Synthetic Wood for Modeling & Tooling

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Automobiles and other mass-produced modern products are generally assemblies of numerous individual components. The design process for these individual components includes these typical steps: planning → sketching → design determination → prototyping → small-quantity production. In the development of automobiles in particular, these processes can be quite time consuming, as they involve planning → sketching → design determination on a clay model → CAD drawing → manufacture of a small-scale model, e.g., 1/4 size → manufacture of a full-scale model of actual size (approval model) → prototyping → small-quantity production → mass production. During these developmental stages, small to large models and dies of various shapes are manufactured, and synthetic wood is often used as the model material. For example, synthetic wood is used in dies for thermoforming plastic parts,master models for engine, body, and other parts (models that become prototypes for mass production parts) **[Photos 1 and 2]**, and also assembly and inspection jigs to ensure fast and accurate final assembly.

Synthetic wood

"Wooden models," and dies have been used in manufacturing for many years, but there are longstanding problems associated with the use of wood. These include dimensional instability due to changes in atmospheric moisture, grain and knots. The need for improved machinability, light weight, high strength, high precision and high heat resistance led to the development of a synthetic wood substitute approximately 30 years ago. Synthetic wood is roughly divided between two types, and **Table 1** lists the properties required for the process or purpose of each. Synthetic wood with the addition of an inorganic filler is dense and high-strength, with a density range from 0.6 g/cm^3 to 1.4 g/cm^3, and is used in master models and inspection jigs. More lightweight synthetic wood with a density range from 0.1 g/cm^3 to 0.5 g/cm^3 is produced by the injection of inert gas or fine hollow resin microspheres within the synthetic wood, and is used for design models. Synthetic wood is roughly classified as either urethane-based or epoxy-based, with the current mainstream material being

Photo 1 Example of a master model

Photo 1,2 provided by: IWAMA Co., Ltd.

Photo 2 A scene from cutting a master model

Table 1 Main product development process

Product development process	Type of model or die	Especially required properties
Planning	Design/CAD design	
Design	Design model ● Mock-up model ● Styling model ● Odd side	● Lightness ● Fine texture ● Favorable manual workability and machinability
Prototyping	Master model ● Casting model ● Vacuum molding die	● Density ● Precision ● Strength ● High machinability
Mass production	Inspection jig Heat-resistant forming die	● Precision ● Strength ● Heat resistance

urethane-based synthetic wood.

Epoxy-based synthetic wood features high heat resistance and a low coefficient of thermal expansion.

These properties are achieved through the addition of a large amount of inorganic filler or the dispersion of glass microspheres. However, this type is quite rigid and difficult to machine, and its application is limited to dies for engine casting and for composite tooling. In contrast, synthetic wood made of urethane resin can be processed into large shapes, as its properties include a dense and smooth cut surface, easy machining, and light weight. Thus, it is preferred for use in many models and dies. Drawbacks to urethane-based synthetic wood include low heat resistance and susceptibility to dimensional changes due to moisture absorption. As the dimensional changes caused by heating during cutting increase if the heat resistance is low, the cutting speed cannot be increased, which affects productivity.

This article introduces the features and latest updates regarding the “SANMODUR” Series, the synthetic wood manufactured by our company.

Synthetic wood “SANMODUR” Series

The “SANMODUR” Series developed by our company is a urethane-based synthetic wood that contains tiny gas bubbles, which is the result of our urethane production and mechanical gas diffusion technologies. These technologies have been refined over many years. The manufacturing procedure is shown in **Fig. 1**.

The most general method for manufacturing synthetic wood is casting into a die, which often results in an imbalance of physical properties depending on the location from which the material is taken. However, when using our continuous manufacturing method, as shown in **Fig. 1**, there is little internal variation in the curing process, and stable physical properties are obtained for all parts, regardless of the location from which the product is taken.

1. Polyol components (polyol, inorganic filler, microspheres, foam stabilizer, etc.) are charged in one tank.
2. Polyisocyanate components (polyisocyanate, inorganic filler, microspheres, etc.) are charged in another tank.
3. The polyol components, polyisocyanate components and inert gas are continuously fed into an agitator to produce the mixture solution, which comes out on a belt conveyor.
4. The mixture solution is cured on the belt conveyor, and the solidified urethane is cut into the specified size.
5. The cut urethane is annealed in the drying furnace to remove internal stresses.
6. Final product is obtained by polishing the surface and cutting.

Fig. 1 Manufacturing procedures for “SANMODUR”

The most significant feature of the “SANMODUR” Series is its extremely small gas bubbles and their uniform dispersion within the urethane resin, as compared with that of the aqueous foaming method, i.e., the general foaming method used to produce urethane resin. Our improved results are attributable to our adoption of the mechanical foaming method (diffusion of an inert gas). Using this technique, the machined surface of the resulting

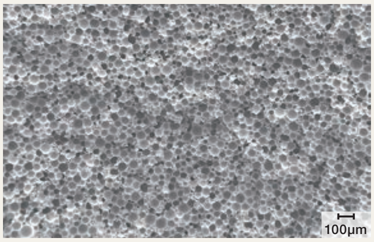

Photo 3 Electron photomicrograph of a cross section of "SANMODUR TW-E" (improved product)

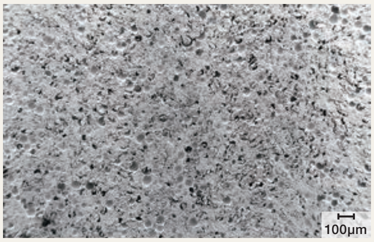

Photo 4 Electron photomicrograph of a cross section of "SANMODUR TW-E" (improved product) that was cut with a ball end mill

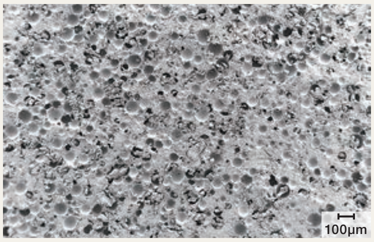

Photo 5 Electron photomicrograph of a cross section of a general synthetic wood that was cut with a ball end mill

synthetic wood is dense and smooth, and the subsequent time required to polish it with sandpaper can be reduced.
We recently released an improved product, whose performance further improves that of "SANMODUR TW-E," which is suited to applications that require excellent performance with respect to precision, strength, and heat resistance. The mechanical foaming method is also adopted for the manufacture of this improved product.
Photo 3 above shows an electron photomicrograph of a cross section (with the surface of the sample broken to make it easier to see the size of the gas bubbles) of "SANMODUR TW-E" (improved product), and **Photo 4** shows an electron photomicrograph of a cross section cut with a ball end mill. The presence of gas bubbles makes it easier to cut the synthetic wood, but we can see that the cut surface is smooth as these gas bubbles are extremely small. **Photo 5** shows an electron photomicrograph of a cross section of a general synthetic wood that was cut with a ball end mill. We can see that the surface is uneven due to the large gas bubbles present.
In addition to the improved heat resistance, which has been an issue of concern with urethane resin, this improved product also undergoes less dimensional change upon moisture absorption, which is achieved by optimizing the composition (structure) of polyol, one of the raw materials in the "SANMODUR" Series.
Figure 2 shows a viscoelasticity chart for the conventional and improved "SANMODUR TW-E" products.
The peak in the tanδ value {loss modulus (E")/storage modulus (E')} in the figure indicates the softening temperature without load on the synthetic wood. While this peak for the conventional product occurs at 118°C, for the improved product, it is increased to 128°C, indicating that the heat resistance has been improved.
We also conducted an accelerated test of the

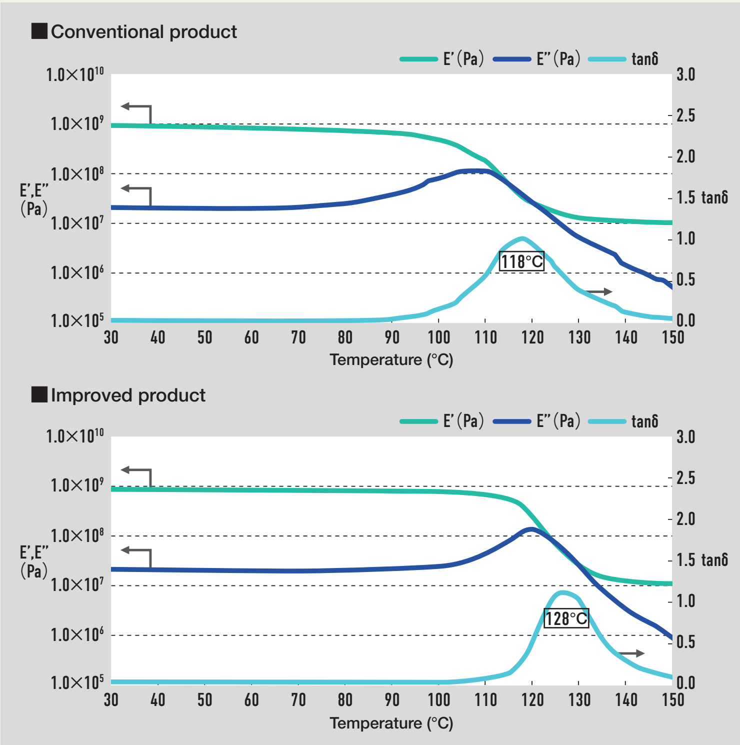

Fig. 2 Viscoelasticity chart for the conventional product (top graph) and improved product of "SANMODUR TW-E"

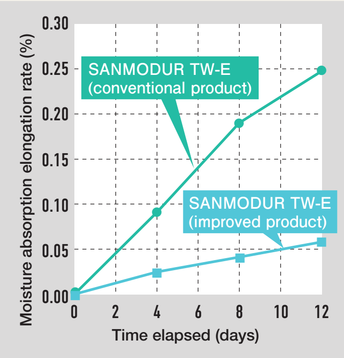

Fig. 3 Moisture absorption elongation rate (%) after soaking in warm water at 50°C

dimensional stability of the products upon moisture absorption by soaking the synthetic wood in warm water at 50°C for a long period. **Figure 3** shows the results. A comparison of the dimensional changes (moisture absorption elongation rate) in the conventional and improved products shows that the dimensional change in the improved product is reduced to 1/4 that of the conventional product, thus demonstrating its excellent dimensional stability.
This stability enables its application in large models that are significantly affected by even a small dimensional change. As the dimensional change is small even in a large model after storage for a long period in a high-moisture environment, it is now possible to use this model repeatedly.
Our company has a full lineup of the 'SANMODUR' Series featuring static prevention, including "SANMODUR TW-E."
To prevent static charge buildup during cutting, measures were taken regarding the powder generated by cutting these materials to cause the powder to adhere to the machine, thereby making it more easily removed by air blowing and collection into a dust collector without fear of generating static.
Table 2 lists the physical properties of the 'SANMODUR' Series.
Although 3D printing has come into the spotlight recently for design applications, synthetic wood has high durability and high strength, and remains an essential material with various advantages, including modifiability (additional machinability) after manufacture. With the current availability of more small and inexpensive cutting machines, many manufacturers are considering the shapes of their products and are manufacturing dies using synthetic wood. We will continue our development efforts to further expand the fields of its successful application.

[Contact for questions on featured products]
Polymer Application Branch 2

[Contact (about the product)]

In Japan
Sales & Marketing Dept. of Modeling materials
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/

Table 2 Major physical properties of the "SANMODUR" Series

Product name	Application	Density (g/cm³, 25°C)	Hardness (Shore D)	Bending strength (MPa)	Linear expansion coefficient (×10⁻⁶/°C)	Thermal deformation temperature (°C)	Surface roughness (μm)
		JIS K 7222	ASTM D2240	JIS K 6911	TMA	JIS K 6911	Method by our company*2
SANMODUR SX	Mock-up model Styling model Odd side	0.27	31	6.4	50	60	15
SANMODUR MH-E*1		0.35	43	7.4	54	54	11
SANMODUR LC		0.40	40	10.0	47	80	13
SANMODUR MS-E*1		0.45	52	13.6	58	65	8
SANMODUR TW-E*1 (conventional product)	Casting model Vacuum molding die Inspection jig	0.75	64	25.0	47	82	4
SANMODUR TW-E*1 (improved product)		0.75	64	25.0	47	95	4
SANMODUR NZ		0.90	80	46.0	29	140	3
SANMODUR NV		1.13	74	32.0	52	93	3

*1 With static prevention effect
*2 Measured with non-contact three-dimensional surface roughness meter manufactured by KEYENCE on a surface of synthetic wood cut with a NC machine tool manufactured by IWAMA Co., Ltd.
Surface roughness refers to the average absolute value for unevenness of a sample surface, whereby a smaller value indicates a smoother surface.