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Development of Custom High Precision Slits for Neutron Facilities

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Abstract

In this paper ADC will discuss the design and test results for a multi-axis, Custom High Precision Slit used in a Neutron facility. The slits features included; micron precision, encoder, and boron carbide blades. It incorporates use of cross-roller bearing technology for exceptional straightness of travel and non-magnetic material.

Introduction

Neutron diffraction or elastic neutron scattering is the application of neutron scattering to the determination of the atomic and/or magnetic structure of a material. A sample to be examined is placed in a beam of thermal or cold neutrons to obtain a diffraction pattern that provides information pertinent to the structure of the material. The technique is similar to X-ray diffraction but due to the different scattering properties of neutrons versus x-rays, complementary information can be obtained.

For neutrons, slits are often used to define the resolution, in place of other collimating devices such as perfect crystals or collimators. R. Tumulka, A. Viale,2, and N. Zangh theoretically describe the intensity one can measure in a double slit setup and compare the results with the experimental data obtained with cold neutrons [1].

The system described here consists of vertical and horizontal slit mechanisms, a non-magnetic structure which houses them, stepper motors with encoders, limit (home position) switches and electrical connections. The total slit size is adjustable in both vertical and horizontal directions depending on the technical requirements. Each of the four blades are individually controlled and motorized. The modeled design can be seen in Figure 1 to the right.

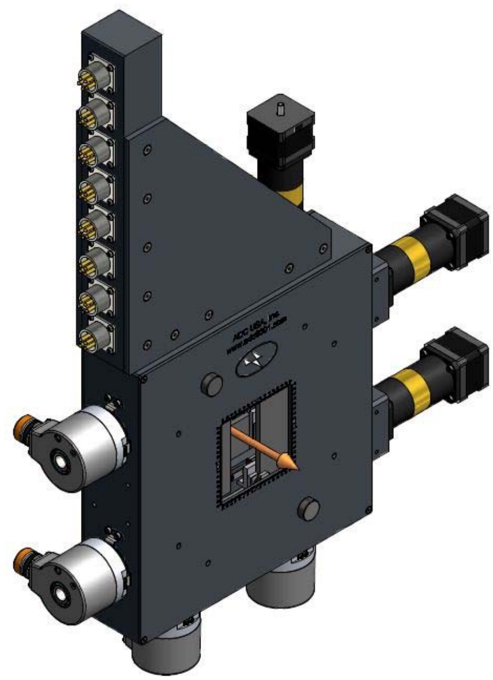

Figure 1: ADC's Modeled Design.

Design

Each axis in the slit is independent of the other, so this slit is fully scanable within its limits. This slit is equipped with high precision motors/gearboxes, limit switches, along with 13 bit multi-turn encoders. The custom system can be seen below in Figure 2.

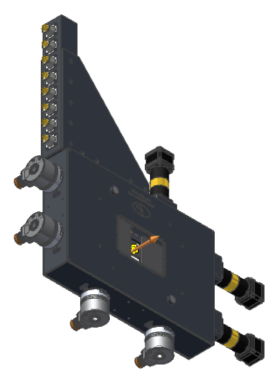

Figure 2: Customizable slit system.

The designed resolution is 0.0003 mm, and an accuracy of 0.005 mm; design test results can be seen in Figure 3 below, as well as a photo of testing being done on the system in Figure 4 below.

ANSTO Design Requirements	
Option	Motorized
Range	0-70 mm/0-115mm
Resolution	0.0003 mm
Repeatability	0.001 mm
Absolute Accuracy	0.005 mm
Radiation Hardness	not required
Vacuum Rating	not required
Non-Magnetic Material	yes
Slit Blade Material	Sintered B_4C of 3 mm thickness

Figure 3: Customizable slit system design results.

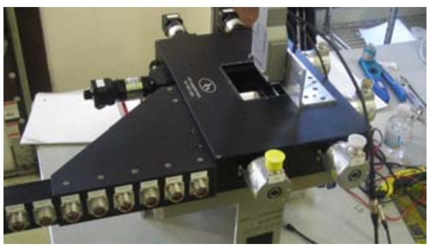

Figure 4: Slit system linear positioning testing.

ADC also offers another type of neutron slits. In this design one motor opens and closes two blades simultaneously and another motor moves a pair of blades together. There would still be 4 motors in the system, but with slightly different configuration. There are customers that do prefer this type of design. This slit is fully scanable within its limits. The slit is equipped with high precision motors/gearboxes, limit switches, along with 13 bit multi-turn encoders. The custom system can be seen below in Figure 5.

Figure 5: Custom High Precision Slit system delivered to ANSTO.

Figure 6, is a custom neutron slits designed and delivered to LANL based on customer requirements.

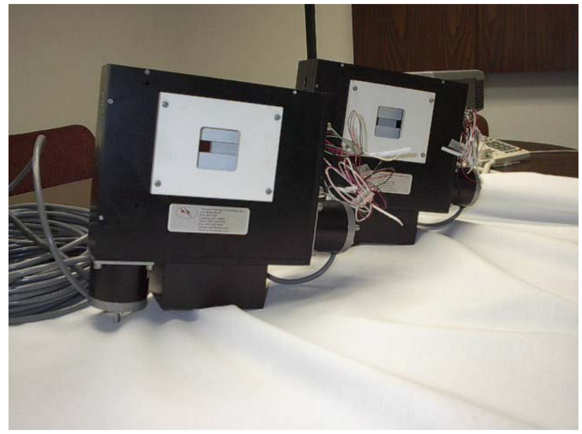

Figure 6: Custom High Precision Slit system delivered to LANL.

Figure 7, is another custom neutron slits designed and delivered to CCLRC based on customer requirements. This high precision slits required a relatively large aperture.

Figure 7: Custom High Precision Slit system delivered to CCLRC.

Blade Polishing

The process begins with a grinding operation designed to minimize the amount of material that must be removed during polishing. An edge and one of the faces are ground to an interior angle of 88° and then a second grinding operation relieves the face. Grinding produces an edge that is straight and true, but with pits and scratches that must be removed by polishing.

Fixturing the slit is critical when polishing. The fixture must be extremely hard so that material is removed only from the blades, otherwise the knife-edge can become rounded. Two or more blades are usually polished together in a matched set to maintain parallelism. Both surfaces must be accessible without removing the blade as repositioning is impossible within the necessary tolerances.

Scratches on the blades are removed using a Buehler low-speed polisher with silicon carbide paper and polycrystalline diamond suspensions on fabrics of differing knaps. As finer grits are used, the blades and fixturing must be thoroughly cleaned in an ultrasonic bath to remove larger particles. A final polish with colloidal silica is used when surface finish is critical.

Wheel speed, applied force and polishing time vary within each step which becomes critical to the final quality. Too large a force leads to grain pull-out. Relatively large force and long polishing time are required, yet over-polishing results in “orange-peel” that destroys the knife-edge.

References

[1] R. Tumulka, A. Viale,2, and N. Zangh (2007).
PACS numbers: 03.65.Yz, 03.65.Ta, 03.75.Dg