Development of the finishing process technology for the minute module-small gear by the fiber-reinforced plastic gear-shaped tool for high precision, high efficiency, and low environmental impact

1. Outline

In recent years, compact geared motors, such as that shown in Fig. 1, have been used in applications such as medical and office equipment, where quiet operation is demanded due to the proximity of people. The requirements of such motors are that they exhibit high strength and operate silently. In order to satisfy these demands, our company has developed the V series of compact geared motors. However, with conventional finishing methods, it is very difficult to achieve the high level of accuracy needed to produce extremely silent gears. To solve this problem, a high-precision small gear finishing process was developed, which uses a fiber-reinforced plastic (FRP) gear-shaped tool and new gear finishing equipment. This allowed efficient mass production of small high-quality gears, and motors using these gears achieved very low noise levels in the industry. Moreover, the newly developed equipment is compact and low in cost, and has less impact on the workplace and the environment.

2. Technical Content

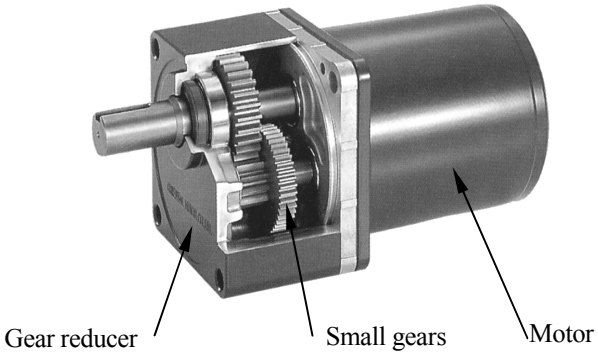
It was previously thought that minute secondary burrs and surface roughness do not contribute much to the noise of small gears. However, an investigation of noise of compact geared motors indicated that this was not the case, and it was found that both the accuracy and the surface finish of the gear tooth flank must be improved. Therefore, it was necessary to reconsider the gear finishing method used. The normal approach is to use a whetstone with bonded grains as a finishing tool, following a heat treatment to harden the surface of the gear. However, in a conventional whetstone, there is a limit to how small the grains can be, and there are difficulties in producing tools that are suitable for small gears**.** To overcome these issues, FRP was investigated as a tool material. FRP is a high-strength composite material in which reinforcing fibers are embedded in epoxy resin. Since the fibers are extremely hard, their tips act as cutting edges. For this reason, it was thought that FRP might be a suitable tool material for producing small gears. In this study, both glass-fiber-reinforced plastic (GFRP) and alumina-fiber-reinforced plastic (ALFRP) were used to produce tools. Figure 2 shows an example of a gear-shaped tool made from GFRP. As shown in Fig. 3, this tool was capable of removing secondary burrs at the side edge of a small gear. With the conventional finish-processing technology, it was impossible to remove the secondary burrs.

In the newly developed processing equipment, the gear to be processed and the FRP gear-shaped tool are meshed together in parallel, and the tool is rotated while also being oscillated along the shaft direction. Final finishing is achieved by this combination of sliding. The equipment was developed and manufactured at our company, and is much more compact and lower in cost than other commercially available gear finishing equipment.

As shown in Fig. 4, this equipment is currently being used in a gear manufacturing line, and it contributes to the high-quality and efficient mass production of gear parts in a manufacturing process. Another advantage of the newly developed process is that it requires significantly less grinding lubricant than conventional processes using a grinding wheel. In fact, processing can be carried out using as little as 0.2 ml/min (5-6 drops) of working fluid. Thus, far less oil mist is released into the workplace, thereby reducing the environmental impact.

3. Conclusion

Using noise-reduction techniques, including the gear finishing process described here, compact geared motors could be produced with noise levels of less than 30 dB at a distance of 1 m. This allowed the mass production of the V series motors (present KII series), which are compatible with what we refer to as BOS (Basis Of Silence). These motors are suitable for use in the environments in which noise levels are a concern, such as hospitals and offices, both in Japan and overseas. Another possible application of quiet, high-strength motors is to personal care equipment, which is becoming increasingly in demand as Japanese society ages.



（size： □ 20mm~□100mm）

Fig. 1　Compact geared motor

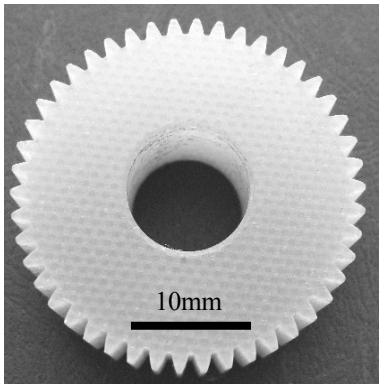
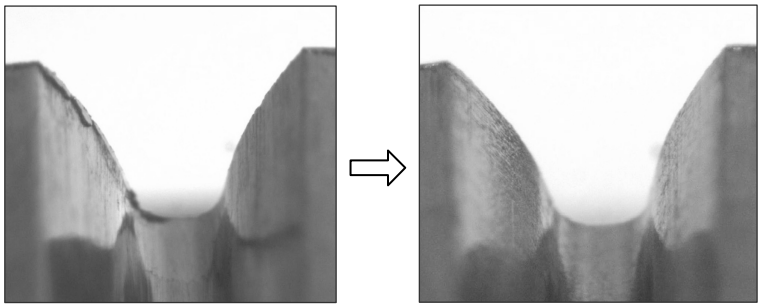


Fig. 2　Sample of GFRP gear-shaped tool



Before processing　　After processing

Fig. 3　Removal of the secondary burrs using GFRP gear-shaped tool

Fig. 4　Finishing equipment for small gear introduced in the gear production line