Rack bolt replacement: Parkes Telescope
Lewis Ball
6 Feb 2002

In January 2002 the 188 bolts that hold the elevation rack gears on the counterweight of the Parkes Radio Telescope were replaced. The racks are driven by the pinions of the zenith gearboxes to tilt the telescope. A large fraction of the nuts on the original rack bolts were extremely corroded.

Discovery of the problem

The corrosion of the rack bolts and nuts was found during a shutdown for maintenance and inspections in November 2001. The nuts are located in a cavity inside the base of the counterweight.

Inspection of the nuts was only possible after the removal of one or more access covers on the sides of the counterweight. There were no external indications of the corrosion that was found inside the cavity, and it seems that prior to November 2001 none of the covers had been removed since the construction of the telescope.

Fig 1: View of the right rack showing (face on) the rack teeth and bolt heads and (side on) the round access covers.

The main purpose of the maintenance shutdown in November 2001 was to undertake non-destructive testing of the telescope structure. CW Pope& Associates were contracted to perform this testing, primarily by visual inspection, ultrasonic probe and magnetic particle techniques. Ultrasonic testing of the rack bolts was planned as part of this program, for which a detailed list of critical test points had been identified in advance. During the same shutdown, ATNF staff including Jon Crocker, Clive Murphy, Barry Turner and Brian Wilcockson took the opportunity to investigate the options for refurbishing, rotating or replacing the rack gears on the counterweight. New gears and pinions for the zenith drives are currently being manufactured and will

be replaced sometime in 2002. The racks are badly worn on one face, and there is a strong imperative to address this at the same time as the gearboxes and pinions are replaced.

The racks are located laterally on the counterweight by tapered steel dowels which ultrasonic testing by CW Pope indicated were in good condition. Ultrasonic testing of the bolts that clamp the racks onto the counterweights was not possible because of the nature of their hexagonal socket heads. The covers that provide access to the nuts on the rack bolts were therefore removed to facilitate a visual inspection of the nuts, and to check the viability of removing the racks themselves at a later date.

It was decided on the basis of the visual inspection of the nuts and bolts, and the ultrasonic testing of the dowels, that there was no danger of immediate mechanical failure of the rack mounting, but that the corrosion was so extreme that replacement of the bolts and nuts was required as soon as scheduling allowed.

It is reasonable to ask why the corrosion had not been found earlier, particularly in the course of structural integrity testing by contracted engineering firms. The answer may be that the November tests were the first for which a list of critical points to be tested had been drawn up in advance.

The replacement

A trial run to remove and replace a small number of bolts was undertaken by Jon Crocker and Barry Turner early in December 2001. Working at night, four bolts were removed and replaced in around four hours.

Plans for the full job were developed on the basis of the trial. The aim was to ensure replacement of all the bolts and nuts, removal and cleaning of all the corrosion within the counterweight cavity, treatment of the cavity with rust converter, and sealing of the cavity with an epoxy paint compound. To meet the target of completing this work within a seven day shutdown, making allowance for possible interruptions due to wind or other bad weather, and for other contingencies, the use of contract engineering labour to supplement staff from Parkes, Narrabri, and Marsfield was required. The team directly involved in the work on the bolts comprised: Jon Crocker, Barry Turner, and Brett Preisig from Parkes; Clive Murphy and Graeme Sunderland from Narrabri; and Paul Cooper and Brian Wilcockson from Marsfield. These staff were supplemented by a team of five from G Engineering, based in Blayney. A draft schedule of work comprised two shifts, from 5am - 2pm and from 2pm to 11 pm. The G Engineering contract allowed for the company’s employees to work up to 12 hours per 24 hour period and the rate was a fixed $36/hour regardless of which hours were worked during the day.

The job went very smoothly with the ATNF staff and the G Engineering employees working very well together. The weather was kind, with the only major interruption involving around 4 hours lost on the Thursday afternoon when a severe storm with 80km/h winds and heavy rain intervened.

The bolts and nuts themselves had been replaced by the end of three 15-18 hour days. The two-shift schedule was dropped from Day 4, and a number of other maintenance jobs were started to take advantage of the shutdown and the available labour. On day

4 the final corrosion cleaning was completed, and rust converter was applied to the cavity. On day 5 the cavity was painted and the telescope was readied for operation again. Over days 4 and 5 Jon Crocker removed, refurbished, and reinstalled a telescope jack that had been inoperable for some 2 months. Over the same 2 days Greg Gilliver from G Engineering repaired a number of cracked welds that had been discovered by the CW Pope inspection in November.

Inspections conducted during the work indicated that seepage of moisture from the counterweight itself into the rack bolt cavity was the most likely source of the corrosion. A number of drain holes were drilled in the counterweight and breathers were fitted to the rack bolt cavity to facilitate the removal of moisture from these areas. Around 40 litres of water flowed from one hole drilled in the main counterweight cavity!

Summary

The use of external labour was clearly a success in this exercise. It ensured that the job was completed rapidly, minimising the time lost to astronomy. The telescope was available for system tests on day 6, two days earlier than anticipated. Day 7 was used entirely for astronomy.

The contribution from ATNF staff from the other sites was enormously valuable and is greatly appreciated. The breadth of expertise that this provided contributed greatly to the smooth operation, and the interaction between the staff from different sites during projects such as this is very valuable for the organisation as a whole.

The supplementation of ATNF staff with the G Engineering team was also a great success. There is clearly a direct financial cost associated with bringing in external contractors, but this needs to be set against the saving of maintenance time which would otherwise be lost to astronomy, the ATNF's core business.

The cost of the G Engineering contract was $9,500. The time saving to astronomy was around 1 week.

We would have no hesitation in using G Engineering again for similar projects.

Of course the solution to the wear on the rack teeth has not yet been implemented, but if the racks are to be removed, the bolts should be easy to undo!

Fig 2: Corroded rack nuts and bolts inside the counterweight cavity.

Fig 3: The team at work.

Fig 4: Some of the worst of the nuts.

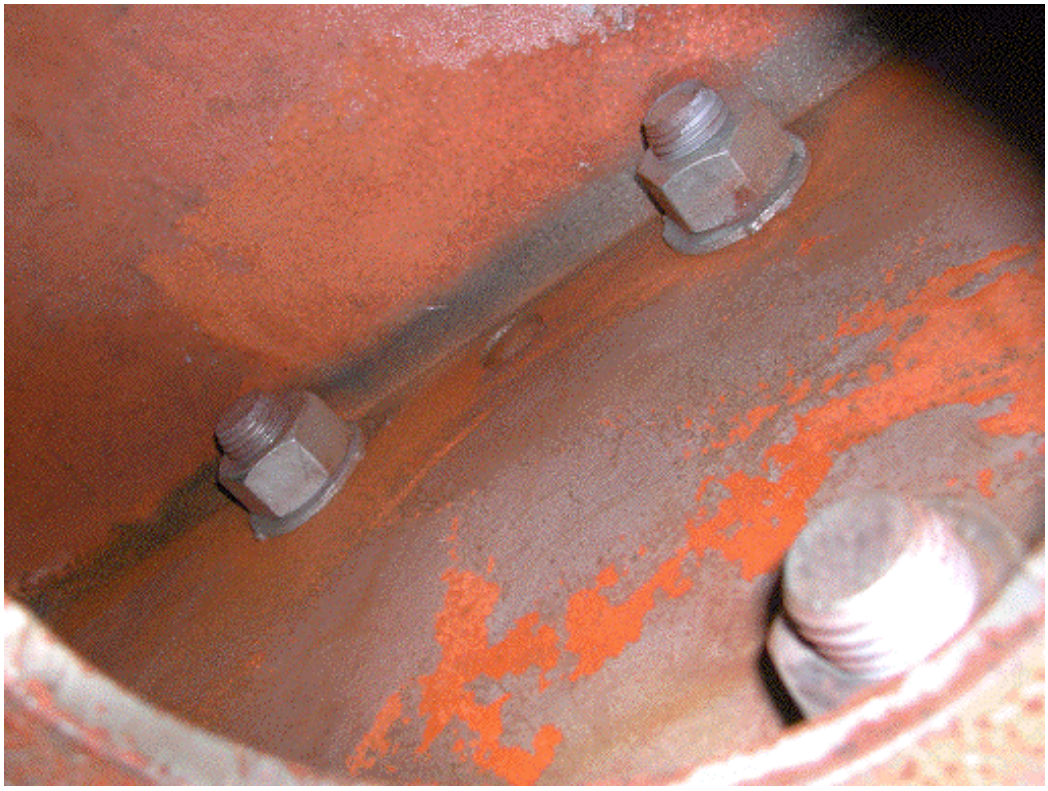

Fig 5: Cleaned up with new bolts and nuts. Note recessed tapered dowel.

Fig 6: Signs of moisture ingress.

Fig 6: After rust converter application. Dark areas are neutralised rust.

Fig 7: The finished job. Dark patches at the bottom are new drain holes.

Fig 8: Wear on the rack teeth (still to be remedied).