Design and Development of Precision Scientific Instruments and Parallel Manipulators

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Introduction

Precision instruments play a vital role in many areas of scientific and engineering applications. The quality of these instruments predicts its performance. Some important quality measures of the instruments are accuracy, precision and reliability. These high precision instruments are designed and manufactured with high end softwares and manufacturing facilities. Subsequently they are tested for functional performance to qualify them.

Neutron Focussing Mechanism for SSPD, Dhruva

It is a PC controlled neutron focusing mechanism[1] known as double curvature monochromator[2] which consists of a 3x5 array of crystals mounted on links provided in the vertical and horizontal direction. The cam and follower based mechanism has been used for designing the instrument. The links are connected to followers at each end which move in the helical groove of the cam for certain rotation of the camshaft. Further the links rotate about pivot points to get the required tilt for given radius of curvature. In the given setup the vertical and horizontal focussing are independent.

Specifications of the instrument

1) Crystal-size: 35mmx25mmx10mm.
2) Horizontal focussing: 500mm to • .
3) Vertical focussing: 5 to -1 degrees
4) Repeatability is 0.1 deg.

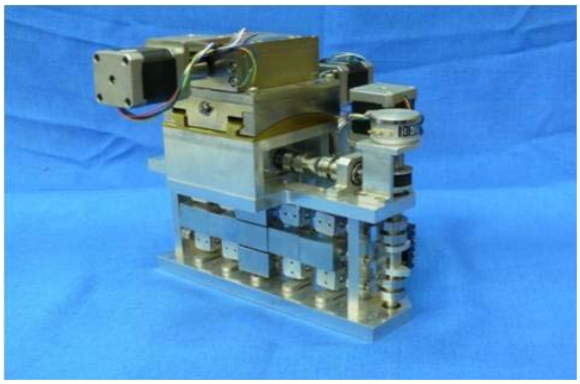

Fig.1: Double Curvature Neutron Focussing Monochromator

Three row Si(113) Crystal Bender(SSPD)

A special type of bender[3] has been designed to bend three nos. of Si(113) crystals arranged in a column simultaneously to focus neutron beam from neutron guide of size 100mm x 25mm to 4mm x 4mm(square). It is to be used as a monochromator for polarised neutron reflectometer in Dhruva Reactor Hall. It comprises of 3 asymmetrically cut Si(113) crystals of size (200mm x 45mm x 4mm(thk)). The crystals are required to be bent precisely in the horizontal plane from infinte radius value to 10-15m.This is being achieved by help of a differential screw and lever mechanism. The vertical focussing is obtained by the inherent nature of the crystals. The double curvature focussing provides a defined range of wavelengths of neutron beam at the sample from the incident neutron beam. The main application of this instrument is to carry out surface film studies.

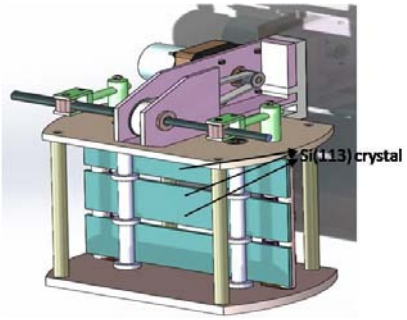

Fig.2: Isometric 3 dimensional view of the three row Si(113) Crystal Bender

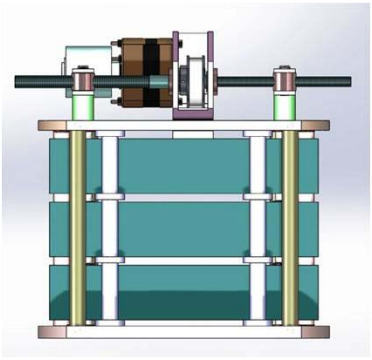

Fig.3 Front view of the three row Si(113) Crystal Bender

Ultra High Vacuum(UHV) compatible miniature hexapods(CDM)

Under the XIIth plan, CDM is developing Ultra High Vacuum (UHV) compatible miniature hexapods[4]. These are required to be of high accuracy and resolution to the level of sub-microns. The typical size of the hexapod will be 200mm(height) x • 120mm(top and bottom plates).The legs of this hexapod will be based on UHV compatible piezo actuators with double hinge joints for connecting the top and bottom plates. These are used for indigenous research and synchrotron beamline applications. The specifications of the same are tabulated below.

	RANGE	RESOLUTION	ACCURACY
X	±15mm	±.5µm	±2 µm
Y	±15mm	±.5µm	±2 µm
Z	±15mm	±.5µm	±2 µm
θ_X	$\pm 2^0$	±.5arcsec	±1arcsec
θ_Y	$\pm 2^0$	±.5arcsec	±1arcsec
θ_Z	$\pm 2^0$	±.5arcsec	±1arcsec

Fig.4: Isometric 3 dimensional view of miniature hexapod

Design and Development of Collimator Shielding for Neutron Radiography at VSSC, Kerala

The assembly comprises of a collimator which is required to collimate from 200 x 200 mm to 10 x 10 mm size and neutron generator for radiography. The complete assembly is mounted on a movable motorised stand using ball screw and LM(linear motion) guides that can translate 500mm along neutron beam direction. The shielding materials used are HDPE(High Density Polyethylene), Lead, Borated Polyethylene. It has been successfully installed and commissioned at VSSC.

Fig.5: Collimator assembly with stand assembly

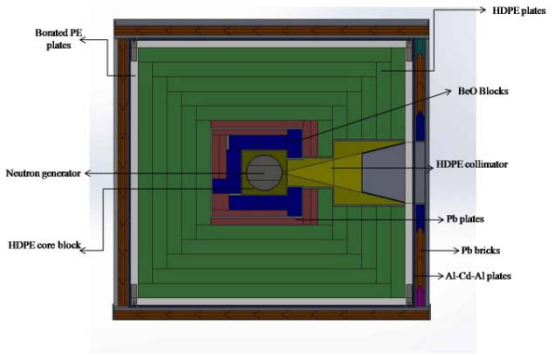

Fig.6: Cross Sectional view of collimator assembly

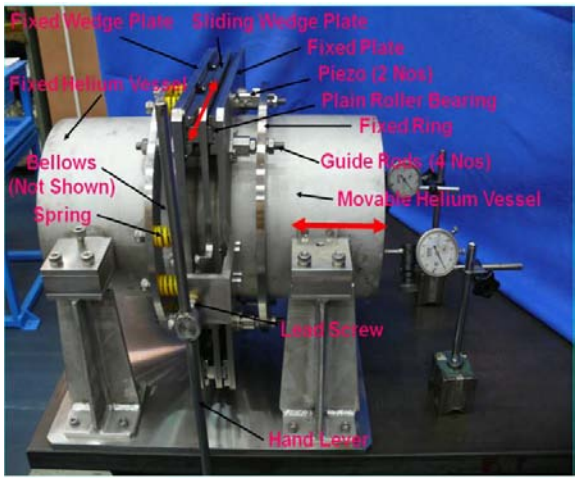

Fig.7: Double Wedge Tuner Assembly

Double Wedge Tuner(DWT) for NPD

A Double Wedge Tuner (DWT)[5] has been designed and developed for compensation of Lorentz force detuning and micro phonics stabilization of the superconducting cavities for International Linear Collider (ILC) operations. This is a co-axial device and can provide both the slow tuning and the fast tuning. DWT is installed around the Helium vessel which is in two halves, one movable and other fixed and is connected by bellows. The RF cavity is located inside Helium Vessel. This tuner mainly consists of two wedges, one fixed and other sliding which can move with respect to the fixed wedge. The fixed wedge is integral part of the flange of movable half of the Helium Vessel. This has been designed & developed with the perspectives of simple design and less cost, as these are needed in very large numbers for the ILC. To validate the design a manually operated prototype has been developed & tested mechanically at Centre for Design and Manufacture (CDM), BARC.

Specifications:

Range of Double Wedge Cavity Tuner

1. Slow Structure Tuning = 2500 microns
2. Fast Tuning using Piezomaterial = 10 microns

References

1. Ramnik Singh, V.K.Mishra, A.K.Sinha, S.B.Jawale, Mala N. Rao Design and Development of a Double Curvature Neutron Focussing Monochromator, Proceedings of DAE-BRNS National Symposium on Nuclear Instrumentation 2013.
2. U Wildgruber and F Frey, A double focusing neutron monochromator consisting of facets,J. Phys. E: Sci. Instrum. 20 (1987).
3. F Frey and W Adlhart, A bent neutron comb monochromator,J. Phys. E: Sci. Instrum., Vol. 13, 1980.
4. D Stewart A platfrom with six degrees of freedom. Proc.Instr.Mech Engrs 1965-66, Vol 180 Pt 1 No.15.
5. Mishra, V.K.; Singh, Ramnik; Aravind, T.; Singh, J.V.; Sinha, A.K.; Suthar, R.L.; Singh, P.; Sahni, V.C. Double wedge tuner (DWT) for RF cavities Proceedings of the DAE-BRNS Indian particle accelerator conference, Vol.46 Issue 11,2009