

Azimuth Servo Upgrade Progress Report #1
October 29, 2009
D. Clark

Introduction

This is the first of a series of reports detailing progress on upgrading the MMT azimuth-axis servo system. In this report, work on the first few items on the Azimuth System Test Plan is detailed, including presentation of the first practical measurements performed on the azimuth hardware.

Test Plan Activities

The following action items in the Test Plan have been completed:

1. The azimuth motor gearboxes have had their lubricant changed and samples taken for laboratory analysis.
2. The bull gear and each motor drive pinion gear have been inspected and new lubricant applied to each. We note that wear marks are visible on the bull gear tooth faces over about 1¼” of their area. No cracking or any other problems were found, though it seemed the lubricant was thin in places on the pinion gears. The SE gearbox appears to have uneven lubricant on its gear teeth which may indicate that it is slightly out of alignment.
3. The drive amplifier offsets and gains were all adjusted during the August 2009 Shutdown.
4. The drive amplifier frequency responses were all measured and recorded during the same period.
5. Cleaning and initial inspection of equipment inside the yoke arms was begun. Parts and other items inside the yoke were cleaned up, including the removal of a dead mouse from the East yoke arm.
6. Finally, precision measurements of the radial runout of the azimuth bearing were made and stored in the MMT MySQL database, the results of which are reported in this document.

During the inspection, other items of interest were noted:

- A. The seal around the SW gear box manual crank lever is weeping oil.
- B. The NW gearbox likewise has a small leak.
- C. Each of the drive motors has a pair of tranzorbs from the motor lead terminal blocks to the motor case; two of the motors have one or both tranzorbs cut off; removal of all of them is in order.
- D. The cover for the azimuth cam switch unit is missing and needs to be located and replaced.
- E. The ancient motor brake assemblies on the two West motors were disassembled long ago and most of the parts left inside the yoke, leaving the SW motor top cover missing; it should be located and replaced to keep dirt and bugs out of the motor.
- F. The motor leads, encoder interpolator cables, and other electrical items appear to be in good shape.

Radial Runout Measurements

Since installation of the pintle bearing in the azimuth axis some years ago, no precision measurement of the radial runout of the azimuth axis has been done. To this end, electronic hardware and software was developed to make this and other measurements possible. Using this equipment, two digital dial indicators were placed on the precision-ground surface just above the bull gear teeth and coherent measurements of the dial gauge outputs and the mount computer's azimuth position were written into the MySQL database. The data are in mm with a resolution of 0.001mm, while the telescope axis under test and positions are recorded in degrees in the database.

The dial indicators were installed as pictured (West on the left, East on the right):

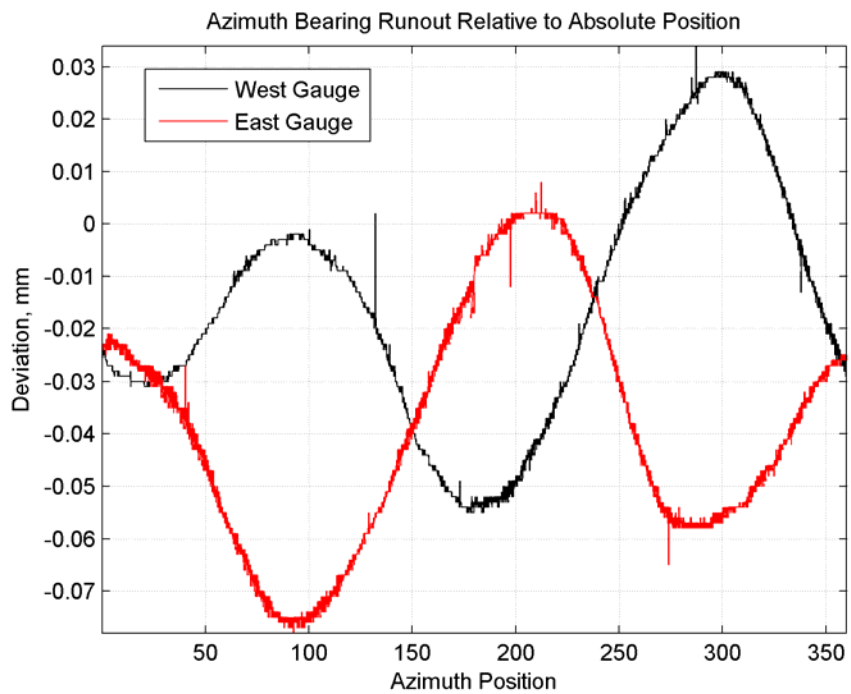
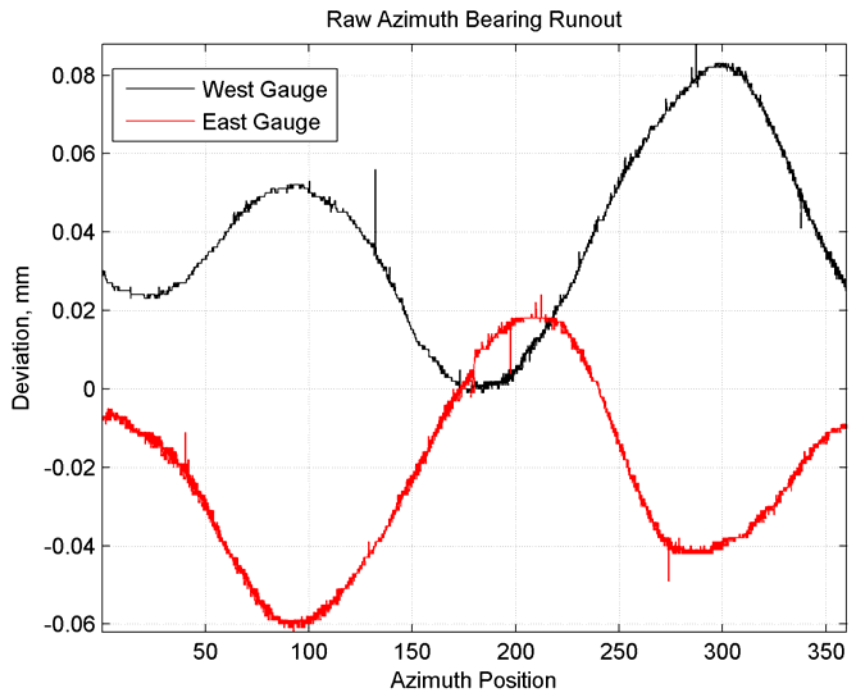


photographs courtesy Ricardo Ortiz

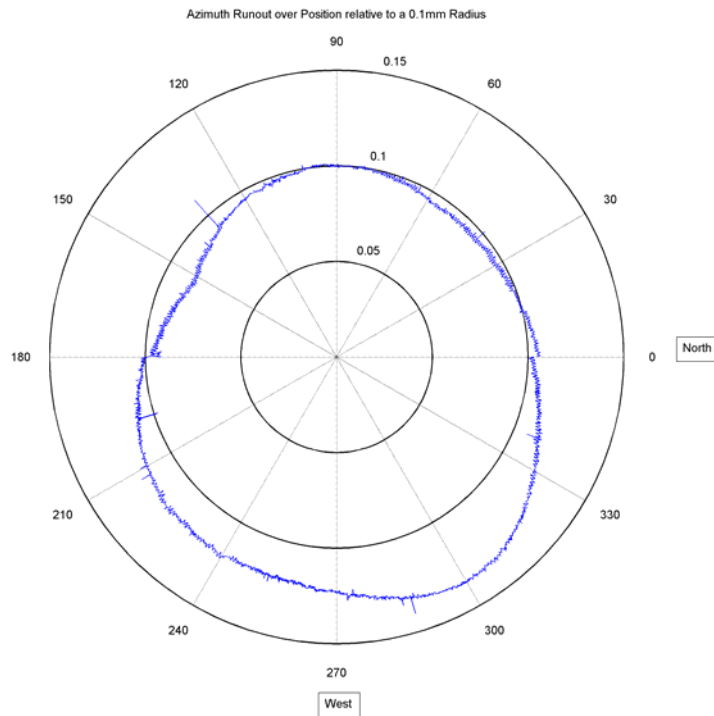
Starting at 180° , the azimuth axis was slewed at $0.25^\circ/\text{s}$ counter-clockwise to a position of -20° , then the position was reset to 180° and the same slew velocity repeated to the west to 360° , giving a total of almost 13,000 data points for analysis. The locations of the dial indicator bases and their probes was marked in case repeating these measurements becomes necessary, and their absolute positions were noted (135° and 227° for East and West, respectively) to relate the output data to absolute azimuth positions. MMTO has never before had measurements of this resolution and quality; storage in the MySQL database makes it available for interested parties in future.

Measurement Data

Below we have graphs of the two dial gauge measurements against the azimuth position:



The first plot shows the raw data as it was collected from each dial indicator against the telescope position; the second the same data where the dial indicator data is “clocked” to bring the measurements into alignment with the absolute azimuth position. Below we have the two orthogonal measurements reduced to a polar-coordinate vector that represents the absolute runout over the telescope position. The dial gauge readings were each offset by 0.1mm to show how the runout varies relative to a constant radius; it makes much clearer how the mechanical center of rotation changes over position.



Since the dial gauges were re-zeroed at the beginning of each data run, we see the sharp inflection in the data where each indicator was reset or motion was stopped (at 0 and 180°) -- a better method of continuously collecting the data would avoid this measurement distortion.

Conclusion

The total radial runout of the MMT azimuth bearing is a remarkable peak to peak value of about 0.09mm. If this deviation is projected to the height of the elevation bearing centerlines (a distance of about 6.8m), the angle subtended by the radial bearing wobble is roughly 2.7 arcseconds over an entire azimuth revolution. It would be interesting to compare the data shown here to TPOINT coefficients from recent pointing data to see if this relationship holds.

More testing on the azimuth mechanical system is planned. Look for more reports as work continues.

