

Notes on Copper Plating of Gear Tothing

Fiat Avio studied the effects of copper plating on gears in the late seventies. The results of this study showed that gear teeth exposed to copper plating experienced a chemical interaction between the tooth flanks and the copper plating. This interaction is known as hydrogen embrittlement where the hydrogen enters the material during the electro-plating process. The result is a diminishment of strength and fatigue life of the gear (but not hardness).


Follow-on testing by MAAG in 1980 confirmed Fiat's finding by use of an in house pulsation tester used to determine the endurance limit in bending. The results were astonishing whereby copper plated gears showed a bending strength loss of 22%!

Additional tests show the embrittlement effect can be reduced by heating the pinions to 150 deg C and tempering. The resulting residual loss in strength was reduced to 7%. Note: Silver plating was also rejected.

With further advances in tothing accuracies as well as improved lead and profile modifications required assuring as best as possible uniform load distribution over the entire face width MAAG officially discontinued the use of plating the pinions in 1982. Prior to that time and after the discovery of hydrogen embrittlement, the rotors were de-rated by 7% in the allowable power rating.

Further studies showed that hydrogen embrittlement can occur with many plating processes. However its effects depend on the material alloy (and may actually increase hardness). When done correctly, hydrogen embrittlement can be avoided. A common cure for hydrogen embrittlement is tempering at the proper temperature, but it must be done immediately after plating. Thus, with tempering you can reduce the loss of bending strength to 7%. However, 7% is well within the usual scatter in bending fatigue tests.

It has been reported that Boeing continues to copper plate helicopter transmission gears. The key is in the tempering process which must take place over a fairly extended period of time to fully purge the effects of the hydrogen embrittlement. In addition the machine grinding of the gear teeth must be done carefully as any residual localized stresses due to the grinding method could attract the hydrogen to locally collect near the ground surfaces.

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