High-density Sintered Sprocket for Silent Chain Made by Die Wall Lubrication Compacting with Liquid Coating

Satoshi Onodera

Core Technology Center, Production Integration Division,
Production Innovation Headquarters

1 Abstract

Sintered sprockets for silent chains of automobile engines require high contact fatigue strength on tooth surfaces. So, the sprockets are densified (7.5Mg/m^3) by removing the residual pores of the tooth surface layer using the tooth flank form rolling method. However, due to the rise of other processes, we started developing an inexpensive densification process to replace the tooth flank form rolling method. Die wall lubrication compacting with liquid coating, which allows high-density compaction of raw powders with the amount of added lubricant minimized using a die uniformly coated with lubricant film, was developed. As a result of this development, industrial production of a low-cost sprocket for silent chains omitting the tooth flank form rolling process was successfully realized.

2 Features of This Technology

- The developed lubricant has two or more times the release capability compared to the general compacting method.
- Lubricant film coating technology utilizing die action is advantageous from the viewpoint of compacting speed (productivity).
- The usage with sprockets for silent chains of timing trains for automobile engines contributes to expanding the application of powder metallurgical products.

3 Background of the Development

Increasing the output and rotation speed of automobile engines tends to increase the stress generated in the sprockets of the engine valve mechanism, due to friction with the chain. Sprockets are required to have high contact fatigue strength for specifications of silent chains that enable a significant reduction in engine noise. One technique for obtaining high contact fatigue strength in sintered parts is densification. The manufacturing methods of sintering forging, compacting twice and sintering twice, warm compaction, and tooth flank form rolling have been industrialized so far.

On the other hand, it is increasingly important for powder-metallurgy processing to enhance cost competitiveness because the acceleration of globalization in recent years has caused parts suppliers for automobile manufacturers to rapidly advance into developing countries. In addition, cost reductions are also required due to the emergence of other methods, such as forging and cutting.

For the above reasons, we started developing die wall lubrication compaction to provide the features of high density and high strength to provide high productivity and excellent cost competitiveness.

4 Technical Details

(1) Mold release characteristic of developed lubricant

We decided to start from the development of a lubricant capable of providing excellent mold release capability in the powder compacting process and, after various investigations, we developed a new lubricant containing mineral oil added to a solid lubricant and extreme-pressure agent. **Figure 1** shows the mold release force in comparison with that of general compacting when Fe-Cu-C base powder was subjected to die wall lubrication compaction to obtain a cylindrical shape (20 mm in diameter × 30 mm in height) at a compaction pressure ranging from 400–1500 MPa using this lubricant. We discovered the following: the mold release force of die wall lubrication compaction using the developed lubricant was at a level lower than that of general compacting, this tendency was significant in higher

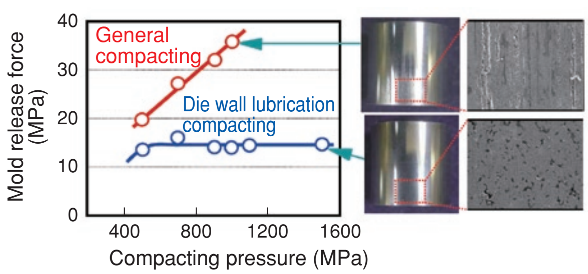

Figure 1 Mold releasability of developed lubricant

compacting pressure, and compaction pressure at 1000 MPa or more reduced the force by 50% or more in comparison with general compacting.

(2) Method for applying lubricants

Following the above, we developed a lubricant film formation technique having the feature that the procedure is completed within a general die action cycle, from release of the mold in the compacting process to the return to the powder filling process. **Figure 2** shows a schematic diagram. Lubricant supplied through the interior of the die is applied to the internal wall and sides of each die during the die action from the mold release position to the powder filling position. This enables high density products to be manufactured without impacting the compacting speed (productivity).

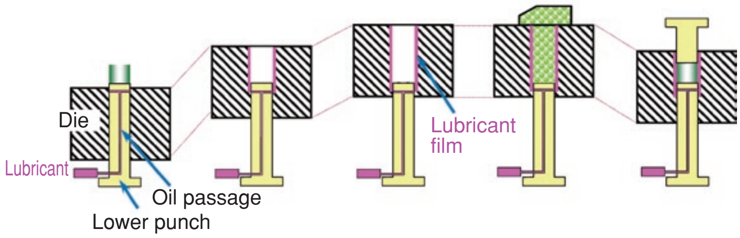

Figure 2 Diagram of steps in the lubricant application method

(3) Applicable products

The proprietary development of die wall lubrication compacting with a liquid coating resulted in the successful industrialization of low cost, high density sprockets while omitting tooth flank form rolling, which is the current manufacturing method. **Figure 3** shows a typical product. This product has many holes for weight reduction and is subjected to multi-stage punch forming. We developed a technology capable of forming a uniform lubricant film all over the die wall surface to satisfy compacting requirements, and minimized the constraint conditions for products to which this method is applied.

Figure 3 High-density sintered sprocket for silent chain made by die wall lubrication compacting with liquid coating

5 Future Business Development

- Expand the market for high density products differentiated from the products of competitor companies
- Create next-generation high densification technology to prepare the way for new product development

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