The Pros — And Mostly Cons — Of Fully Ground Root Fillets

QUESTION

For maximum life in carburized and ground gearing, I have been advised that fully grinding a radius into the root gives maximum resistance against fatigue failures. Others have advised that a hobbed and unground radius root form is best. Which is best, and why?

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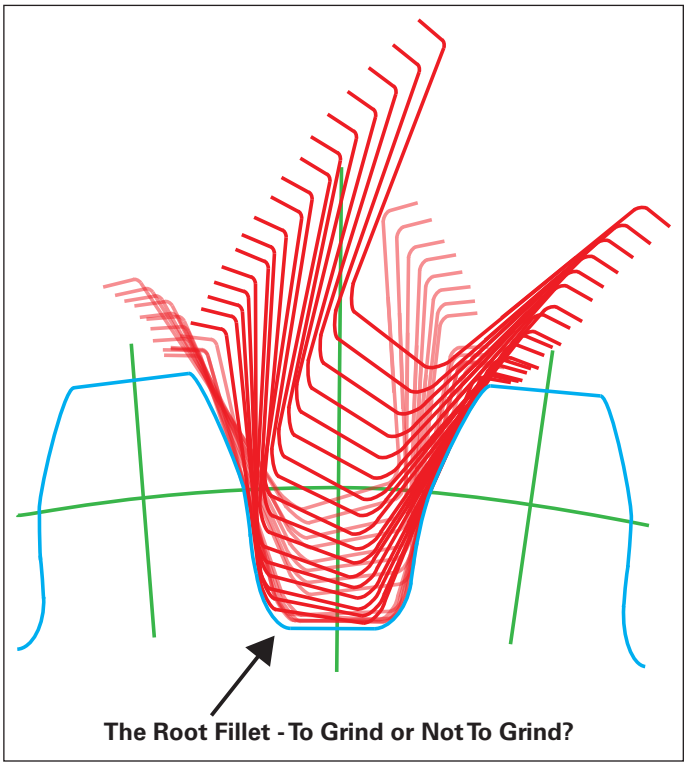
EXPERT ANSWER PROVIDED BY: Robert Errichello, owner/operator of GEARTECH:

It depends on the processing.

With fully ground root fillets, any distortion due to heat treatment must be very carefully controlled, ensuring that stock removed during grinding is minimized and there remains adequate case depth after grinding. This is practical only for small gears and those that are re-heat-quenched. Furthermore, it requires a quench press to adequately control distortion. Generally, grinding is detrimental because it imparts tensile residual stresses. Consequently, root fillets are usually shot peened after they are ground to ensure they have beneficial, compressive residual stresses. In addition, with grinding there is always a risk that the heat associated with grinding might cause tempering or rehardening of the gear tooth surfaces. Therefore, critical gears should be surface-temper-etch-inspected to confirm there are no grind-damaged areas. But this extra processing increases manufacturing costs, rendering ground root fillets practical and cost-effective only for critical gears such as those used in aerospace applications.



The Root Fillet - To Grind or Not To Grind?

Properly processed gears with unground root fillets can have bending fatigue capacity that is nearly the same as aerospace gears that are processed as described above. However, if the gears are gas-carburized, there will be intergranular oxidation (IGO). The IGO must be controlled to Grade 3 requirements according to AGMA 923-B05 to adequately maintain bending fatigue resistance. Furthermore, the root fillets should be shot peened to mitigate the effects of IGO. Alternatively, the gears can be vacuum-carburized to eliminate the IGO. Therefore, for most industrial gears, properly processed gears with unground root fillets are the best choice for reliable and cost-effective gears.

The above discussion applies only to bending fatigue resistance and caution should be exercised regarding shot peening and Hertzian fatigue resistance. The tooth flanks should not be shot peened because their surfaces will be made somewhat harder and rougher, and the flanks might create micropitting on the mating gears. To prevent this problem, the shot peened flanks can be superfinished. Generally, shot peened flanks that are superfinished after shot peening have maximum micropitting and macropitting resistance.

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