the box and die so that the resin powder is distributed uniformly throughout the die, melting it and forming a skin, [4] Cooling the die, and [5] Form removal. To mold a skin material with a uniform thickness with this molding method, it is necessary to ensure excellent fluidity and sharp meltability of the resin powder to be used.

## Materials for slush molding

Materials that are used for skin material in slush molding include polyvinyl chloride (hereinafter referred to as PVC), thermoplastic polyurethane (hereinafter referred to as TPU) and thermoplastic polyolefin (hereinafter referred to as TPO). Conventionally, PVC that is low in cost and has favorable scratch resistance had been used popularly as the material for slush molding. However, movements to discontinue the use of PVC started spreading mainly from Europe due to environmental consideration around 1990, and various automobile manufacturers started adopting materials such as TPU and TPO. Although TPO came under the spotlight as the needs for weight reduction and recyclability had been high at the time, its adoption did not spread widely since TPO did not match PVC in terms of scratch

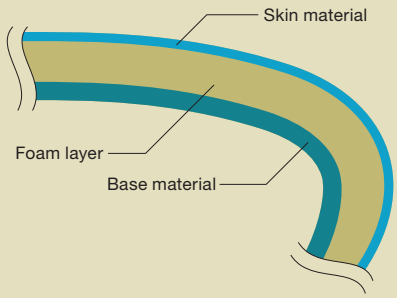



Fig. 1 Cross section of a soft instrument panel

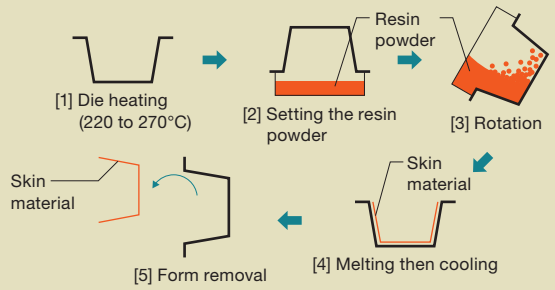



Fig. 2 Instrument panel manufacture processes using slush molding method

resistance or soft feeling, and had higher molding temperature at approximately 300°C as well as lower powder fluidity. Compared to this, replacement from PVC advanced for TPU slush molding materials including our company's 'THERPUS' Series, with high evaluation of features such as the excellent scratch resistance, soft feeling, etc. compared to TPO, being able to use the existing slush molding facilities without change, and excellent extension at low temperatures, which had been an issue with PVC.

## Characteristics of TPU

TPU is a collective term for polymers whose main raw materials are polyisocyanate and active hydrogen compounds (such as polyol and polyamine), and it is known to consist of a hard segment (urethane or urea bond) and a soft segment (polyol chain, etc.), which form a phase separated structure **(Fig. 3)**. By arbitrarily combining the hard segment with a strong cohesive force and the soft segment with high flexibility, it is possible to easily adjust the mechanical and physical properties such as abrasion resistance, tear strength, impact resilience, and extension under low temperatures as well as the chemical properties such as chemical resistance.

TPU comes as pulverized type and bead type, and our company developed and owns urethane bead skin material for automobile interiors 'THERPUS' Series, which has excellent mechanical properties typical of TPU and the shape and powder fluidity appropriate for slush molding method, through utilization of our rich knowledge on polyurethane.

## Features of 'THERPUS' Series

[1] Since 'THERPUS' Series is a bead type, and has higher powder fluidity than PVC, TPO or pulverized TPU, the resin is distributed to every corner evenly in the die for an instrument panel with a complex shape and has lower tendency to generate defects such as pinholes. It also excels in meltability, and is suited to the slush molding method.

[2] It has high flexibility and soft feeling characteristic to polyurethane.

[3] It has little changes in appearance, discoloration, hardening, contraction or warping due to aging, and does not lose the soft feeling, as it excels in heat resistance and light resistance compared to PVC thanks to the use of multi-functional acrylate.

With such features being highlighted, 'THERPUS LA' was first adopted as a material for interior parts (instrument panel, door trim, console box, etc.) of "Celsior," a high-end sedan by Toyota Motor Corp., in 2000. Later, the needs became centered on the processing technique to form a tear line for the air bag on the back side of the skin material (invisible air bag which does not show the tear line to the occupants) in order to improve the design properties of instrument panels. Our company thus developed 'THERPUS LB' and 'THERPUS LC,' which enabled the invisible air bag processing.

These products offer the following advantages in addition to the features of the conventional 'THERPUS' Series:

[1] High durability under long periods of use without tearing

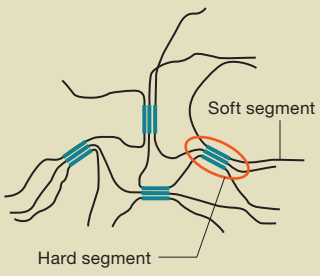



**Fig. 3** Phase separated structure of TPU

**Table 1** Properties of materials for slush molding

| | | Our company products for thin film | Conventional product of our company | | Product of another manufacture | | |
|---|---|---|---|---|---|---|---|
| Item/product name | | THERPUS LF | THERPUS LB | THERPUS LC | PVC | Modified PVC | Pulverized TPU |
| Formability | Fluidity | ○ | ◎ | ◎ | △ | △ | × |
| | Meltability | ◎ | ○ | ○ | ○ | △ | ◎ |
| | Form removal property | ○ | ○ | ○ | ○ | ○ | △ |
| Material properties | Form adhesion | ○ | ○ | ○ | ○ | ○ | × |
| | Dimensional stability (after heat resistance test) | ○ | ○ | ○ | × | △ | ○ |
| | Low-temperature properties (after heat resistance test) | ◎ | ○ | ◎ | × | △ | ◎ |
| | Light resistance | ○ | ○ | ○ | △ | △ | × |
| | Chemical resistance: Polar solvents | ○ | ○ | ○ | ○ | ○ | ○ |
| | Chemical resistance: Nonpolar solvents | ○ | ○ | ○ | ○ | ○ | △ |
| | Scratch resistance | ◎ | △ | ○ | ○ | △ | × |
| Overall evaluation | | ◎ | ○ | ○ | △ | △ | × |

◎: Excellent, ○: Good, △: Slightly inferior, ×: Inferior

at the tear line for the air bag at an unnecessary time.

[2] Proper deployment of the air bag even under low temperatures (it maintains the soft feeling and resin extends even under low temperatures).

As a consequence, the vehicle models adopting our products expanded from high-end vehicles such as Lexus to mid-range models.

## Urethane bead skin material for automobile interiors supporting thin films 'THERPUS LF'

In recent years, the need for fuel efficiency improvement by weight reduction in automobile parts have increased more than ever, and needs related to high design properties including stitch processing to actually stitch the molded skin with string and instrument panels with complex shapes have also increased. Our company developed 'THERPUS LF' as a new TPU skin material to meet these needs **(Table 1)**.

[1] Weight reduction in skin material (increased resin strength)

Compared to the conventional products of our company, we achieved viscosity reduction for 'THERPUS LF' in the molding temperature range (190°C and higher), which is necessary for molding of the skin material, by reducing the hard segment concentration **(Fig. 4)**. Furthermore, to increase the strength with a low hard segment concentration, we introduced a unique structure proprietary to our company by using polyester group with high cohesive force in the soft segment and forming hydrogen bond with urethane group at the terminal group **(Fig. 5)**. This unique structure enabled us to improve the tensile strength of the skin material to approximately two times **(Fig. 6)**.

This unique structure has a characteristic in which the molecules become strongly attracted again when it is cooled to the normal temperature after molding, even though the attractive force between molecules weakens at 150°C and higher **(Fig. 7)**. 'THERPUS LF,' which has better meltability than the conventional products of our company, while maintaining the powder characteristics, is suited for the slush molding method. Furthermore, it is theoretically possible to mold a uniform thin-film skin material with thickness approximately half and contribute to weight reduction in instrument panels, as we increased the resin strength to two times. We also enabled the creation of a skin material which can give even better softness feeling, as the soft touch of the foam layer can be more easily reflected by reducing the thickness of the skin.

[2] Design property improvement for skin material

In order to achieve design property improvement in skin materials, viscosity reduction and powder fluidity in the molding temperature range are

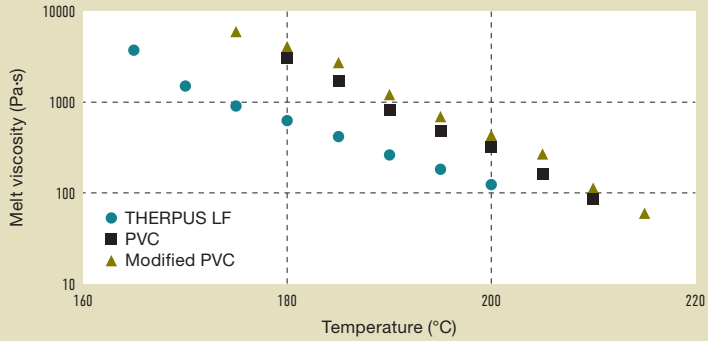



**Fig. 4** Melt viscosity of each skin material

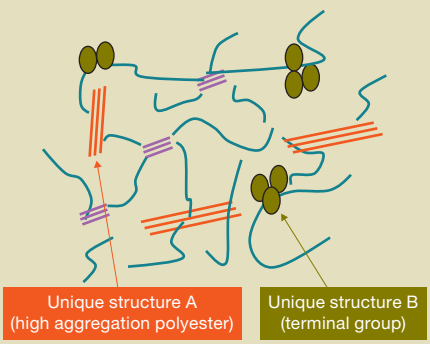



**Fig. 5** Molecular structure of 'THERPUS LF'

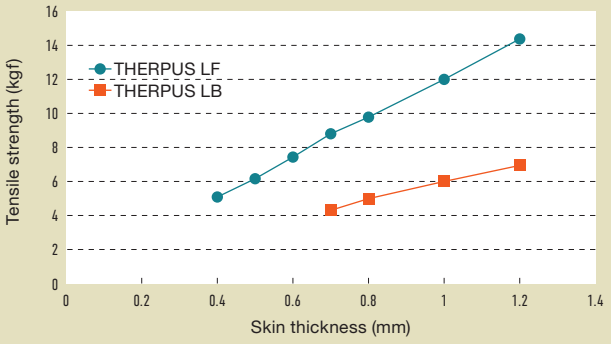



**Fig. 6** Relationship between skin material thickness and tensile strength

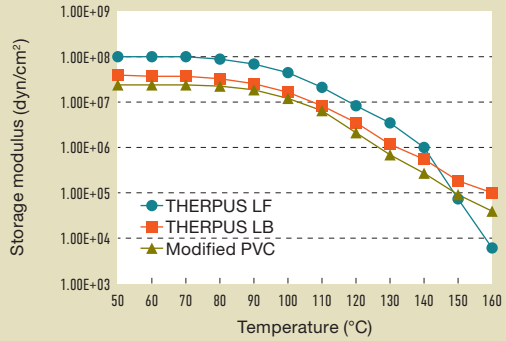



**Fig. 7** Relationship between temperature and storage modulus

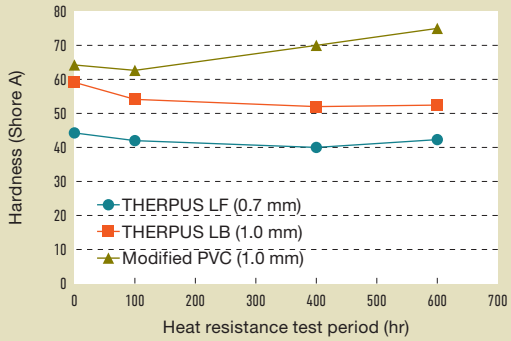



**Fig. 8** Changes in hardness of the skin material due to temporal changes in heat resistance test (130°C)

considered important factors. Compared with pulverized TPU, PVC and modified PVC by other manufacturers, 'THERPUS LF' not only has each grain nearly spherical, but also decreases in viscosity in the molding temperature range owing to our proprietary production method, and enables design property improvement as the resin becomes thoroughly distributed to the minute parts of the die in instrument panels with complex shape with false stitch processing, etc. **(Table 2)**.

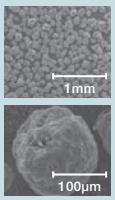
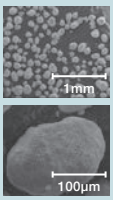
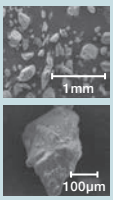
[3] Durability of skin material

While the skin materials made of PVC or modified PVC to which plasticizers are added in large amounts to make them soft often harden or become warped as the amount of plasticizer decreases due to evaporation, 'THERPUS LF,' which is flexible even with a small amount of plasticizer, maintains the soft feeling almost permanently and suppresses contraction without hardening of the skin material. It therefore has no defects, including the air bag tear line becoming visible, and formation of cracks as distortion occurs in the stitch parts that are stitched with strings **(Fig. 8)**.

[4] Advantages in molding process

It can reduce the molding temperature thanks to the lower viscosity in the molding temperature range. This leads to not only reduction in energy use during instrument panel production but also extension of the die life by reducing the load on the die with a smaller temperature difference in heating and cooling.

**Table 2** Particle shape and powder fluidity of each skin material

| Powder fluidity | Favorable ⟷ Not favorable | | |
|---|---|---|---|
| Particle appearance (particle shape) |  |  |  |
| Product name | THERPUS LF | PVC, modified PVC (product of another manufacturer) | Pulverized TPU (product of another manufacturer) |
| Flowing time (sec) | 12 | 19 | 20 |
| Angle of repose (°) | 31 | 33 | 39 |
| Angle of rupture (°) | 51 | 55 | 58 |
| Formability | ○ | △ | × |

With these factors being recognized, 'THERPUS LF' received "FY 2015 Project Award [Engineering category]" and "FY 2015 Superior Value Improvement Award" from Toyota Motor Corp.

We will try to spread the adoption of 'THERPUS LF,' which delivers favorable powder characteristics and which can be used to mold high-strength and uniform thin skin at a low temperature, as a material that can contribute to weight reduction in and design property improvement for the instrument panels, widely through not only the domestic market but also the markets in North America and Europe, and even China and Southeast Asia in the future.

**[Contact (about the product)]**

**In Japan**
**Sales & Marketing Dept. of Transport & Polyurethane Foam Industry**
**https://www.sanyo-chemical.co.jp/eng/**

**In U.S.A**
**SANAM Corporation**
**State Highway 837**
**P. O. Box 567**
**West Elizabeth, PA 15088-0567**
**https://www.sanamcorp.com/**