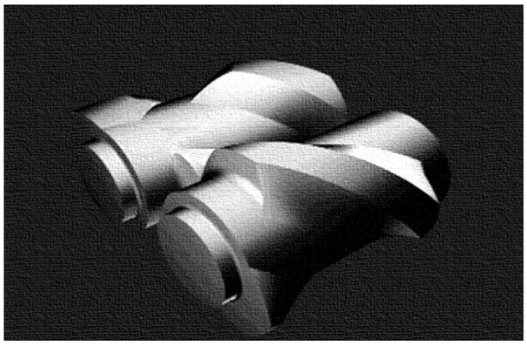
# Mitsubishi Internal Mixer Contributing to the Global Environment



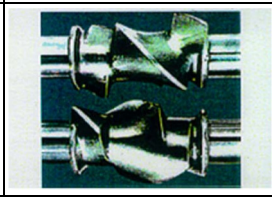
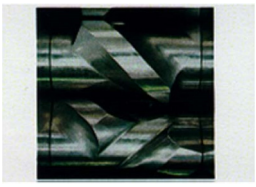
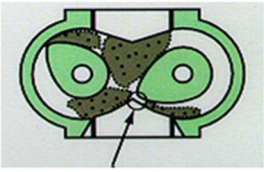
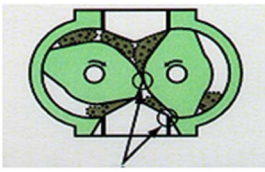
Mitsubishi Heavy Industries
Machinery Technology Corporation

The demand for higher quality and higher functionality of various rubber products such as automobile tires, rubber hoses, belts, gaskets and seals has been increasing. To manufacture a rubber product, various raw materials are mixed according to the application and processed into a final product. Internal mixers (closed-type mixers) are widely used in the mixing process, which is the most upstream process in the manufacture of rubber products, as the production equipment which affects the quality of product rubber.

In view of customer needs for advanced mixing technologies, Mitsubishi Heavy Industries Machinery Technology Corporation developed the MR-EX internal mixer (**Figure 1**) equipped with a new proprietary intermeshing rotor system, and has contributed to an increase in the quality of rubber and tire products and the improvement of productivity.

**Figure 1 Mitsubishi Internal Mixer**

**Table 1 Rotor types and functions**

| Rotor type | | Tangential rotor | Intermeshing rotor |
|---|---|---|---|
| Rotor shape | |  |  |
| Mixing mechanism | |  (1) Between rotor and chamber wall |  (1) Between rotor and chamber wall (2) Between rotor and rotor |
| Function | Shearing | ◎Excellent | ◎Excellent |
| | Distribution | ○Good | ◎Excellent |
| | Intake | ◎Excellent | ○Good |
| | Cooling | △Acceptable | ◎Excellent |

## 1. Features of intermeshing MR-EX mixer

### 1.1 Function of mixing rotor

Internal mixers are broadly divided into the tangential type and the intermeshing type, as shown in **Table 1**, depending on the type of rotors installed in the mixer. In the tangential rotor system, mixing is performed between the rotors and the chamber wall. The mixing time is generally short because the clearance between the rotors is large and the intake of raw material is fast. However, intense shearing force is applied at the rotor tip, and the temperature of the rubber during mixing increases at a rapid rate. Accordingly, the tangential type has problems in cooling performance. In particular, in the mixing of rubber compounds with high-heat generating compounds, when the allowable temperature limit is reached, the mixing operation needs to be

stopped. To obtain the desired rubber quality, the rubber is discharged and cooled, and then mixing is repeated again.

On the other hand, the intermeshing rotor system has a structure where two rotors mesh with each other. Mixing is performed not only between the rotors and the chamber wall, but also between the two rotors. The intake of raw material is weaker than that of the tangential rotor system because the clearance between the rotors is small. Due to the rolling effect between the rotors, however, a higher shearing force is applied, and at the same time, due to the larger contact area with the rubber, excellent cooling performance is exhibited during mixing.

### 1.2 Rotor structure

The structure of MHI's intermeshing rotor system is shown in **Figure 2**. This rotor system adopts a unique rotor wing system that combines the benefits of both conventional tangential and intermeshing rotors to form an intermeshing rotor system designed with importance placed on mixing and cooling performances in particular. This rotor system has the following features:

(1) The three wings of the intermeshing rotor design employ an arrangement of a four-winged tangential rotor system to improve rubber fluidity and intake performance.

(2) The proper clearance fluctuation is applied between the rotors to improve the shearing and intake performances.

(3) A 2-piece structure consisting of the rotor wing and the rotor shaft is employed and coolant is spirally circulated in the rotor wing to increase the cooling effect even at the tip.

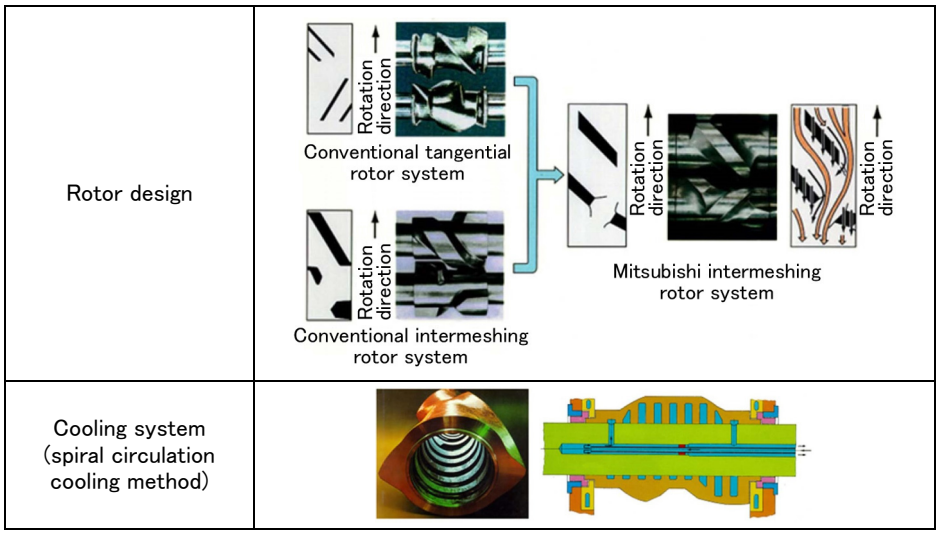



**Figure 2 Structure of Mitsubishi intermeshing rotor system**

## 2. Rubber mixing characteristics

### 2.1 Example of improvement by the intermeshing rotor system

The results of a comparison of the mixing performance between a conventional tangential rotor system and our intermeshing rotor system are shown in **Figure 3**. Our intermeshing rotor system has a high cooling performance with the rubber discharge temperature being low, and the filler dispersion is enhanced, resulting in the improvement of rubber properties. Furthermore, the improvement of productivity due to the reduction of mixing stages, which was difficult with conventional tangential rotor systems, was achieved. **Figure 4** shows an example of productivity improvement. The introduction of our intermeshing type mixer reduces the number of mixing stages, shortens production time and contributes to the improvement of production efficiency.

### 2.2 Application to fuel-efficient tires

In Japan, the system for indicating the fuel-efficiency performance on automobile tires (Labeling System) started in 2010. As a result, in the tire industry, the demand for silica compound rubber with a high fuel efficiency has been rapidly increasing. The manufacture of silica compound rubber requires the control of the chemical reaction specific to silica material. With existing mixers for tires, it was difficult to uniformly mix silica particles. MHI developed a new intermeshing rotor (Type EX7), which has an optimum rotor wing shape and superior cooling performance that allows the cooling of even the wing tip. This results in the uniform mixing of the silica compound and the

control of the reaction. **Table 2** shows the results of a comparison of the mixing performances for silica compound rubber. Compared to conventional intermeshing rotors (Type E), the new intermeshing rotor uses a lower mixing energy (unit work) and exhibits increased mixing efficiency. Therefore, with our new intermeshing rotor system, an energy saving effect can be expected and the enhancement of silica dispersion has been achieved.

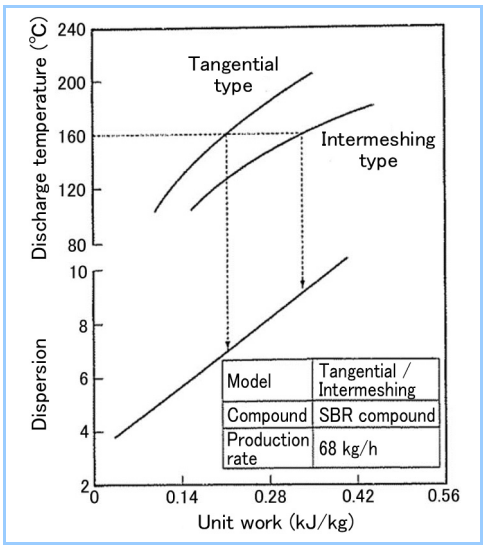



**Figure 3 Comparison of rubber mixing performance**

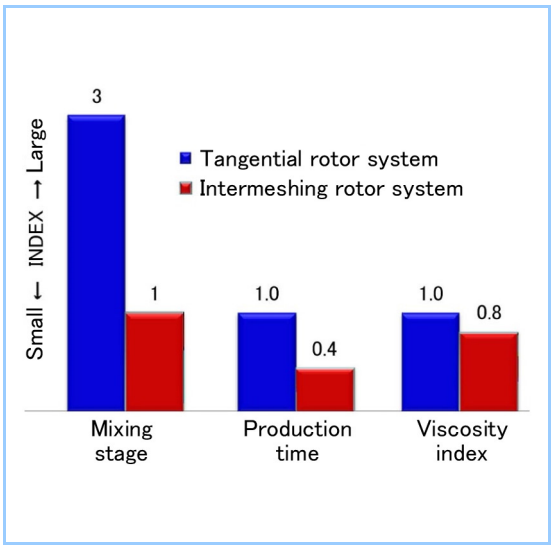
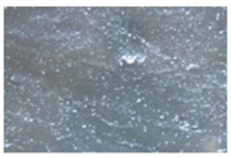



**Figure 4 Example of productivity improvement**

**Table 2 Comparison of mixing performance of silica compound rubber**

| Rotor type | Conventional intermeshing (Type E) | New intermeshing (Type EX7) |
|---|---|---|
| Mixing time | 5 min | 5 min |
| Mixing energy | 0.73 kWh/kg | 0.66 kWh/kg |
| Silica dispersion | X=4.6  | X=6.8  |

## 3. Future prospects

In the recent situation where measures for global environmental conservation and resource conservation are increasingly demanded, the rubber and tire industry is facing an urgent need for innovation of the production process and expectations for technological innovation are high.

MHI developed the MR-EX mixer equipped with a new intermeshing rotor. The MR-EX mixer has achieved a reduction in the number of mixing stages, which has been difficult until now, and the improvement of rubber quality. In addition, through the realization of energy saving and the improvement of productivity, a contribution to a reduction in environmental load can be expected.

We are willing to continuously endeavor for technological innovation and the enhancement of functions to satisfy further diversifying customer needs.