

Development for New Bumper Face Material in Asia-Pacific Region

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ABSTRACT

This paper describes the development of a low-cost polypropylene (PP) bumper face material at Honda R&D Asia Pacific. This material realizes high impact performance at low temperature, and low specific gravity, which are Honda's worldwide quality requirements.

In order to simultaneously realize good low-temperature properties, high rigidity, and low specific gravity as the conventional bumper characteristics, it was necessary to polymerize block co-polymer polypropylene (BCPP), the main component, and then add expensive rubber material and high crystallization PP during the subsequent compounding process.

In this development, new catalyst properties and profile rationalization were employed, permitting manufacture of a more rigid BCPP that contains a large amount of rubber, which is advantageous for impact performance. By using this BCPP as a base resin, a less expensive bumper face material that had good productivity was developed.

1. Introduction

In recent years, the rising price of crude oil has brought about an increase in the price of naphtha, and because naphtha is a raw material of polypropylene (PP), the price of PP has also risen, as shown in Fig. 1^{(1), (2)}. This situation shows the same tendency as that of steel, copper, and other metallic materials. In order to cope with this increase in the price of materials, it is important for suppliers who handle industrial products to search for, and implement, ways of reducing the cost of materials and the products made from them, from a variety of fronts.

Regarding the recent situation of automobiles in the Asia-Pacific region, sales of small automobiles are tending to spread centered on the Indian market, while in Thailand the eco-car concept has been realized, and it is considered a matter of urgency to concentrate automobile development on these vehicles in order to strengthen the cost competitiveness of small models.

Considering measures for reducing costs, firstly, it is necessary to develop inexpensive and high-grade materials. In other words, it is necessary to search for high performance, highly functional materials that can be substituted for expensive materials or contribute to a reduction in their use. Secondly, it is important to reduce waste as far as possible and strive to reduce investment costs and raise productivity, through means such as

reducing the number of processes, rationalization, integration, increased accuracy and yield, and the like. Thirdly, it is necessary to reduce the cost of raw materials, particularly at Honda's overseas centers, and use specialty products of each region concerned as well as materials assumed to be locally procured, in order to help eliminate transportation costs, customs duty, administration costs, and the like. As a start in this direction, development aimed at realizing an inexpensive cost bumper face material was carried out. A description of this development is set out below.

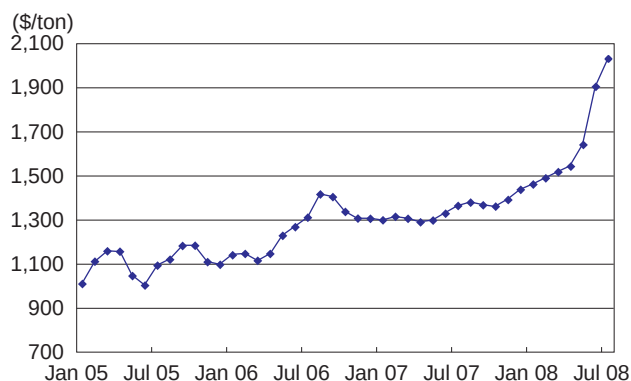


Fig. 1 Polypropylene price (platts)

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2. Material Composition, and Proposals Aimed at Cost Reduction

The role of the bumper face material is to retain the shape of the bumper, even when it is thin; to help ensure that the bumper is rigid so that it does not deform when hot; and to help prevent deformation or cracking of the bumper in the event of a minor collision. Needless to say, it is desirable that a bumper face material be light and inexpensive. In order to satisfy these requirements, the bumper face material consists of block co-polymer polypropylene (BCPP) as a base, and high crystallization PP, rubber, and talc, as shown in Table 1. The manufacturing process consists of a process in which PP is polymerized by naphtha, followed by a compounding process in which the physical properties and color are adjusted, as shown in Fig. 2. The resulting material is formed into resin pellets that are finally sent to the injection molding stage⁽³⁾.

In this development, a new material design was considered from the viewpoint of cost reduction. Of the constituents of the bumper face material, the structure of BCPP consists of elastomer “islands” in a “sea” of high crystallization PP, as shown in Fig. 3. Conventionally, the characteristics of the bumper face material are determined with the goal of acquiring rigidity and impact resistance. This BCPP on its own does not have all of the physical properties necessary for achieving this goal, so in the subsequent compounding process, BCPP is blended with rubber, high crystallization PP, and talc. However, because of its low production efficiency, this rubber is a high-cost material compared to BCPP, so rightfully the amount added should be reduced in quantity or its use should be

Table 1 Role of material

Process	Composition	Role
Polymerization process	BCPP	Rigidity, paintability and impact
Compound process	High crystallization PP	Rigidity
	Post-addition elastomer	Impact and paintability
	Talc	Rigidity

eliminated altogether. Likewise, regarding high crystallization PP as well, promoting crystallization to reduce the required amount of high crystallization PP as far as possible should also help reduce the cost of the material. Figure 4 shows a diagrammatic representation of the material constituents based on the above conjecture.

In other words, material design for cost reduction involves approaching the final composition as much as possible during the BCPP polymerization process so as to help eliminate subsequent addition or adjustment.

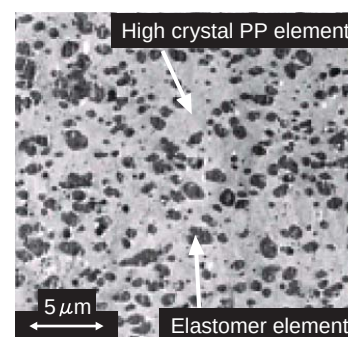


Fig. 3 Structure of BCPP

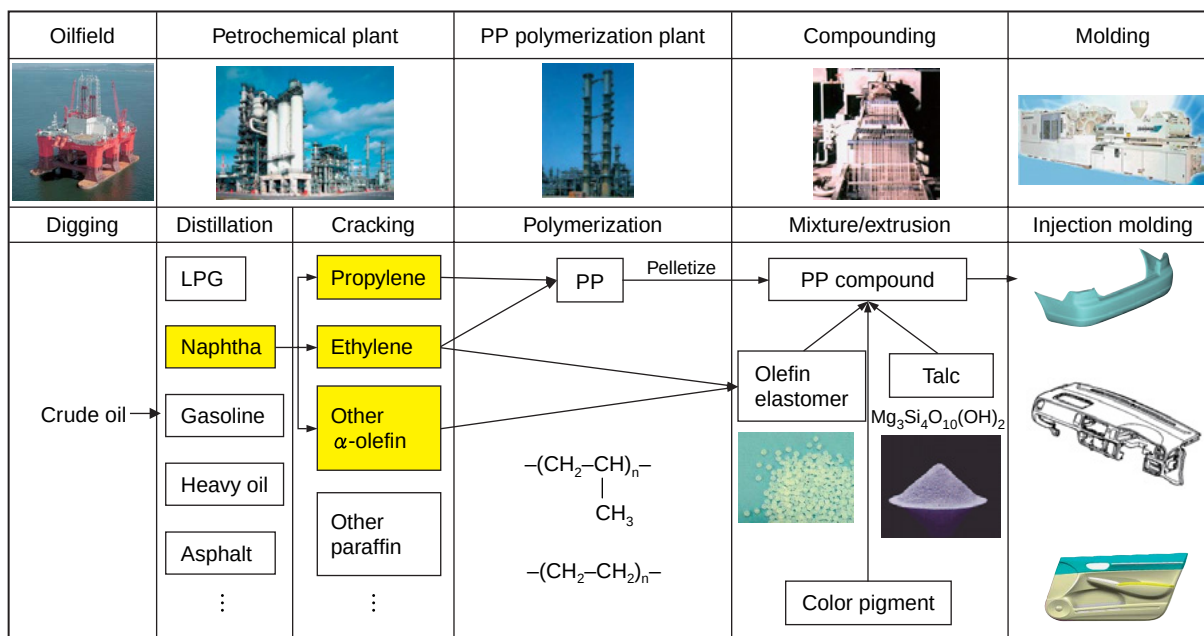


Fig. 2 Manufacturing process

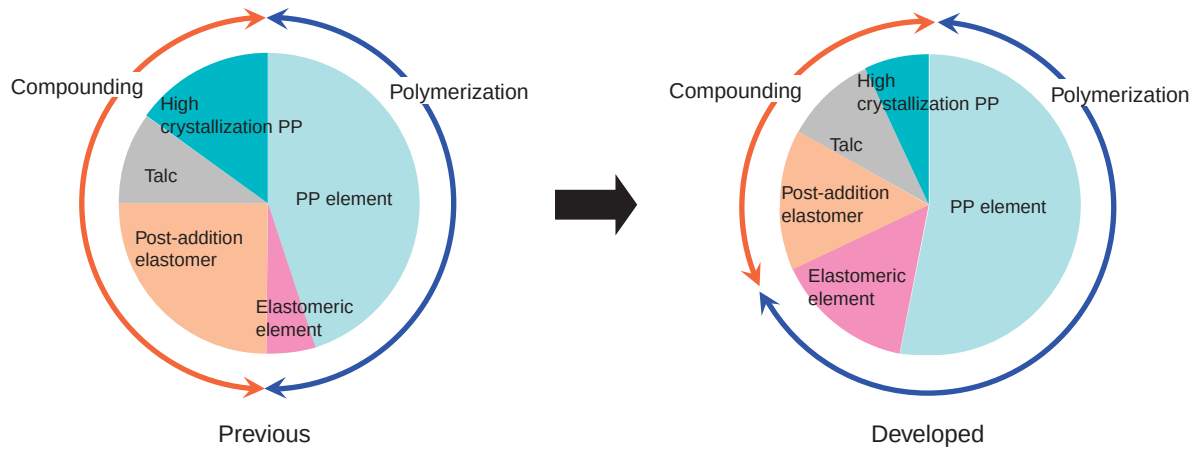


Fig. 4 Idea of bumper material composition design

Concretely, this means promoting high rubber content⁽⁴⁾ and high crystallization of PP. Each of these is described in the following section.

3. Promoting High Rubber Content in BCPP

The key to the promotion of high rubber content is the use of a PP polymerization catalyst. Conventionally, as shown in

Figure 5, BCPP that is extracted from the PP polymerization plant after the reaction that takes place there consists of a dry powder having a grain diameter of about 0.5 mm, which does not produce blocking. If the rubber content is increased in this condition, the amount of rubber existing on the powder grain surface will

increase as shown in Fig. 6, and the powder will become more tacky. As a result, sticking and reduction of fluidity will occur, leading to reduced productivity. In order to overcome this, first of all a study of the use of large grains in order to reduce the relative surface area of the BCPP powder and thus reduce the opportunities for the rubber to come into contact with it was carried out. Because the grain diameter of the powder depends upon the grain diameter of the polymerization catalyst, a large grain diameter catalyst was used, resulting in a powder that had a grain diameter of about 1.5 mm, as shown in Fig. 7⁽³⁾. In addition, a study of the shape of the catalyst was carried out with the goal of reducing the rubber content at the surface of the powder, and it was decided to use a porous catalyst. As a result, a large amount of rubber was

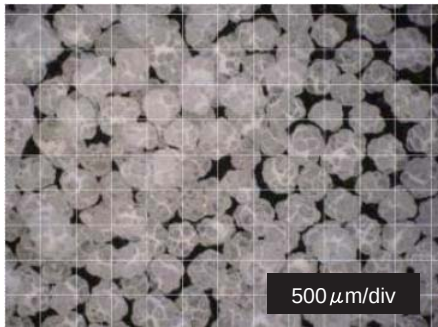


Fig. 5 BCPP powder

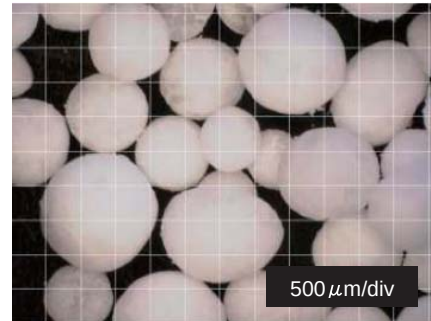


Fig. 7 BCPP powder

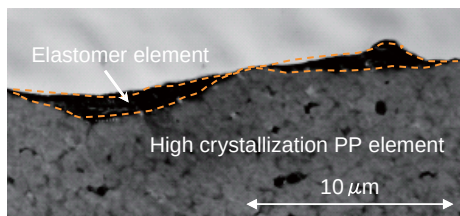


Fig. 6 Surface of BCPP powder

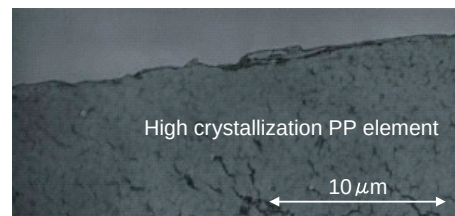


Fig. 8 Surface of BCPP powder (porous catalyst)

taken into the powder, and as shown in Fig. 8, the rubber concentration at the surface could no longer be seen.

Figure 9 shows the relationship between the rubber content and fluidity of the powder for different grain diameters. Fluidity is an index that expresses the degree of tackiness of the rubber component from the velocity at which the PP powder inside the polymerization reaction unit drops. In this development, the target fluidity was 10 or less. When using the conventional powder grain diameter, the rubber content should be no more than about 10% to help ensure adequate productivity. It was found that if the powder grain diameter is increased, the rubber content will rise, and if this measure is combined with the use of a porous catalyst, a rubber content of at least 23% or so can be achieved. However, because there are limits to the porosity and increase in the grain diameter of the catalyst itself, the catalyst was optimized in consideration of realistic production, and the rubber content was set.

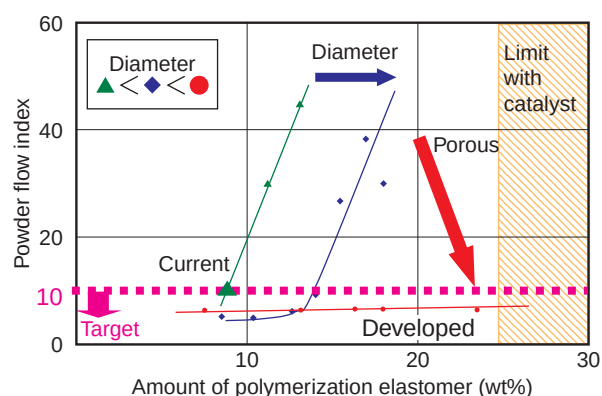


Fig. 9 Effect of BCPP elastomer content

4. Developing a Highly Rigid Bumper Face Material

In the conventional bumper face material, high crystallization PP was post-added during the compounding process in order to enhance the rigidity of BCPP. In the case of the newly developed bumper face material, however, the addition of a nucleator during the compounding process raised the crystallinity and increased rigidity, enabling the amount of post-added high crystallization PP to be reduced, thus contributing to cost reduction. Table 2 shows an example in which particular attention was placed on rigidity and the effectiveness of adding a nucleator to increase rigidity was verified using Homo PP.

5. Performance of the Developed Material

Table 3 shows the physical properties of the developed BCPP. It can be seen that the impact

Table 2 Effect of nucleator

Properties	Unit	Homo PP	Homo PP + nucleator
Specific gravity	—	0.9	0.9
Flexural strength	MPa	54	65
Flexural modulus	MPa	1850	2250
Izod impact (23 °C)	J/m	22	20

Table 3 Physical properties of BCPP

Properties	Unit	Previous	Developed
Specific gravity	—	0.9	0.9
Flexural strength	MPa	35	27
Flexural modulus	MPa	1200	1000
Izod impact (23 °C)	J/m	50	90

performance has been increased by 80% as a result of using high rubber content in a BCPP condition. By using this BCPP, a new bumper face material for use in the Asia-Pacific region having the same performance as that of the existing material and satisfying Honda's global standards was able to be developed.

6. Effectiveness of Using the New Material

As a result of the promotion of high rubber content during polymerization and the use of a nucleator for high rigidity, a cost reduction of 6% compared to that of the previous material was attained.

Previously, in the Asia-Pacific region, dedicated materials limited to that region were used in parallel with material that conformed to Honda's global standards. As a result of the development of the new inexpensive material, however, the previous materials can be integrated into a single material, thus reducing loss due to changeover between materials.

7. Conclusion

A new bumper face material employing a combination of high rubber content BCPP that is based on the use of a new catalyst technology and crystallization technology was developed, and is being used for the first time on the 2008 model year ACCORD produced in Thailand.

- (1) By using a large grain diameter porous catalyst as the polymerization catalyst for BCPP, which is the base polymer, high rubber content (approximately 20%) BCPP was developed, enabling the amount of expensive post-added rubber to be reduced (by approximately 5%).
- (2) At the same time, the degree of crystallization of PP was raised, enabling the amount of post-added high

- crystallization PP to be reduced (by approximately 5%).
- (3) As a result, the newly developed bumper face material had good productivity and was inexpensive to produce (approximately 6% lower than that of the previous material), and moreover, the material has retained Honda's worldwide required quality, low-temperature impact performance, high rigidity, and low specific gravity.
 - (4) Subsequent to its adoption on the 2008 model year ACCORD, the new material has come to be used on all models being produced in Thailand, and in addition is being used throughout the Asia-Pacific region (Taiwan, Malaysia, India, and Pakistan).

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