VHMC01 – 4-AXIS MACHINING CENTER (RAD HARD)

Eberhard Bamberg, PhD
Co-Founder & President
Viteris Technologies
Fit inside hotcell (900 x 900 x 1500 mm), <500 kg
To be operated and maintained using master-slave manipulators
Prepare test specimen from Zircaloy rod section (Ø 16.2 x 200 mm)

- Compact fracture test specimen (Ø 16.2 x 6 mm) with Ø3 through holes (2x), top and bottom V-grooves (200 micron deep), and center slot (300 micron wide)
- Tensile test specimen (30 x 8 x 2 mm)
- Small punch test disk (Ø 6 x 0.6 mm)
  - Tight tolerances of ± 5 microns
  - Material is electrically conductive
  - Specimen geometries require machining from multiple directions

Open Synroc canisters (used to dispose medical isotopes) and extract multiple core samples

- Core samples (Ø 10 x 20 mm)
  - Outside is stainless steel (electrically conductive)
  - Inside is ceramics (electrically insulating)
  - Outside geometry highly irregular
Prepare minimum volume samples that allow highly active materials to be handled and examined outside hotcell
- Pillar array (0.05 x 0.05 x 1 mm)
- Electrically conductive material

Radiation hardened
- 5E7 rad over 15 year period
- Gamma radiation only
Solution 1: Electrical wire discharge machining (WEDM)

- Thermo-electrically driven process with adjustable (small) energy transfer → good surface finish and very small geometries are achievable
- Non-contact machining process → tight tolerances achievable
- Process requires work piece to be submerged in dielectric fluid (typically de-ionized water or EDM oil) → removed radioactive material is captured within the fluid system and can be filtered out using disposable filter cartridges
- EDM wire is continuously replaced → no unhandled tool wear
- Dual wire sections (vertical and horizontal) allow machining in two plane → all test specimen can be cut in a single setup (no changes to the work piece setup)

But:

- Material must be electrically conductive → does not work for Synroc canister
- Viteris WEDM system is NOT self-threading → does not work for internal geometries
- Micro-WEDM electronics is not rad hard → electronics must be housed outside hotcell, negatively impacting EDM performance
Solution 2: Highspeed milling

- Use of an abrasive wheel orbiting around the Synroc canister allows the top of the canister to be sliced off
- Diamond core drill capable of extracting core samples
- Center drill and jobber drill can machine Ø3 holes in compact fracture test specimen

But:

- Multiple tools are required → requires automatic tool changer
- Shared processes (WEDM and milling) requires work pieces to be registered with both processes (to achieve required accuracies)
- Milling process may produce airborne particulates → use EDM dielectric fluid as coolant. De-ionized water provides zero lubrication, therefore use EDM oil instead (also easier to maintain)
Advanced user control unit mounted to outside of hotcell

Automatic toolchanger with for 10 HSK32E tool holders

Dielectric pump and filtration unit

VHMC01 MACHINE OVERVIEW

5.5 kW, 24,000 rpm spindle with HSK32E interface

μwire-EDM with vertical and horizontal cutting sections

Machine vision system

Pneumatic clamping of work pieces

Work piece clamping setup station

Setup table

Vertical and horizontal toolsetter to measure height and radius of milling tools
WEDM is mounted to 2. vertical axis (W-axis)

- supply spool (DIN 125)
- supply spool carrier
- wire orifice
- toggle clamp
- takeup spool
- supply spool carrier

Vertical wire section

Horizontal wire section
Milling spindle is mounted to left vertical axis (Z-axis)

Highspeed spindle, 5.5 kW, 24,000 rpm

Toolrack for 10 HSK32E tool holders. Slot #1 is reserved for touch probe

HSK32E tool fork

Pneumatic tool lift with HSK32E tool fork is mounted to work tank

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Milling spindle is mounted to left vertical axis (Z-axis)

The touch probe utilizes a pogo-pin connector that establishes electrical connection as the tool holder is inserted into the spindle.

The tool setter features a vertical and horizontal microswitch with 0.0005 mm repeatability that measures the tool height and tool radius.
- Provides real-time video stream within the control unit
- Camera can freely be positioned using the manipulators
- Camera is industrial USB camera (~600 USD) and is user replaceable
- Pneumatic 2-axis clamps
- Interchangeable jaws (work piece specific)
- Clamps are registered inside the work tank with locator (diamond) pins and held pneumatically using swing clamps
- Work pieces are setup using the external setup station (on setup table near the window), then clamps are transferred to the work tank using the manipulator
Tensile test specimen from A16061 machined in a single setup using the vertical and horizontal WEDM of the VHMC01. Six samples can be machined together from a rod section of 32 mm (1.26 in) length and 16 mm (0.63 in) diameter. The samples remain attached to the work piece by small tabs in the lower left corner and can be snapped off later using the manipulator.

Fracture toughness test specimen cut on VHMC01 in a single setup. First, the milling spindle center drilled and then drilled two diameter 3 mm (0.118 in) holes. Next, the horizontal WEDM machined two v-grooves with 0.15 mm (0.006 in) depth into the center of the top and bottom surfaces. Finally, the vertical WEDM machined a 0.3 mm (0.012 in) wide slot from the outside to the center of the disk. The machining was programmed in a single G-Code file, combining the milling, the horizontal and the vertical WEDM instructions.

TEM (transmission electron microscopy) samples are machined as disks with 3 mm (0.118 in) diameter and 0.5 mm (0.02 in) thickness. 17 disks are machined together from a 12 mm (0.47 in) section in a single setup using the vertical and horizontal WEDM of the VHMC01. The disks remain attached to the work piece by small tabs at the bottom and can be snapped off later using the manipulator.

Ring compression test specimen machined from tubular Zircaloy in a single setup using the vertical WEDM of VHMC01.
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