09/03/04

From:  Bruce Lamartine

To:  Tim Wright

In re:  Question.

To what extent can the failure mileage of a Loctite adhesively bonded camshaft drive sprocket be extended over that of a non-treated one?

Plan of attack:  We make our best guess of the useful contact area and the tensile stress of the bonding material at operating temperature.  With that information, we then calculate the increment of force that can be borne by the adhesive and subtract that increment from the median force that the drive sprocket normally sees.  As shown in my assessment paper, this distribution of force has the net effect of extending the failure mileage distribution.

Figure 1 below shows the application of the adhesive to one available void.  Subsequent modeling assumes application to all voids.

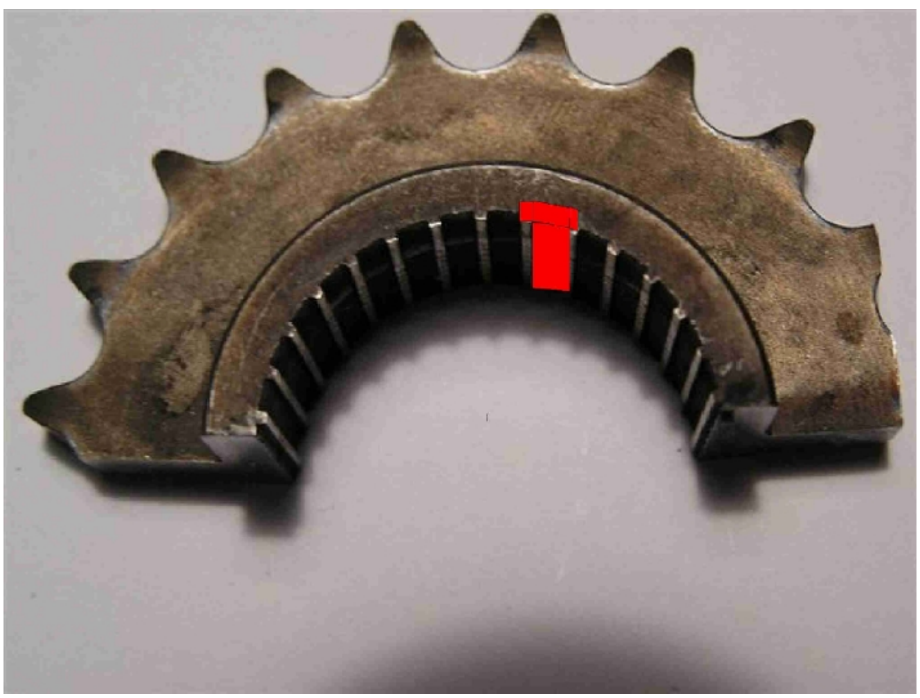
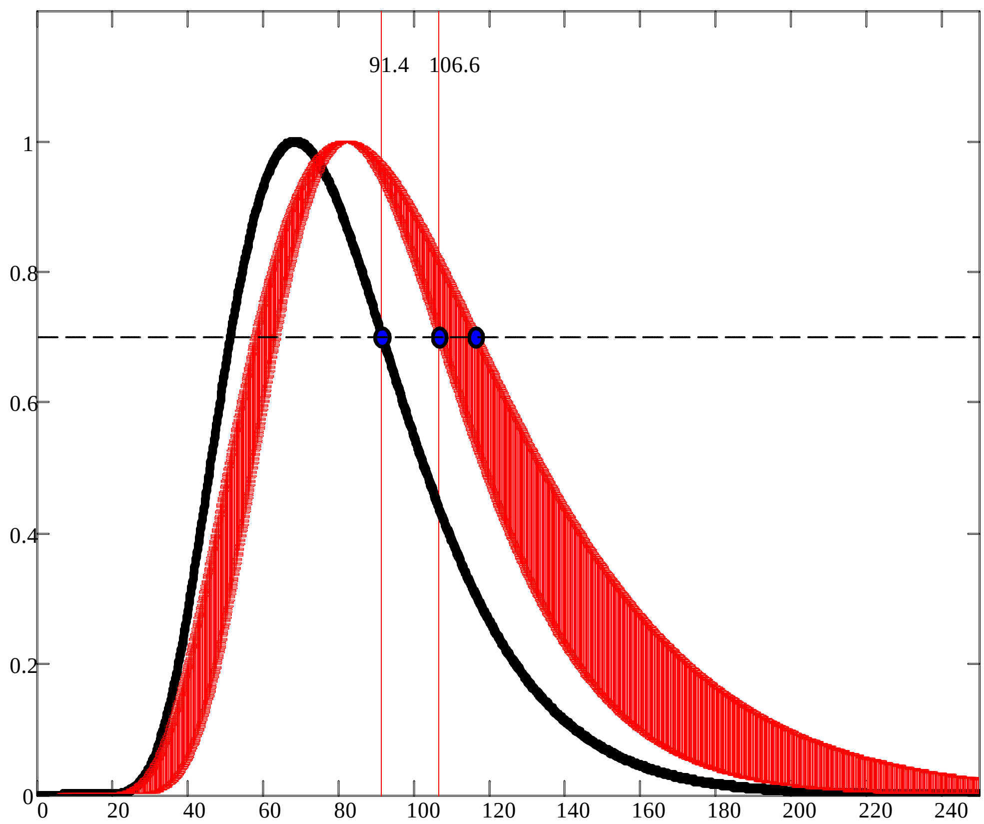


Figure 1.  Gen III camshaft drive sprocket courtesy of Bob Gervais.  Downloaded with permission from www.v8sho.com.  The red detail of suggested adhesive void fill was added by B.C. Lamartine per a suggestion from Tim Wright.  Adhesive fill must be replicated for all sprocket voids.

A search of the literature for values of tensile strengths of Loctite 294 or chemically related acrylics, cyanoacrylates, or acrylate/epoxy adhesives yielded reasonably complete specifications on Hysol EA 9686, a related Loctite compound which was tested at 121 C, a temperature close to that in an operating engine. Unlike that in steels, the tensile strength in most adhesives is highly dependent upon temperature. We find a tensile strength at 121C for Hysol EA 9686 of only about 3 MPa. Using this value and further assuming additional contact area is available only inside the sprocket voids, we can apply the model set forth previously in the paper. The results are shown in Fig. 2 below.




**Normalized failure frequency**

**Failure mileage, thousands**

Figure 2. A comparison of the failure frequencies of unbonded and bonded camshaft sprockets as a function of miles driven. The black curve is the best fit (better than 95% confidence) of the camshaft failure data through March 2004. The red band is the estimate of the failure frequencies of void-bonded camshafts bounded by a span of either 6 standard deviations (upper bound) or 8 standard deviations (lower bound). The progression of blue dots shows one possible improvement in failure mileage after bonding.

The most probable failure mileage (peak) shifts from 68,397 miles to 82,058 miles after bonding. It is also interesting to note that the most benefit appears to derive from bonding good sprockets on the right (high mileage) branch of the failure curve. For example, as shown in Fig. 2, if good camshaft drive sprockets in an engine at 91,400 miles are adhesively bonded as described above, one may expect that a failure could be prevented with some confidence to at least 106,600 miles.  If the model is correct, then this treatment should be sufficient to afford a drive to any shop in the United States for subsequent welding.