Left, inner bearing and spacer mating face

There is a noticeable difference between the inner and outer bearing spacer mating faces. The inner bearing has heavily marked the spacer actually displacing metal. This looks more like overload than fretting. The outer bearing has no such marking. This is down to differing stress levels, load being the same at both ends of the spacer.

4) Design analysis

Consider for a moment how the drive is transmitted through the axle assembly, it will 'wind up' under torque. Torque will be split between the axle and the spacers, bearing inner race etc according to their relative stiffness. Calculation shows that the spacers will transmit slightly more than 50% up to the point where they slip relative to the drive hub. If the nut is providing full clamp load this is likely to be beyond the limit of traction. If the clamp load relaxes for any reason, then the assembly will start to fret under power-on, power-off conditions and the whole will not just suffer deformation, it will also wear, the proverbial slippery slope.

Recall that from the survey 4 owners reported pre-load had been lost but the nut had not loosened, this can only happen with loss of material length of the spacer or abutment, this in turn most likely due to overload and/or subsequent fretting.

A hardened spacer will not suffer significant wear or deformation and represents a good way to ensure the inner bearing does not damage the spacer, but we also have to consider the other end of the inner bearing inner race, the axle face, which sees similar stress levels.

Left picture of the bearing abutment on the axle removed from the LHS of my Europa.

Quite clearly the inner bearing inner race has removed material where it has contacted the axle. Steve Veris did some hardness assessments of the axle and came up with 27R, on the C scale I assume. This equates to c.880MPa tensile strength, source:

http://www.steelexpress.co.uk/steel-hardness-conversion.html

To analyse how this loss of clamp load might occur requires some numbers.

The schematic following shows the forces acting on the axle/hub during a 1g constant speed turn assuming a ground coefficient of 1, 55% of mass over rear wheels and 0.5 metres CG height. Some data has been lifted from an e-mail on the knowledge base dated 3 Aug 2009 from Steve Veris regarding hardness of the components. BTW, apologies to those still working in English units, I was trained in metric.