Salvaging an Expensive Shaft by Brush Electroplating

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An expensive shaft was salvaged by depositing nickel on an undersized bearing journal. The shaft is a component in the Master Equatorial instrument, required for the 64-m-diameter antenna of the Deep Space Network. In special cases, this electroplating process could be considered part of the fabrication method rather than a salvage process.

I. Introduction

The DSN 64-m-diameter antenna employs a precision reference instrument, called the Master Equatorial, which allows the antenna to be directed accurately where desired. Figure 1 shows the fork and polar axle of the Master Equatorial, a mild steel weldment weighing approximately 800 kilograms. Its shaft has journals for the two highly precise (ABEC class 9) angular contact ball bearings.

Several problems are encountered in grinding the journals of a shaft of this size to the required accuracy. If it is turned on dead centers, the process usually assumed to produce the best degree of roundness, the wear on the centers will be excessive because of the high weight loading. The addition of a steady rest support, which might otherwise seem desirable, negates some of the inherent advantages of turning on dead centers. The fact that the part is not symmetrical about every plane through the longitudinal shaft axis means that gravity loading deflections vary with the angle of rotation. These problems can be eliminated by mounting the part vertically, as, for example, on the turntable of a vertical boring mill or vertical grinder. However, this method introduces another serious problem: the inaccuracies of the machine turntable bearings will be reflected in the journal being ground.

Thus it is always difficult to obtain simultaneously, through grinding, the required degree of roundness and a specified diameter to within a very small tolerance range, and yet these are exactly the requirements that must be met to ensure that the installed bearings will

have their intrinsic accuracies realized. Thin bearings in particular will conform to the shape of the journal when installed with a zero clearance or interference fit.

Hence, the roundness of the inner race will be no better than that of the journal. Obviously a too-small journal would allow the part to move with respect to the bearing, unless an excessively high axial preload were applied in order to expand the inner race. But this higher preload would increase the bearing friction. An increase in bearing friction would also occur if the bearing journal is too large, thus producing more interference fit than desired. From the bearing performance point of view, it is necessary that journal roundness to a specified diameter be maintained.

II. Hand Salvaging of Shafts

Recently two fork and axle units were manufactured for use at DSS 43 and DSS 63. The journals were ground by a tool post grinder mounted on a vertical boring mill. It was determined experimentally that the machine runout was quite small and that the machine-made journals would be near enough round so that a moderate amount of hand work would make them satisfactory. It was agreed to attempt to grind them to a diametral dimension from 0 to 8.0 μm over the upper dimensional limit. The lower dimensional limit is 5.0 μm less.

This process worked out very well for the first shaft. A moderate amount of hand lapping produced a surface round to within 0.50 μm and within the dimensional limits of the drawing.

However, the large journal of the second shaft came out undersized by approximately 12.0 μm. After hand lapping to achieve roundness, it was undersized by 17.0 μm.

This shaft was then brush electroplated using the proprietary "Dalic Process," which is a method of electroplating localized areas without using immersion tanks. Various metals can be deposited onto conductive surfaces from highly concentrated electrolyte solutions which are held in absorbent materials attached to portable electrodes. Thickness of the deposited metal can be controlled by an ampere-hour meter.

A nickel solution was chosen for electroplating the shaft. The result was not uniformly thick, thus requiring some additional hand lapping to restore roundness. It is believed that the lack of thickness uniformity was caused by the necessity of stopping the turning of the part frequently during plating in order to replenish the solution. A more sophisticated arrangement could have prevented this.

Thus a very expensive part was salvaged through an inexpensive process. It may be that for bearing journals of this size, where roundness and dimension must be met simultaneously, the designer should consider this kind of brush plating as part of the fabrication method, rather than as a strictly salvage process.

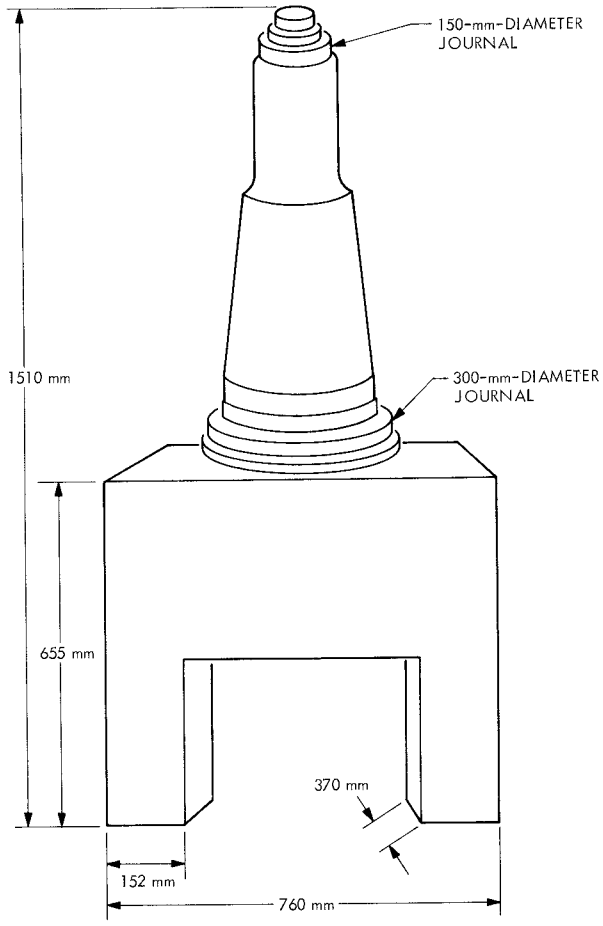

Fig. 1. Sketch of Master Equatorial polar axle and fork