Advanced Development of Exchange Blow Molding

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Preface

Exchange - Blow Molding is a technique which makes multiple kinds of plastic with different properties to be blow molded integrally, and different from ordinary multi-layer molding, it is under a concept to utilize the individual feature of each types of plastic. Single layered parison of different material properties is selectively extruded from die-head alternately, and whole parison made from partly different materials (a parison which single layer and another single layer are selectively combined) is formed and it is blow molded.

For example, multiple parts composed by the combination of metal ducts and rubber hoses can be integrally blow molded by using soft plastic and hard plastic, whereas the soft plastic is assigned to an assembly portion or bellows portion of duct or pipe, and the hard plastic is assigned to the main body. By using this, reduction of components and cost is enabled, and is widely used mainly to air intake ducts of automobiles and other applications.

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○ Glossary

MES

3D blow molding method developed by Excell Corporation. Abbreviation of Multi - Dimensional Extrusion Molding.

Parison

A tubular molten plastic extruded from die-head in blow molding.

Draw down

A phenomenon which a parison extruded from die head is stretched due to its weight.

Multi functional Exchange - Blow Molding

A technique to make a resonator (resonating silencer) to the hard portion of exchange blow molded part which consists of soft plastic and hard plastic.

1. Exchange - Blow Molding

In Exchange - Blow Molding, plastic materials with different properties molten by multiple extruders are merged in the extruder heads, and by using the extrusion control of the extruder, the plastic material is selectively switched, and those plastics are extruded from the edge of the nozzle continuously and alternately, and makes a ring-shaped single layered parison with to the droop down direction (Fig.1), the parison is stored inside a mold, and after air blow and cooling, exchange - blow molded part is made.

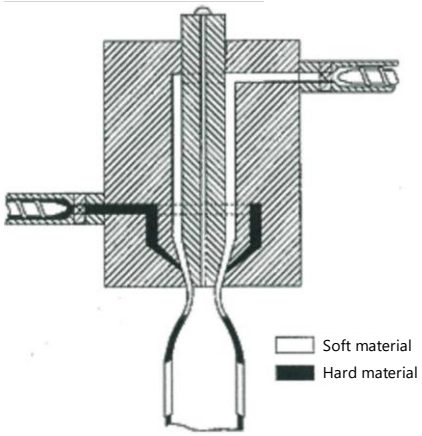


Fig. 1 Structure of Exchange Blow Molding and example of exchanged parison

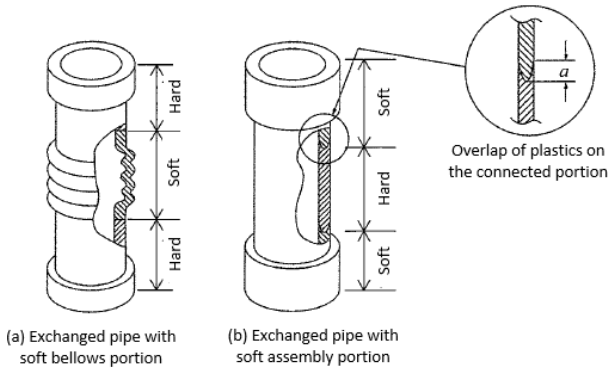


Fig. 2 Basic composition of Exchange - Blow molded part

As shown in the basic structure of molded part shown in Fig.2, by using soft plastic on assembly portion or bellows portion, and hard material on main body portion, what was composed conventionally of multiple parts would be integrated, and there is a feature that the overlap of plastics on the switching portion of plastic is short. Because of this, plastics with different characteristic can basically be single layer, and it enables to have flexibility of the soft material portion on bellows portion or assembly portion, and rigidity on the residing hard material portion can be secured.

2. MES - Exchange Blow Molding

The feature of Exchange - Blow Molding is utilized utmost by combining with our Multidimensional Extrusion System (MES). The basic concept of the molding method is shown in Fig.3.

In MES Blow Molding, the die head which extrudes the parison moves along the cavity of a blow mold which is laid horizontally, and blow molds by storing the parison into the mold, and there are benefits such as;

① the multidimensionally molded part can be made without flash. Also, multiple bellows can be set to any position, and various insert parts can be set.

② Engineering plastics or elastomers with less pinch off strength can be molded. Mold is laid horizontally, so engineering plastic, elastomer, or filler-reinforced material can be molded with less affect caused by draw down.

An example of air intake pipe molded with MES - Exchange Molding, which is the combination of the above technique and Exchange - Blow Molding, is shown in Fig. 4. Fig.4. (a) shows the conventional structure, and Fig.4. (b) shows the MES - Exchange Molding. The main pipe which was conventionally made of metal etc. is replaced by hard plastic, and rubber material by soft plastic, and made into integrated simple blow molded part. In this example, number of parts and assembly process cycle can be reduced to 65% to 70% in comparison with conventional products.

The MES - Exchange Blow molded part has features such as;

① Multiple parts can be integrated, and flexibility in design and reliability will increase.

② Part number and assembly cycle will be greatly reduced, and allows cost reduction.

③ Using plastic allows weight reduction, and also becomes possible to be recycled.

④ High-grade product can be made by using engineering plastic.

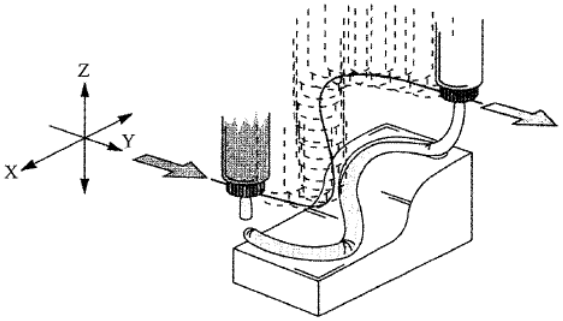
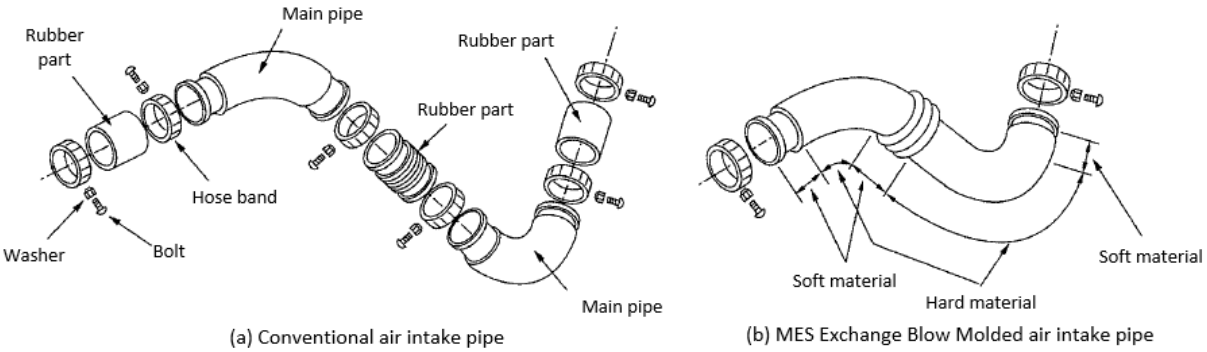


Fig. 3 Basic concept of MES (3D Blow molding)

Table 1 Combination of plastics with good adhesion

Hard material	Melting point (°C)	Soft material, Hardness, Elastic modulus
PP, PP-GF	165	TPV, Oil-resistant TPV, A70 to A85
PA6, PA6-GF	225	TPAE (PA6, PA11, PA12), A90 to D50
PBT, PBT-GF	225	TPC (ET, ES), D40 to D60
PPA-GF	275	PPA-Soft, F.M. 500 to 1,000MPa
PPS-GF	280	PPS-Soft, F.M. 500 to 1,000MPa

A,D: Durometer hardness, F.M. : Flexural Modulus



(a) Conventional air intake pipe

(b) MES Exchange Blow Molded air intake pipe

Fig. 4 Replacement of plastic in air intake pipe

3. Combination of Molding Material and Samples

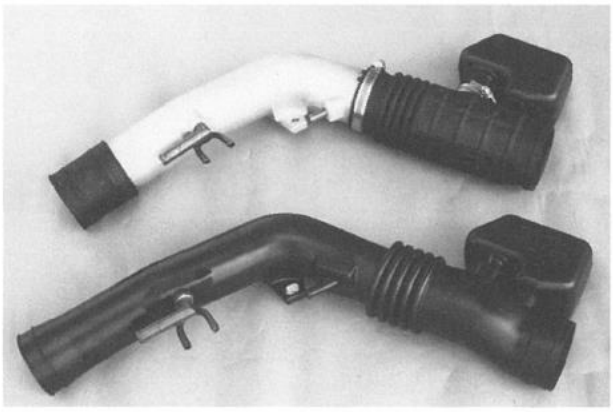
In Exchange - Blow Molding which molds integrally using multiple plastics, the adhesion between plastic is important. It is required that the switching portion of different material to have sufficient strength against external stress such as tensile strength, compressing, vibration, and thermal shock.

Table 1 shows the combination of hard plastic and soft plastic with good mutual adhesion.

The plastic is selected depending on the required performance of a product (heat resistance, oil resistance), and apply it on the Exchange Blow Molded product.

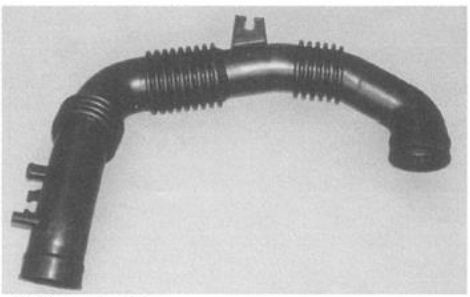
The MES - Exchange Blow molded part which can integrate subcomponents is mainly adopted to air intake parts of automobiles. In air intake parts of automobiles, there are various performance requirements such as heat resistance, vibration resistance, durability, chemical resistance, and it varies between the locations used. In air intake ducts for general use, the combination of olefin type polypropylene (PP) and dynamically cross-linked thermo vulcanized elastomer (TPV) is used, but if heat resistance is required PA6 and polyamide type elastomer TPAE is applied. Also, PA6-GF and TPAE is used for turbocharger ducts, and if higher long-term heat resistance is required, a combination of polybutylene terephthalate (PBT) -GF and polyester type elastomer (TPC) is used. Recently, polyphthalamide (PPA) or polyphenylene sulfide (PPS) is also investigated, due to higher charged air temperature derived from increasing boost pressure, or reflux of EGR gas causing condensed water which includes not only mineral acid but also organic acid.

Some of applied samples are introduced as below. Fig.5 shows example of an intake air flow duct for passenger car, and conventionally the product was made of metal duct and rubber hoses (part shown on top), and then integrated by MES - Exchange



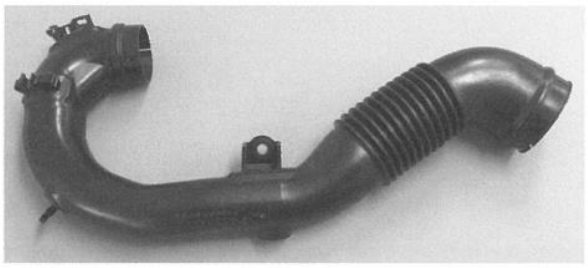
(Top) Conventional air intake duct
Main body: Metal duct, Both ends and bellows: Rubber hose
(Bottom) MES - Exchange duct
Main body: PP, Both ends and bellows: TPV

Fig. 5 Intake air flow duct



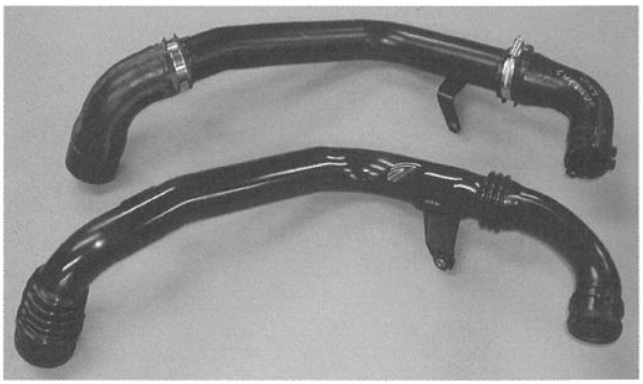
Main body: PP
Assembly portion on both ends and bellows: TPV
(Soft / Hard is switched 9 times)

Fig. 6 Air flow duct



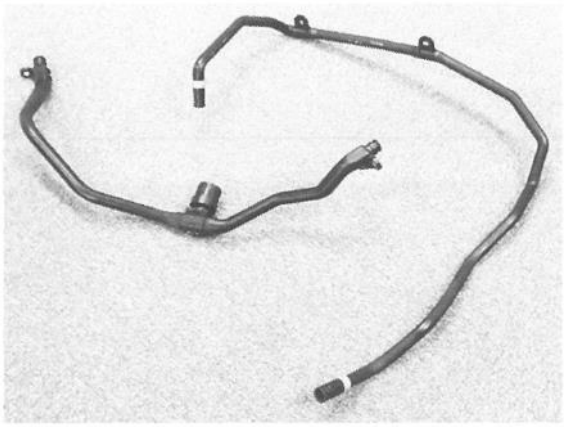
Main body: PA6, Both ends and bellows: TPAE

Fig. 7 Air flow duct



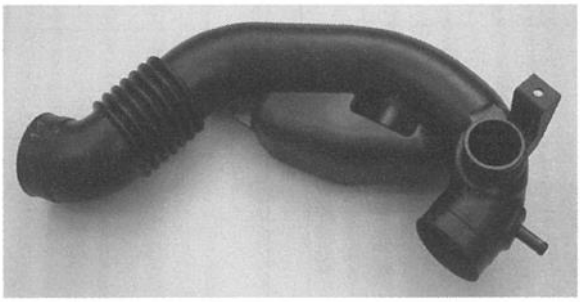
(Top) Conventional turbo pipe
Main body: Metal duct,
Both ends and bellows: Fiber-reinforced rubber hose
(Bottom) MES - Exchange pipe
Main body: PP, Both ends and bellows: TPV

Fig. 8 Turbo pipe



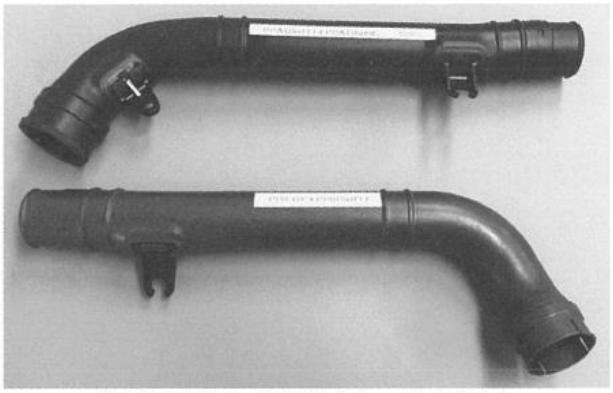
(Left) Main body: TPAE, Both ends: PA6 ϕ18 x L750
(Right) Main body: PP-GF, Both ends: Oil-resistant TPV, ϕ16 x L1,120

Fig. 9 PCV pipe



Main body & Resonator: PP, Both ends & Bellows: TPV

Fig. 10 Multi Functional Exchange Blow Molded intake air duct



(Top) Main body: PPA-GF, Both ends: PPA-Soft
(Bottom) Main body: PPS-GF, Both ends: PPS-Soft

Fig. 11 Exchange Blow molded ducts with super engineering plastic

Blow. Metal duct is replaced by PP, and bellows and assembly portion on both ends are replaced by TPV, and it achieved great reduction of parts numbers and assembly cycles, weight reduction and cost reduction. Fig. 6 also shows example of an intake air flow duct, and bellows and assembly portion on both ends are replaced by TPV and the other portion by PP, and by switching the material of PP/TPV for 9times it resulted in improving vibration absorption and assembly performance.

Fig.8 shows an example of turbocharger pipe for diesel engine type, which required high heat resistance. With the combination of PBT-GF and TPC, a part which was made of metal pipe and fiber-reinforced rubber was replaced to plastic, and it resulted to 40% of weight reduction and reduction of parts number.

Fig.9 shows an example of PCV pipe which returns the blow-by gas from engine to intake air duct. It is long and in narrow diameter (ϕ 16 to 18mm, L= 750 to 1,100 mm). Both two parts were made by combination of metal pipes and rubber hoses, whereas left part on Fig. 9 is replaced by plastic, by having flexibility using TPAE on the main body, and using PA6 on both ends by having assembly structure of O-ring, and right part is replaced by plastic by using PP-GF and oil-resistant TPV.

Fig.10 shows a part made by multi functional exchange blow molding with special parison control, by using soft material TPV on assembly portion of both ends and bellows portion, and by using large-sized hard material PP parison on main body that consists of resonator (refer to Fig. 5), and the resonator which was conventionally assembled as a separate part is molded integrally.

Fig.11 shows a development prototype part for super engineering plastic, and it is made in combination of PPS-GF and PPA-Soft, and of PPS-GF and PPS-Soft. It is prospected to deal with a location which requires high heat resistance and strong chemical resistance.

Overall, mainly about air intake ducts for automobiles were introduced, but would like to note that 3D Blow molding and Exchange Blow molding are also applicable to coolant parts as well.