High Quality Hard Metal Machining System, "ASC"

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Mitsubishi Electric has developed a corrosion preventive technology called "high quality hard metal machining system (Aqua Surface Control: ASC)." The ASC system ensures corrosion-free hard metal die and mold machining even when it takes a long time, while taking advantage of the high machining speed of the wire-cut electric discharge machining (EDM) process using water as machining fluid. With this technology, the ion balance in the machining fluid is controlled to maintain steady conditions so that the surface of hard metal is passivated to prevent corrosion.

1. The Challenge of Hard Metal Machining

Hard metals are compound materials composed of Group IVa, Va or VIa metal carbides of the periodic table and sintered with iron group metals (Fe, Co, Ni). Among others, WC-Co composed of tungsten carbide (WC) bound by cobalt is widely used. However, WC-Co is susceptible to corrosion when immersed in machining fluid (water) because corrosion-susceptible Co dissolves out. In addition, when wire-cut EDM is applied to hard metals, a work-affected layer is created on the machined surface. These are potential sources of chipping or cracks of hard metal dies and molds, affecting their service life.

Mitsubishi Electric has already developed a corrosion preventive system (PAM), which enables the machining of hard metal dies and molds without creating any corrosion layer or deteriorating the quality of the dies and molds even after immersing the hard metal in machining fluid for 24 hours. Mitsubishi has also developed an anti-electrolysis power supply (AE power supply) and super fine-finish power supply (FS power supply), which allow the work-affected layers and corrosion layers to be removed during hard metal machining.

Figure 1 shows the effect of PAM. After hard metal pieces finished with a FS power supply have been immersed in machining fluid for 24 or 96 hours, the pieces without PAM are corroded while those with PAM are not corroded after 24 hours.

Meanwhile, as the dies and molds used for IC lead frames, etc. are miniaturized and require higher precision, hard metals are immersed and processed in machining fluid for over 24 hours and so are likely to suffer corrosion due to the longer time required for the wire-cut EDM process. For example, across a weekend, machined works may be left immersed in machining fluid for 96 hours. As shown in Fig. 1, the effect of PAM deteriorates in 96 hours. In addition, PAM is an electric corrosion prevention method as shown in Fig. 2, and so the corrosion preventive effect is reduced in the area away from the electrode, resulting in a limited corrosion preventive range.

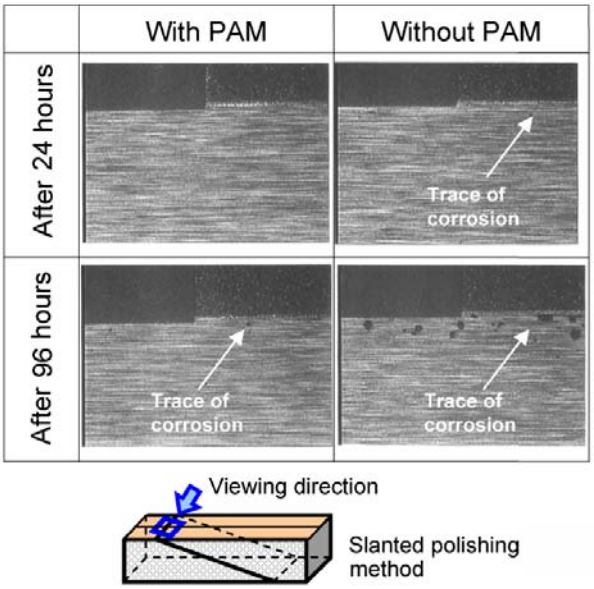


Fig. 1 PAM test results

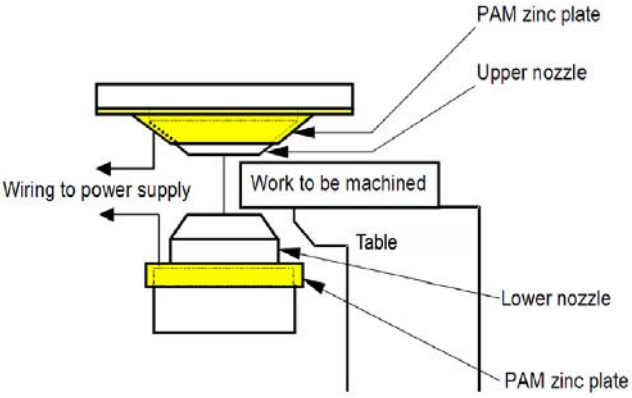


Fig. 2 PAM schematic illustration

With this background, we developed a high quality hard metal machining system to prevent the corrosion of hard metals in the entire machining range for the machining time of 96 hours (4 days).

**Nagoya Works*

2. Overview of the ASC System

In our high quality hard metal machining (ASC) system, the ion balance in the machining fluid is maintained in steady conditions so that the surface of the hard metal is passivated to prevent Co, which is a cause of corrosion, from dissolving out. The conventional wire-cut EDM apparatus uses water that has passed through ion exchange resin to control the specific resistance value at about 100,000 Ω·cm, while the ASC system is configured as shown in Fig. 3, where the supply of machining fluid to the ASC resin (specialized ion exchange resin) is automatically controlled with a sensor and controller for maintaining a steady ion balance.

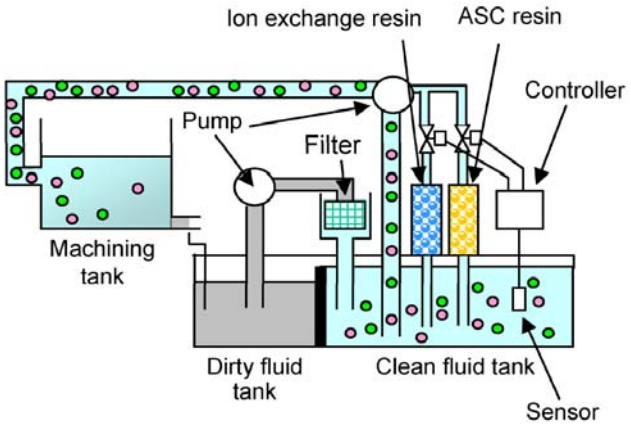


Fig. 3 ASC configuration

3. Features of the ASC System

(1) Corrosion preventive effect against prolonged water immersion
- Corrosion is prevented by controlling the machining fluid so that the ion balance is maintained in steady conditions to passivate the surface of hard metal.
- Corrosion is prevented in the entire machining range.

(2) Significant improvement in productivity
- High-speed and high-quality machining without micro cracks, taking advantage of water based machining in combination with an anti-electrolysis power supply (AE power supply)
- Reduction of process time by eliminating the time for removing the corrosion layer
- The fire defense law is not applicable, allowing unmanned operation of multiple machines day and night, and easy implementation of an automated system.

(3) Easy process control
- Automatic control of machining fluid conditions eliminates concerns about the concentration, as opposed to anti-corrosion agents.

4. Benefits of the ASC System

Figure 4 shows the benefit of the ASC system after hard metal pieces are immersed in machining fluid for 96 hours. With the standard system, traces of corrosion are observed and WC dropped out due to the dissolving of the binder element of Co, whereas no WC dropped out from the test piece immersed in machining fluid with the ion balance controlled by the ASC system, thus confirming the corrosion prevention effect.

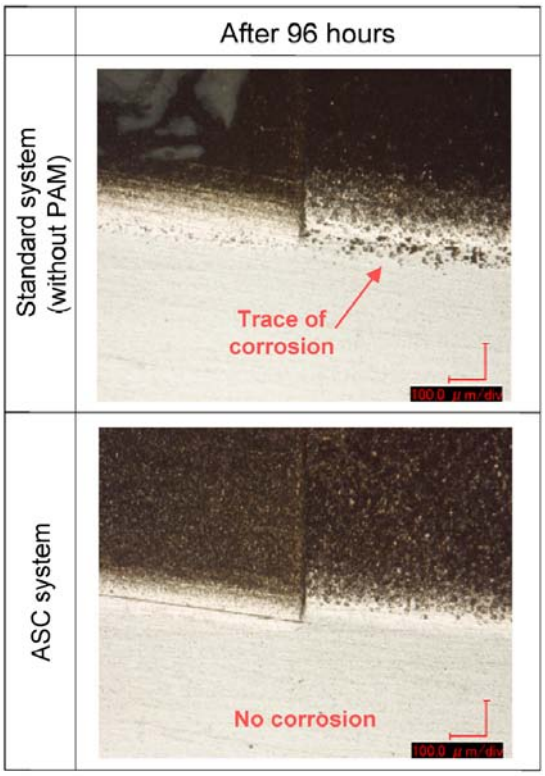
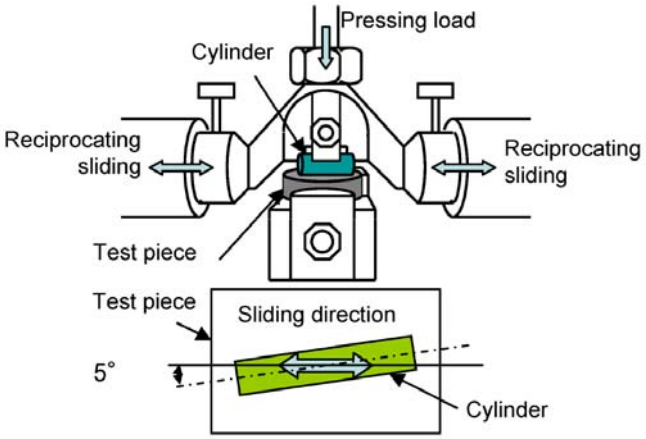


Fig. 4 ASC test results

To simulate the use of hard metal as a die or mold, after hard metal pieces had been immersed in various machining fluids for 96 hours, frictional wear tests were conducted on the EDM finished surface. Figure 5 shows the friction wear test configuration, where a cylindrical material is sliding against an EDM finished surface of the hard metal test piece. The test results are shown in Fig. 6. On the test piece machined with standard machining fluid, an apparent dropout of WC is observed, whereas no dropout is observed when using the ion-balance-controlled fluid and ASC system, confirming that the wear resistance is not deteriorated and the quality remains equivalent to that of the test piece machined in corrosion-free machining oil.

These test results suggest that the ASC system provides corrosion-free and high-quality machining of dies and molds, even when the hard metal machining takes a long time, and also offers high-speed machining using water (pure water) as machining fluid.



Testing conditions
Dimensions of cylinder: ϕ15 x L22
Hardness of side surface of cylinder: HRC61
Load: 28N
Stroke: 0.85 ± 0.05mm
Frequency: 5Hz
Lubrication: None (Degreased with acetone)
Test duration: 5 hours (Equivalent to 180,000 shots)
Test piece: Hard metal material (Equivalent to JIS V40)
Roughness of machined surface: 1.0 μmRz

Fig. 5 Frictional wear test method

5. Vision for the Future

We have developed a high quality hard metal machining system for hard metals. We will continue to work on expanding the range of applications to the iron group materials generally used for dies and molds.

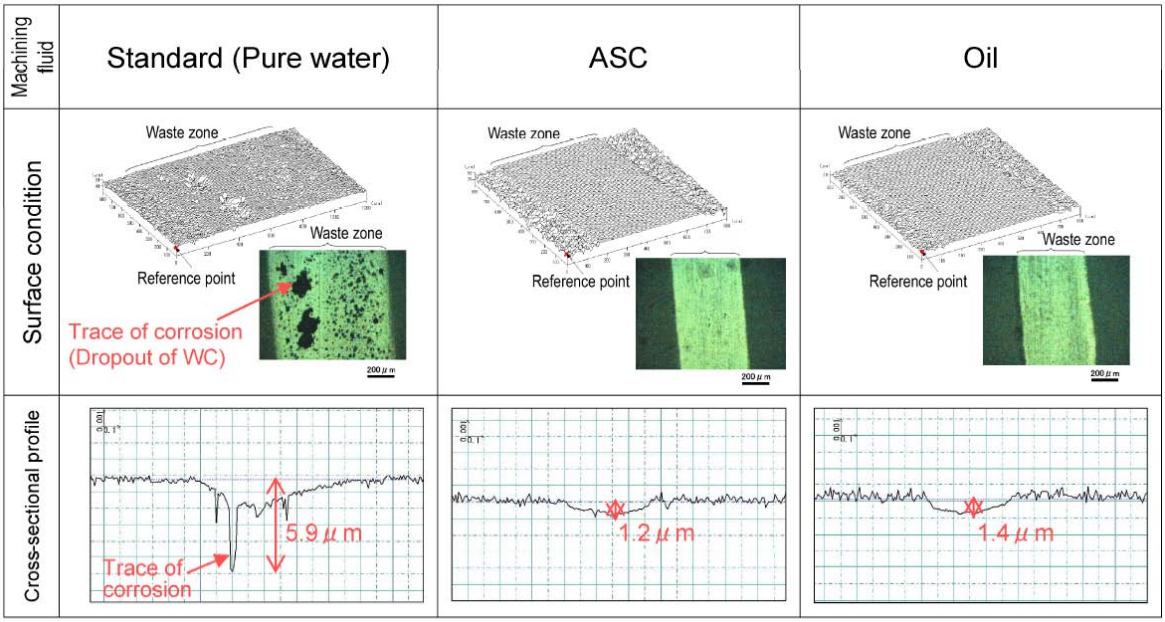


Fig. 6 Frictional wear test results