Wire for Electrical Discharge Machine (EDM) to Realize Highly Precise Processing of Metal Surfaces

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Oki Electric Cable Co., Ltd. (hereinafter referred to as OEC) has been manufacturing and selling electrode wires (hereinafter referred to as wires) used in EDM for over 40 years since 1976. Product image and schematic of a wire-cut EDM (WEDM) is shown in **Figure 1**. In WEDM, a wire is used as an electrode and a voltage is applied between it and a work material (workpiece) to generate an electrical discharge. The heat that is generated melts away material and shapes the workpiece into the desired form. Since the wire side is also eroded by the electrical discharge, the wire is fed at a constant speed to always supply a new section for processing. Therefore, it is desirable that the wire be uniform in the longitudinal direction.

The wire is a functional component that has great influence on the performance of the WEDM. The discharge behavior differs depending on the material and structure of the wire, thus wire selection is important for customers using WEDM. The selection criteria for wires vary depending on the application. Wires for performing high-speed machining or high-precision machining are couple of examples. OEC has always provided stable quality, high-performance wires, and at the same time focused on developing wires that meet customer needs. To meet the needs of high-precision machining, OEC has developed an electrode wire (hereinafter referred to as high-precision wire) for the EDM that realizes highly precise processing of metal surfaces. This article introduces the features and effects of this high-precision wire.

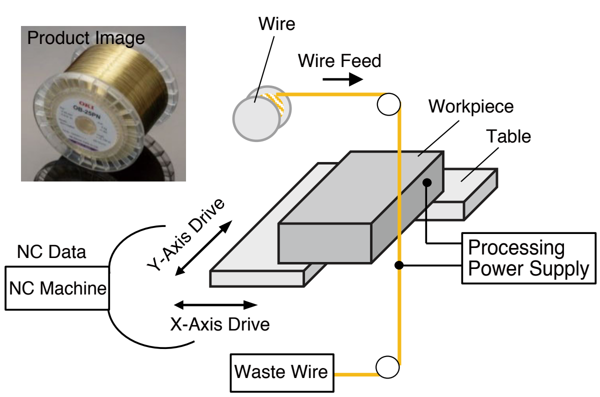


Figure 1. Product Image and WEDM Schematic

Roundness of High-Precision Wire

Stable discharge is essential for obtaining good EDM surface properties. There are mainly two approaches to achieving stable discharge, and they are either from the EDM side or from the wire side. Taking the wire side approach, OEC developed a high-precision wire focusing on the roundness of the wire.

In general, diamond die used during wire manufacturing wears out as the wire is drawn. Therefore, if wire continues to be drawn using the same diamond die, the advancing wear of the die hole will also deteriorate the roundness of the drawn wire (**Figure 2**).

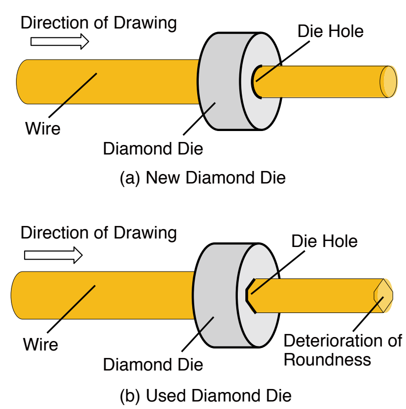


Figure 2. Diamond Die Wear

In the development, a new manufacturing method was devised to avoid such deterioration of roundness making it possible to manufacture wires that are close to perfection in roundness. **Figure 3** shows the outer diameter distribution in the circumferential direction of a general-purpose wire manufactured using the conventional method and a high-precision wire manufactured using the new method, respectively.

The outer diameter of the general-purpose wire (**Figure 3 (a)**) varies by about 0.6μm. This variation can have ill effect on high-precision machining. On the other hand, the high-precision wire (**Figure 3 (b)**) has an outer diameter variation of 0.2μm or less, which is close to perfect roundness.

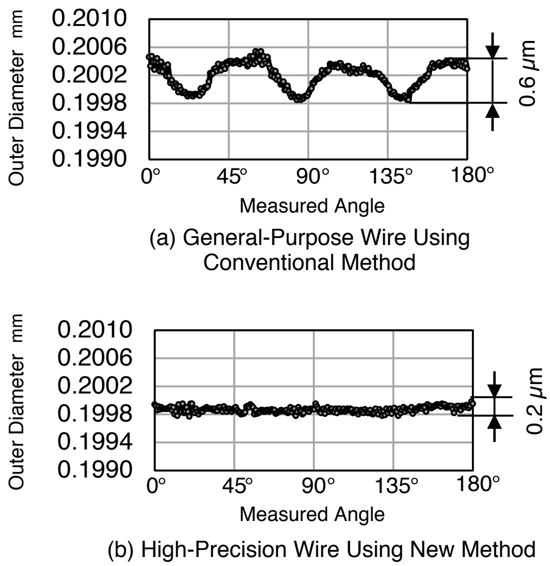


Figure 3. Outer Diameter Distribution in Circumferential Direction

Longitudinal Stability of High-Precision Wire

The previous section presented local improvement in roundness, but this section describes stability in the longitudinal direction. **Figure 4** shows the transition of roundness in the longitudinal direction for each manufacturing method. Using the conventional method, the roundness deteriorates with the length of wire manufactured, thus there are cases where the roundness changes within the product or between products in a purchased lot. On the contrary, in the new manufacturing method, there is almost no change in roundness associated with the manufactured length, and the wire has stability in the longitudinal direction. Furthermore, the range of roundness management is held to one-fourth of the conventional method ensuring constant availability of stable products.

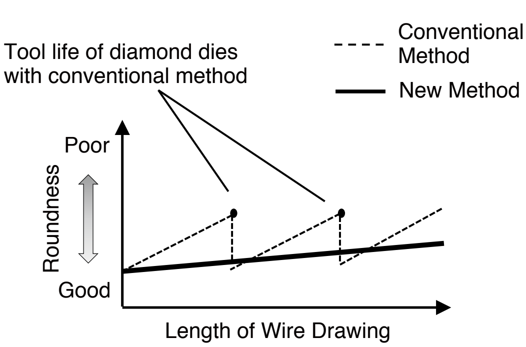


Figure 4. Longitudinal Roundness Transition with Each Manufacturing Method

Improvement of EDM Surface Roughness and Waviness

This section describes what effect the aforementioned high roundness performance has on an EDM surface. **Figure 5** shows the roughness and waviness of EDM surfaces using each wire. **Table 1** shows the names of each parameter that appears in **Figure 5** and the classification of wavelength components. It can be confirmed from **Figure 5 (a)** that the roughness parameter is only improved slightly. Since the roughness of the EDM surface is largely due to the EDM processing condition and wire material, the roundness is thought to have minimal influence. On the other hand, the waviness parameter in **Figure 5 (b)** is greatly affected by the high-precision wire and shows an improvement of about 30%. It is considered that the high roundness has an effect of suppressing such behaviors as rotation and misalignment of the fed wire during the EDM process.

From these results, it can be said that the high-precision wire maintains the same roughness as before, but at the same time improves on the waviness of the EDM surface.

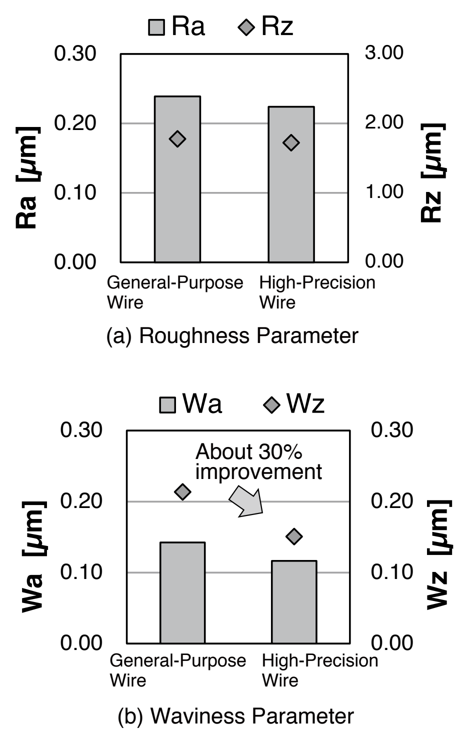


Figure 5. Roughness and Waviness Parameters of EDM Surface

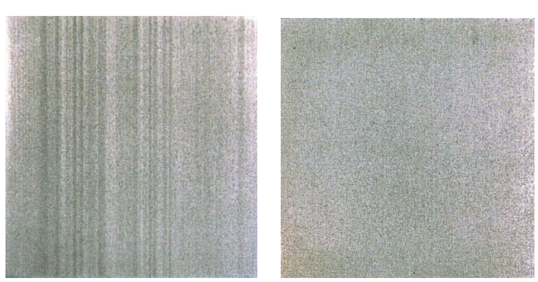
Table 1. Parameter Names and Classification of Wavelength Components

Parameter Symbol	Ra	Rz	Wa	Wz
Parameter Name	Arithmetic Mean of Roughness	Max. Height of Roughness	Arithmetic Mean of Waviness	Max. Height of Waviness
Classification of Wavelength Component	Short		Long	

Reduction of EDM Surface Streaks

In WEDM, there are cases when streaks are found on the processed EDM surface. The streaks are related to the waviness of the EDM surface described previously, and become prominent when the values of Wa and Wz are large, and on the contrary, they are difficult to notice when the values are small. It is considered that this is due to the waviness being a long wavelength component, which is recognizable with the human eye, of the EDM surface's unevenness. **Figure 6** shows EDM surface streaks using each wire. Since the streaks are most prominent after a slight polishing of the EDM surface, the photos in the figure show surfaces that have been polished. **Figure 6 (a)** is an example of streaks confirmed on an EDM surface using the general-purpose wire. As such, streaks are confirmed on EDM surfaces in which the values of Wa and Wz are relatively large. On the other hand, no streaks are apparent on the EDM surface using the high-precision wire (**Figure 6 (b)**).

These results show that the high-precision wire is effective not only for numerical improvement of the EDM surface, but also for visual improvement. WEDM is mainly used for mold making, and if there are streaks on the surface of the mold, those streaks are also transferred to the surface of the molded product. The high-precision wire dispels such concern by providing visual improvement to the EDM surface.



(a) General-Purpose Wire (b) High-Precision Wire

Figure 6. EDM Surface Streaks (after slight polishing)

Reduction of Post-Process Work

Figure 7 shows the general flow of mold making. The EDM process is classified as high-precision machining, and it is often used as a finishing process after the cutting/grinding process is completed. After the EDM process, polishing is performed using a grindstone or diamond paste. Since polishing is often performed manually, the precision of the EDM surface has a large effect on the polishing time. For example, if the EDM surface has streaks, it is necessary to remove the streaks in the polishing process. The time required for removal is determined by the amount of streaks on the EDM surface before the polishing. Therefore, it is desirable to minimize surface streaks as much as possible.

The polishing required for removing the streaks from EDM surfaces machined with general-purpose wire and high-precision wire is shown in **Figure 8**. The surface machined with general-purpose wire needed to be polished about 4μm until the streaks were completely removed, whereas the surface machined with high-precision wire needed about 2μm of polishing. The reason why the amount of streaks peak when the polishing reaches 1μm is that the EDM surface and the polished surface intermingle, and the streaks become prominent due to the difference in roughness between the two surfaces.

The results confirm that the high-precision wire reduces post-process work and contributes to shortening the delivery time of the mold.

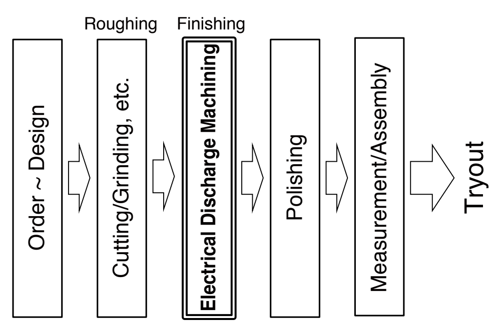


Figure 7. General Flow of Mold Making

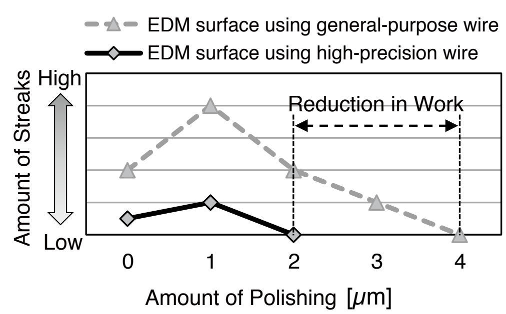


Figure 8. Polishing Required for Streak Removal

Conclusion

The high-precision wire introduced in this article has improved roundness using a new manufacturing method and also has stability in the longitudinal direction. The improved roundness reduced the waviness of the EDM surface by about 30%, and at the same time, reduced visual streaks. This in turn reduced the polishing time required in the post-process and contributed to shortening the delivery time of the completed mold.

As stated in the introduction, the wire plays a large role in WEDM, and it is important to select the optimum wire according to application. With this perspective, OEC developed the high-precision wire and expanded the range of wire selection for customers. OEC will continue with developments that meet customer needs in the hopes the EDM field will expand further. ◆◆

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TIPS

【Glossary】

Electrical discharge machining
A processing method in which electrical discharge is repeatedly generated between an electrode and a work material (workpiece), and the work material (workpiece) is melted and removed. If the work material is conductive, it can be processed regardless of hardness. The processing method provides higher accuracy than cutting. It is mainly used for making molds.

Wire-cut electrical discharge machining
An electrical discharge machining method that uses a wire-shaped electrode.