Ultra-high Accuracy Wire Electrical Discharge Machine

UPN-01
Pursuing the ultimate in ultra-precision machining

Makino's new UPN-01 ultra-high accuracy EDM machine pursues the ultimate in wire EDM performance, delivering fine surface quality and superb accuracy every time. It achieves a best surface finish of 0.17 μm Rz, approaching the elusive 0.1 μm level. Machining accuracy is also impressive ≤0.5 μm. The UPN-01 breaks the micron barrier to advance closer to the world of 0.1 μm machining. This remarkable EDM machine promises to promote further advances in microtechnology.

Finish machining of narrow slits 32 μm in width

<table>
<thead>
<tr>
<th>Workpiece material</th>
<th>Carbide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire used</td>
<td>0.02 mm dia. (brass wire)</td>
</tr>
<tr>
<td>Plate thickness</td>
<td>3 mm</td>
</tr>
<tr>
<td>No. of machining passes</td>
<td>3</td>
</tr>
<tr>
<td>Surface finish</td>
<td>≤0.5 μm Rz</td>
</tr>
<tr>
<td>Slot width</td>
<td>≤32 ±0.5 μm</td>
</tr>
</tbody>
</table>

Best surface finish of 0.17 μm Rz

<table>
<thead>
<tr>
<th>Workpiece material</th>
<th>Carbide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire used</td>
<td>0.1 mm dia. (brass wire)</td>
</tr>
<tr>
<td>Plate thickness</td>
<td>10 mm</td>
</tr>
<tr>
<td>No. of machining passes</td>
<td>20</td>
</tr>
<tr>
<td>Surface finish</td>
<td>0.17 μm Rz</td>
</tr>
</tbody>
</table>

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<td>0.1 mm dia. (brass wire)</td>
</tr>
<tr>
<td>Plate thickness</td>
<td>10 mm</td>
</tr>
<tr>
<td>Taper angle</td>
<td>0.166° (10 min)</td>
</tr>
<tr>
<td>Surface finish of straight portion (cutting edge)</td>
<td>≤0.3 μm Rz (3 machining passes)</td>
</tr>
<tr>
<td>Surface finish of taper portion</td>
<td>≤1.6 μm Rz (4 machining passes)</td>
</tr>
</tbody>
</table>

Featuring the MGW-V1 NC generator that produces ultra-small electric pulses

The UPN-01 is fitted with Makino’s newly developed MGW-V1 NC power supply unit that produces ultra-small electric pulses at 50 nanosecond cycles. The pursuit of the ultimate performance in fine-wire machining achieves ultra-high accuracy. Using a 0.02 mm diameter wire, the UPN-01 can machine tiny slots having a finish width of 32 μm.

SPG machining circuit

The UPN-01 comes with Makino’s SPG machining circuit that provides best surface finishes of outstanding quality. Featuring outstanding surface finish, the UPN-01 promises to promote further advances in microtechnology.

New AS control feature enables uniform machining along the entire cutting edge length

Makino's AS control technology facilitates more accurate taper machining. A machining trial is performed to execute the basic shape for the three patterns of arbitrary angle compensation, cutting edge compensation and parting direction compensation. The measured results are then fed back to enable taper machining according to the accuracy standard of the measuring instrument used.
Comb-shaped electrode machining

- Workpiece material: SKD-61
- Wire used: 0.07 mm dia. (max. 6mm)
- Thickness: 10mm
- No. of machining passes: 9
- Machining time: 22hr. 3min.
- Surface finish: 0.8μmRz

Light guide plate machining

- Workpiece material: Carbide
- Wire used: 0.02 mm dia. (max. 6mm)
- No. of machining passes: 4
- Machining time: 2hr. 47min.
- Surface finish: 0.5μmRz

Multiface index machining

- Workpiece material: Carbide
- Wire used: 0.02 mm dia. (max. 6mm)
- Thickness: 3mm
- No. of machining passes: 6
- Machining time: 27hr. 36min. (cont.
- Surface finish: 0.5μmRz

Ultra-fine hole with 0.4 μm roundness

- Workpiece material: Carbide
- Wire used: 0.02 mm dia. (max. 6mm)
- Machined hole diameter: 0.07 mm dia.
- Surface finish: 0.5μmRz

Micro-gear machining

- Workpiece material: Carbide
- Wire used: 0.015 mm dia. (tungsten)
- Pitch circle: 0.18 mm dia.
- Module: 0.018
- Plate thickness: 0.2 mm
- No. of machining passes: 2
- Machining time: 7hr. 7min.
- Surface finish: 0.5μmRz

Special bearing machining

- Workpiece material: Carbide
- Wire used: 0.02 mm dia. (max. 6mm)
- Plate thickness: 3mm
- No. of machining passes: 4
- Machining time: 9hr. 2min.
- Surface finish: 0.5μmRz

*All machining conditions must be arranged individually as special specifications.*
Ultra-high Accuracy Wire Electrical Discharge Machine

**UPN-01**

- Submerged oil EDM machine with a horizontal wire feed system
- Superb automatic threading of wire electrodes 0.02-0.1 mm in diameter
- Advanced automated features, including workpiece indexing, automatic core removal and automatic workpiece changing
- Operator friendliness for easy operation and simple maintenance

**Oil submerged machining**

The oil-based dielectric fluid is advantageous for fine machining with a small spark gap.

- Axis travels (X × Y × Z) : 160 × 160 × 50 mm
- Axis travels (U × V) : ±7 × ±7 mm
- Max. workpiece size : 150 × 150 × 40 mm
- Max. workpiece weight : 8 kg (including holder)
- Wire electrode diameter : 0.02, 0.03, 0.05, 0.07, 0.1 mm dia.

Reliably threads even 0.02 mm diameter wire

Automatic wire threading

The UPN-01 reliably threads fine wire electrodes 0.02 mm in diameter, which are even hard to see with the naked eye. Naturally, 0.1 mm diameter wire is no problem. The automatic threading nozzle that carries the wire electrode and the suction nozzle are brought close to both sides of the workpiece. Air is then discharged to thread the wire electrode. The use of air also serves to clean the start hole and eliminates troublesome wire guide maintenance. A 0.03 mm diameter wire electrode can be consecutively threaded through 0.05 mm diameter start holes in close proximity. Moreover, a 0.02 mm diameter wire electrode can be threaded through a 0.03 mm diameter start hole that is correctly positioned.

Fine Hole Electrical Discharge Machine

**EDFH1**

This machine is ideal for machining fine holes with high accuracy using pipe electrodes, tungsten electrodes or shaping electrodes. It also facilitates sinker EDMing of counterbores and other jobs.

- Axis travels : 220 × 180 × 300 mm
- Axis travels (W axis) : 220 mm
- Work tank inner dimensions : 450 × 350 × 200 mm
- Max. workpiece weight : 50 kg
- Minimum electrode diameter : 0.08 mm dia. (changed by ATC)

Oil submerged machining

The tank capacity is 180 liters, a 35% reduction from previous machines.

Explanations with an Eco mark describe eco-friendly, energy-saving features.
Pneumatic static pressure guideways enable fine feeds

Pneumatic static pressure guideways made of granite are used in the X and Y axes to ensure excellent following capability for fine feeds. High accuracy is permanently maintained by the non-contact guideways.

This technology is also friendly to the environment because no lubrication oil is used.

**Static accuracy**

- Scale feedback resolution: 0.01μm
- Minimum increment: 0.1μm

<table>
<thead>
<tr>
<th>No. of samples</th>
<th>Hole diameter variation (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13579</td>
<td>-0.0020</td>
</tr>
<tr>
<td>1</td>
<td>-0.0010</td>
</tr>
<tr>
<td>1</td>
<td>0.0010</td>
</tr>
<tr>
<td>3</td>
<td>0.0010</td>
</tr>
<tr>
<td>1</td>
<td>0.0010</td>
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<td>5</td>
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</tr>
<tr>
<td>7</td>
<td>0.0010</td>
</tr>
<tr>
<td>1</td>
<td>0.0010</td>
</tr>
</tbody>
</table>

**Pitch machining accuracy ±0.5μm**

- Hole diameter variation ±0.5μm

<table>
<thead>
<tr>
<th>No. of sample</th>
<th>Hole diameter variation (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>1</td>
<td>-0.0010</td>
</tr>
<tr>
<td>1</td>
<td>0.0010</td>
</tr>
<tr>
<td>3</td>
<td>0.0010</td>
</tr>
<tr>
<td>1</td>
<td>0.0010</td>
</tr>
<tr>
<td>5</td>
<td>0.0010</td>
</tr>
<tr>
<td>1</td>
<td>0.0010</td>
</tr>
<tr>
<td>7</td>
<td>0.0010</td>
</tr>
<tr>
<td>1</td>
<td>0.0010</td>
</tr>
</tbody>
</table>

**Hole position**

- Pitch machining accuracy
- Hole diameter variation

**Thermal Chamber**

Tightly sealed machine covers and a high-performance air conditioner control the temperature variation in different parts of the machine to within ±0.5°C.

**Constant temperature technology for controlling the ambient air temperature**

- Keeping the machine temperature constant also helps to reduce the cost of air-conditioning the entire shop.

A gentle shower of temperature-controlled air is discharged from ceiling ducts to maintain a constant temperature in the machining chamber.

**Thermal Chamber**

- Room temperature setting: 23°C
- Temperature rise in machining chamber: ±0.5°C

**Insulation**

- Insulation material: Metal plate
- Metal plate: Atmospheric layer
- Inner side: Metal plate
- Outer side: Insulation material

**Isolating the machine from the ambient air temperature**

- Insulation is placed on the inside of the machine covers and the machining chamber door. In addition, an air layer is provided between the two metal sheets forming the machining chamber door to isolate the effects of the ambient air temperature.

- Dielectric fluid cooling unit
- Thermostat-controlled air dryer
- Air conditioner (for Thermal Chamber)

**Custom pitch function**

- High-accuracy pitch machining is performed at the accuracy standard of the measuring instrument used. This is accomplished by simply entering in advance the targeted pitch accuracy and the measured results obtained in actual machining.

- Workpiece material: Carbide
- Wire used: 0.1 mm dia. (brass wire)
- Plate thickness: 3 mm
- No. of machining passes: 5
- Machined hole diameter: 1 mm dia.
- Surface finish: 0.5μmRa

- This technology is also friendly to the environment because no lubrication oil is used.

- Keeping the machine temperature constant also helps to reduce the cost of air-conditioning the entire shop.

Values measured in Makino's environmental testing chamber.

- These measures reduce the power consumption of the Thermal Chamber air conditioner.
Cut out cores fall naturally
With the horizontal wire feed system, the machining heads are positioned on the right and left sides of the workpiece. This design allows cores cut out from the bottom face of workpieces to fall naturally.

Core removal unit (Optional)
Because the workpiece is suspended vertically with the horizontal wire feed system, machined cores remain in the workpiece. Cores up to around 15 mm x 15 mm in size are flushed out by dielectric fluid discharged from a jet nozzle. An extruding pin fitted with a sensor confirms core removal to facilitate completely unattended operation from roughing to finish machining.

NC indexing unit (Optional)
This built-in type of indexing unit provides exceptionally high accuracy. The inclination of a 50 mm workpiece due to indexing error is less than ±0.48 μm. Multiface machining can be executed with high accuracy in one chucking operation.

Minimum programmable increment: 0.00001"  
Indexing accuracy: ±2 second

Wire tip trimming device
If the wire tip is damaged by unexpected breakage, this device automatically trims the damaged portion to facilitate reliable resumption of machining. This ensures that continuous unattended machining is not interrupted.

An extruding pin fitted with a sensor confirms core removal to facilitate completely unattended operation from roughing to finish machining.

Cut-out cores can be lifted up and recovered without sticking a hand into the dielectric fluid.

The workpiece temperature before and after machining is also controlled by keeping the temperature inside the magazine at the same level as in the machining chamber.

16-workpiece automatic work changer (Optional)
Workpieces are changed by a rotary magazine and a conveyor built into the machine.

Cut-out cores can fall naturally. With the horizontal wire feed system, the machining heads are positioned on the right and left sides of the workpiece. This design allows cores cut out from the bottom face of workpieces to fall naturally.
Even a 0.02 mm diameter wire is easy to set
The machining chamber opens up wide for outstanding access to the wire feed system.

After changing bobbins, the wire is easily set in the wire feed system by the force of an air discharge.

Easy wire guide maintenance
Cleaning takes only a few minutes. Since the guide is not removed, there is no need to align the wire vertically after cleaning.

Space-saving L-shaped layout
The L-shaped design ensures ample working space for the operator even if the machine is installed near an aisle.

Outstanding operating ease even with fine wire electrodes

Simple procedures supporting ultra-high accuracy machining

NC operation
Standard features for enhanced operating ease include a large 15" liquid crystal display screen, touch panel, trackball mouse, portable control panel and Ethernet port, among other functions.

Wire Navigator
A programming guidance system that guides the operator along the shortest path to the start of machining.
Machining data can be entered without any wasted effort by simply following the logical progression from programming to actual machining.
Three separate screens are provided to make each task easier to understand.

WIRE NAVI

Program
The operator is guided through the programming procedure according to the work flow. It is also easy to call up, edit and save existing part programs.

Setup
All setup tasks are concentrated in one screen, including setting the coordinate system, automatic wire threading and positioning. In addition, the approach directions of various measurement patterns are also shown in screen diagrams.

Operation
One screen shows all the information indicating the operating status during machining, including a graphic display of the wire path, the coordinate system and machining conditions.
This allows the operator to check the machining status at a glance without wasting any time changing screens.

EDM Viewer
The EDM Viewer is a Windows-based application for viewing the NC screens of Makino wire EDM and NC EDM machines on a personal computer connected to the network.

- The NC screens of each connected machine can be checked and switched from the personal computer.
- The NC screens of multiple machines can be displayed simultaneously.

Each connected machine requires the MEL Machine Kit. (Optional)
The MEL Machine Kit is a communications interface that is installed on the machine for interfacing with Windows-based applications such as the EDM Viewer and EDM Explorer. Installing this kit provides an interface with machines connected to the network.

Applicable machines

<table>
<thead>
<tr>
<th>NC EDM</th>
<th>WIRE EDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended: MGH3 or later generator</td>
<td>Recommended: MGH4 or later generator</td>
</tr>
<tr>
<td>Software version: E*.004 or newer version</td>
<td>Software version: E*.008-2 or newer version</td>
</tr>
</tbody>
</table>

Please contact Makino about the operating environment and other details.
Environment and Construction Work for Machine Installation

1. Floor area and foundation work

<table>
<thead>
<tr>
<th>Required installation space (including maintenance area)</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>Depth</td>
</tr>
<tr>
<td>2025</td>
<td>2200</td>
</tr>
</tbody>
</table>

Preparation of a foundation for machine installing is recommended, because a solid foundation is essential for maintaining high accuracy. Allowable vibration: 0.7 m/s² (0.07 G).

2. Factory air-conditioning system

Recommended ambient temperature: 20 ± 1°C

Relative humidity: 75% maximum (without any condensation)

3. Measures against electromagnetic interference

It is recommended that the machine be installed in a shielded room. Use the power supply line filter (optional equipment) is also recommended if there is a possibility that electromagnetic noise from the power supply line might affect the operation of other equipment.

4. Electrical work

<table>
<thead>
<tr>
<th>Power supply specification</th>
<th>AC3 phase, 300V ± 16%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer power (VA)</td>
<td>67</td>
</tr>
<tr>
<td>Breaker capacity (A)</td>
<td>60</td>
</tr>
<tr>
<td>Circuit breaker</td>
<td>For inverter circuit 30 mAh current sensitivity (when not installed in a shielded room)</td>
</tr>
<tr>
<td>Power line size (m²)</td>
<td>30</td>
</tr>
<tr>
<td>Power line terminal size</td>
<td>3-mm terminal using 14 mm² ground wire</td>
</tr>
</tbody>
</table>

Recommended grounding: Class C grounding using 14 mm² ground wire.

5. Provision of compressed air supply

<table>
<thead>
<tr>
<th>Compressed air supply</th>
<th>0.6MPa, 200L/min (equivalent to a 0.75 kW compressor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection port</td>
<td>8 mm dia. high coupler (standard equipment)</td>
</tr>
</tbody>
</table>

6. Factory environment

The following environment is recommended for maintaining high machine accuracy at all times.

- Isolation of the machine from other equipment that generates dust.
- Avoidance of exposure to direct sunlight and direct discharges from an air conditioner.
- Avoidance of partial heating of the machine by a stove or other heater.

**Environment andConstruction Work for Machine Installation**

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*All the items are treated more prior to this specifications.

*These specifications may be changed prior to this specifications.

*This product including technical data and software, may be subject to the Japanese Foreign Exchange and Foreign Trade Law.

*Prior to any re-sale, or transfer or re-export of the specified item, please consult Makino to obtain any required authorization or approval.
Tooling systems for simple, accurate workpiece fixturing

A wide variety of workpiece holders are available to match various workpiece shapes and machining objectives. All types of workpiece can be fixtured simply and accurately.

<table>
<thead>
<tr>
<th>Workpiece holder</th>
<th>Standard</th>
<th>NC index device</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Automatic clamping chuck</td>
<td>Automatic clamping chuck</td>
</tr>
<tr>
<td></td>
<td>ER-007521 (EROWA) 3R-600.86-20 (system3R)</td>
<td>ER-007521 (EROWA) 3R-600.86-20 (system3R)</td>
</tr>
<tr>
<td>Maximum workpiece size</td>
<td>150x150x150 mm</td>
<td>Maximum workpiece size</td>
</tr>
<tr>
<td>Fixed plate holder</td>
<td>EHuwPw-1520</td>
<td>Universal holder</td>
</tr>
<tr>
<td></td>
<td>100x100x100 mm</td>
<td>EUuwPw-30c</td>
</tr>
<tr>
<td></td>
<td>EHuwPw-1020</td>
<td>Maximum workpiece size</td>
</tr>
<tr>
<td></td>
<td>100x100x100 mm</td>
<td>60x150x30 mm</td>
</tr>
<tr>
<td></td>
<td>EHuwPw-1015L</td>
<td>Universal holder</td>
</tr>
<tr>
<td></td>
<td>200x200x200 mm</td>
<td>EUwLw-100a</td>
</tr>
<tr>
<td></td>
<td>Universal holder</td>
<td>Maximum workpiece size</td>
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<tr>
<td></td>
<td>EUuwPw-60c</td>
<td>60x150x30 mm</td>
</tr>
<tr>
<td></td>
<td>EUuwPw-30c</td>
<td>Universal holder</td>
</tr>
<tr>
<td></td>
<td>EUuwPw-100c</td>
<td>EUwLw-100a</td>
</tr>
<tr>
<td></td>
<td>EUuwPw-100c</td>
<td>Maximum workpiece size</td>
</tr>
<tr>
<td></td>
<td>EUwLw-150</td>
<td>200x400x40 mm</td>
</tr>
<tr>
<td></td>
<td>EUwLw-60d</td>
<td>Universal holder</td>
</tr>
<tr>
<td></td>
<td>EUwLw-60a</td>
<td>Maximum workpiece size</td>
</tr>
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</table>
### Machine Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travels</td>
<td></td>
</tr>
<tr>
<td>X axis (workpiece longitudinal)</td>
<td>160 mm</td>
</tr>
<tr>
<td>Y axis (workpiece vertical)</td>
<td>160 mm</td>
</tr>
<tr>
<td>Z axis (right head lateral)</td>
<td>50 mm</td>
</tr>
<tr>
<td>U axis (left head longitudinal)</td>
<td>±7 mm</td>
</tr>
<tr>
<td>V axis (left head vertical)</td>
<td>±7 mm</td>
</tr>
<tr>
<td>Workpiece</td>
<td></td>
</tr>
<tr>
<td>Fixturing method</td>
<td>Automatic chucking system (EROWA, system 3R)</td>
</tr>
<tr>
<td>Maximum workpiece size</td>
<td>150 × 150 × 40 mm</td>
</tr>
<tr>
<td>Maximum suspended weight</td>
<td>8 kg (including holder)</td>
</tr>
<tr>
<td>Wire electrode diameter</td>
<td>0.02～0.1 mm dia.</td>
</tr>
<tr>
<td>Maximum taper angle</td>
<td>±6° (with 0.1 wire dia. and 40 mm plate thickness)</td>
</tr>
<tr>
<td>Wire travel system</td>
<td></td>
</tr>
<tr>
<td>Wire feedrate</td>
<td>0.10 ～ 120 mm / s</td>
</tr>
<tr>
<td>Wire tension</td>
<td>0.25 ～ 8 N</td>
</tr>
<tr>
<td>Maximum wire reel weight</td>
<td>3 kg</td>
</tr>
<tr>
<td>Dielectric fluid</td>
<td>Oil-based</td>
</tr>
<tr>
<td>Tank capacity</td>
<td>180 L (clean tank capacity 55 L)</td>
</tr>
<tr>
<td>Machine size</td>
<td>W × D × H = 2025 × 1765 × 2100 mm</td>
</tr>
<tr>
<td>Machine weight</td>
<td>3700 kg (including NC power supply unit)</td>
</tr>
</tbody>
</table>

### Standard Specifications

- Oil submerged machining specification
- Taper machining unit
- Vertical sliding tank
- Automatic work chuck (selection form EROWA, 3R)
- Work holder (selection of one)
- φ0.1～0.05 Split round guide (selection of one type)
- High performance automatic wire threading
- Automatic wire threading nozzle φ0.15, 0.1, 0.08 (selection of one)
- Scale feedback 0.01 μm (X, Y, U, V axes)
- Dielectric fluid cooling unit
- Automatic fire extinguisher
- Safety guide
- Thermal chamber
- Air dryer with temperature control function
- Power supply line filter
- 2 Work light (fluorescent lamps)
- Automatic power failure recovery unit
- Trackball mouse
- Ethernet (10/100BASE-TX)
- Portable control panel (FPB 2)
- USB Flash Memory

### MGW-V1 Power Supply Unit

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit type</td>
<td>Transistor pulse circuit</td>
</tr>
<tr>
<td>Maximum machining current</td>
<td>15A</td>
</tr>
<tr>
<td>Current settings</td>
<td>128 levels</td>
</tr>
<tr>
<td>Voltage settings</td>
<td>35 levels</td>
</tr>
<tr>
<td>OFF intervals</td>
<td>256 levels</td>
</tr>
<tr>
<td>Automatic voltage regulator</td>
<td>Standard</td>
</tr>
<tr>
<td>Cooling system</td>
<td>Forced air cooling</td>
</tr>
</tbody>
</table>

### Automatic wire threading nozzles and start hole (Guarantee value)

<table>
<thead>
<tr>
<th>Nozzle dia used</th>
<th>0.01</th>
<th>0.02</th>
<th>0.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 mm</td>
<td>φ0.1</td>
<td>φ0.2</td>
<td>φ0.3</td>
</tr>
<tr>
<td>0.07 mm</td>
<td>φ0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05 mm</td>
<td>φ0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.03 mm</td>
<td>φ0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.02 mm</td>
<td>φ0.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Optional Specifications

- Automatic work changer (16-pc)
- Air booster
- Core removing unit
- NC indexing unit
- φ0.02 Split round guide
- φ0.03 Split round guide
- φ0.1～0.05 Additional split round guide
- Additional automatic wire threading nozzle (φ0.15, 0.1, 0.08)
- Additional wire vertical aligning jig
- Standard supplies set (standard consumables set)
- Maintenance set (wire vertical aligning jig, measurement block)
- Flame sensor

### Control system

- Export transformer
- Additional part program storage : 3000 m
- Program Master
- 3.5" built-in floppy disk drive
- Alarm signal tower (1, 2, or 3-lamp types)
- Circuit breaker
- MEL development kit
- MEL machine kit
- EDM Explorer
- EDM Viewer

### Optional Equipment list

- (optional specifications are not retrofittable)