9th Edit. of the Mech. Eng. Des. of Synchrotron Radiat. Equip. and Instrum. Conf. MEDSI2016, Barcelona, Spain JACoW Publishing
ISBN: 978-3-95450-188-5 doi:10.18429/JACoW-MEDSI2016-MOPE23

AN ASSEMBLING CALIBRATION METHOD OF XBPM DIAMOND BLADES IN TPS

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Abstract

Diamond blade type X-ray Beam Position Monitors (XBPM) were adopted to monitor photon position at the beamline front-end in Taiwan Photon Source (TPS) [1]. Due to the thin thickness (125um) and fragile characteristic, the assembling precision of the diamond blades is difficult to measure and influences the accuracy of monitor. A non-contact method was thus developed by using a LED laser with telecentric objective lens and a CCD-array to calibrate the diamond blades assembling configuration within micrometer accuracy. According to the measurement results, XBPM can be correlated to four fiducial points for survey network. This paper describes this method and calibrating results in detail.

INTRODUCTION

XBPM are adopted in synchrotron machine to monitor the photon beam position in beamline frontend [2]. It can eliminate controversy for beam position and stability for machine user. The blade position accuracy will influence the accuracy of the monitor. Due to the thin thickness (125um), vacuum parts and fragile characteristic, the assembling precision of the diamond blades is hard to measure. At the begging, we use non-contact method like telescope and microscope, which may have vision and projection lens error, we need to move and rotate the XBPM, XBPM 3D accuracy error will be over 0.2 mm. Now we developed a new non-contact method by using LED laser with telecentric objective lens and a CCD-array assembling configuration instead of a microscope and accuracy of 5 um. Measurement space can be minimized perfectly and measurement time can be saved. Finally, XBPM can be correlated to four fiducial points for easy survey alignment network installation.

MECHANICAL DESIGN

We hope the measurement accuracy will reach within 5 um with this CCD method and easy blades alignment. During measuring process, moving or rotating the XBPM is forbidden (XBPM weight over 15kg, 240x240 mm). Finally, XBPM measurement data can be correlated to four fiducial holes at about 1/4” for survey alignment network installation. Here is a telecentric objective lens which provides an image of the same size in the so-called telecentric range, which produces a constant accuracy [3]. The line scan camera in the receiver which measures the projected outer contour of the fiducial as shown in Figure 1.

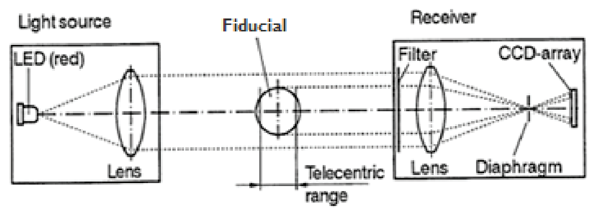

Figure 1: CCD array measurement range of 40 mm, resolution of 0.1 um, and LED wavelength of 670nm.

We make four fiducial holes on the XBPM base template, move the light source and receiver to the fiducial at about 150 mm by using sliders sliding on the rail, and mount and scan fiducial round bar contour. We can make a centre line relative to the rail movement direction by a receiver. Due to the limitation of CCD array area of 40x2 mm, fiducials round bar has a full length which was set up to 75 mm. And the round diameter Ø8 mm concentricity required 2 µm in 55 mm length relative to the hole, the 55mm full length accuracy was controlled within 2 µm. If the measurement range exceeds CCD array range, we can thus move the X-Z stage (450x400 mm travel range) in 1µm resolution. Using a rotatable arm pivot, we can rotate the light source and receiver in 90°. In vertical direction, we measure the blade by using the top surface of the fiducial as a standard point for measurement. In the horizontal direction, the blade is measured by using the side of the fiducial and a side of the blade as a standard point. Scanning step by step, we can measure the gap in the diamond blades and the fiducial centre length. Figure 2 and 3 show the vertical and horizontal sensor scanning.

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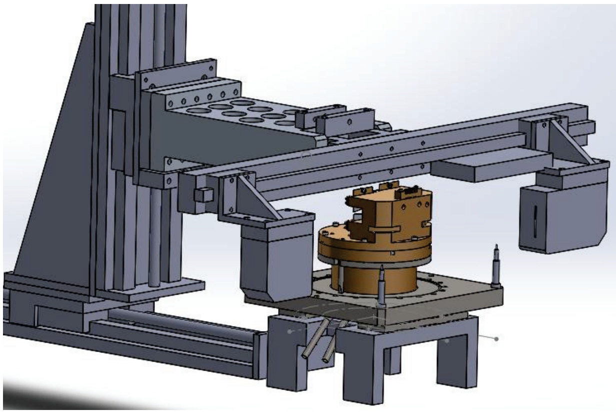

Figure 2: Vertical direction measurement.

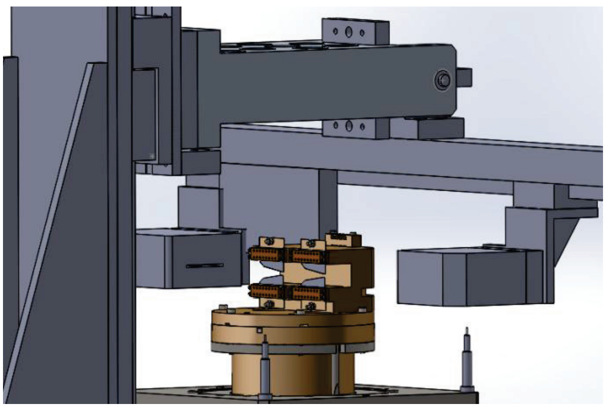

Figure 3: Horizontal direction measurement.

MEASUREMENT

The measurement device was set on the optical table. We use levelling bubble and calliper to set up rail plane and parallel gauge block to reduce misalign for XBPM as shown Figure 4. In order to get a corrected value for the receiver sensor before using, we calibrate receiver sensor with stage and gauge block for its linear as shown in Figure 5.

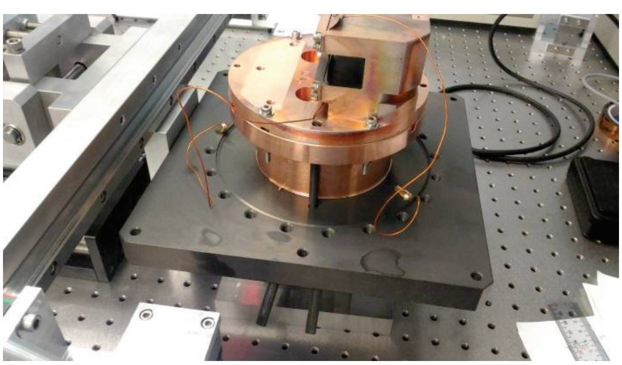

Figure 4: Parallel gauge block to reduce misalign.

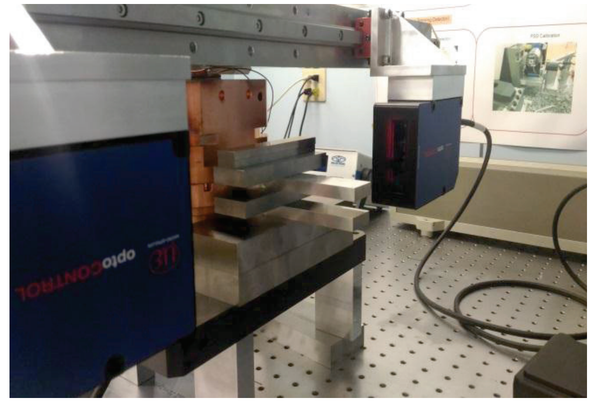

Figure 5: Receiver sensor with gauge block gap calibration.

Here is a receiver sensor height calibration compensate linear value as shown in table 1 and Figure 6.

Table 1: Receiver Sensor Compensated Value

Sensor (mm)	Sensor value	Stage linear encoder(mm)	Sensor value-Linear encoder
39.997	0	0	0
39.5074	0.4896	0.498	-0.0084
39.0095	0.9875	1.002	-0.0145
37.9546	2.0424	2.066	-0.0236
35.3216	4.6754	4.728	-0.0526
32.2158	7.7812	7.863	-0.0818
28.6685	11.3285	11.421	-0.0925
20.3553	19.6417	19.771	-0.1293
14.093	25.904	26.048	-0.144
7.4988	32.4982	32.651	-0.1528
0.0084	39.9886	40.172	-0.1834

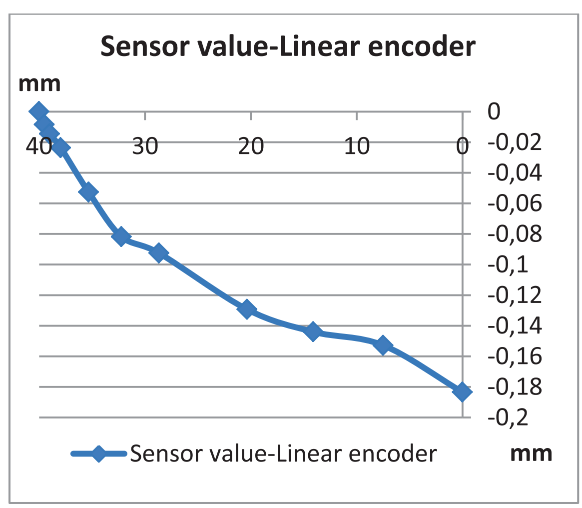

Figure 6: Receiver sensor compensated value.

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Table 2: Receiver Sensor Value in Horizontal and Vertical Direction

	#A	#B	#C	#D	#E	#F
Horizontal direction(sensor reading)	33.996 mm	33.992 mm	33.9951 mm	39.9952 mm	39.805 mm	39.9954 mm
Stage position reading (horizontal)	(0 , 0) mm	(0 , 0) mm	(219.979 , 0) mm	(226.057 , 0) mm	(113.644,38.877)mm	(120.277,38.878) mm
Vertical direction(sensor reading)	9.0054 mm	9.0290 mm	9.0021 mm	9.046 mm	38.0001mm	39.039 mm
Stage position reading (verticall)	(0 , 0) mm	(0 , 0) mm	(220.023, -0.001) mm	(220.045,0.001) mm	(108.241,14.500)mm	(113.461,28.999) mm

RESULTS

Each of the horizontal and vertical direction measurement location is as shown in Figure 7, the receiver sensor value is as shown as table 2.

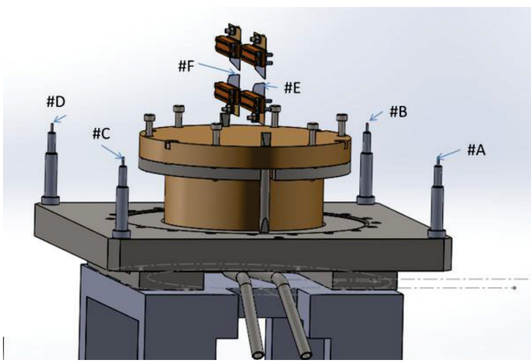

Figure 7: Measurement data locations.

Fiducial hole centre from
#A to #C is 219.978 mm.
#B to #D is 219.9938mm(39.9952mm -33.992mm = 6.0032mm + compensated value 0.06mm =6.0632mm, 226.057mm -6.0632mm = 219.9938 mm).
#A to #E is 115.503mm
#A to #F is 122.336mm
Gap from #E to #F is 122.336mm
Template to blade #E is 98.6146 mm (38mm – 9.0054mm = 28.9946mm + compensated value 0.12mm = 29.1146mm + 14.5mm + fiducial height 55mm = 98.6146 mm)
Template surface to blade #F is 99.6531 mm
Gap from Template surface to #E is 3.025mm
Gap from Template surface to #E to #F is 2.798 mm

We had checked the fiducial holes centre length, the tolerance is within 5µm .The blade height is checked with a calliper, the tolerance is about 0.1 mm(cannot be in contact with blade).

CONCLUSION

The accuracy using this non-contact measurement can be achieved at about 5um. Our system could also reduce a large amount of space, making it more compact as well as save a lot of time while measuring. In the future, we will try to develop a system that could be automatically controlled and measured.

ACKNOWLEDGEMENT

Authors would like to thank the magnet group of NSRRC for providing measurement system ODC2600. The authors would also like to thank MICRO-EPSILON Company for the technical data and measurement principle used in this research.

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