

SURFACE PROPERTIES

The surface properties of gear steels can be improved by thermochemical and mechanical treatments.

PROPER SELECTION OF STEEL AND ITS HEAT TREATMENT IS A

fundamental challenge for gear designers and manufacturers. However, performance and endurance limits of the teeth depend strongly not only on the bulk mechanical properties of the steel used for the design but also on surface properties of the gear flank. The latter can be shaped by thermochemical as well as mechanical surface treatments.

Wear and subsurface-initiated fatigue are the main failure modes of case-hardened gears [1]. Surface properties of engineering components including gears can be improved by the thermochemical processes such as carburizing and nitriding as well as by additional mechanical processes such as shot peening applied as a finishing operation [2]. Wear tests have shown that nitriding can be a viable alternative to carburizing, combining the benefits of low-temperature treatment with equivalent or better tribological properties [3]. It should be noted that the carburized layer must be thicker than the nitrided layer to compensate for insufficient core hardness of the steels used for this process. Carburizing also requires post-treatment quenching and tempering as well as grinding. In the majority of situations, the as-nitrided surface is ready to use. It is important that the required surface treatment be carried out in a way that results in improved bending and contact fatigue properties as well as increased wear resistance of the gear teeth.

For example, the bending fatigue data for 41CrAlMo7 steel are shown in Figure 1, and the wear data are shown in Figure 2. Note that nitriding alone provides the best bending fatigue properties for the steel among all of the treatments. The addition of shot peening improves performance of the steel when compared with its quenched and tempered condition, but it is not a match to the as-nitrided condition. Nevertheless, shot peening is effective in further improving the contact fatigue properties of the steel as well as its wear resistance [2]. Regardless of the contact pressure of the test carried out in the range of 50-600 MPa, samples in the nitrided and the double-shot peened condition show the least wear depth (see Figure 2). Proper application

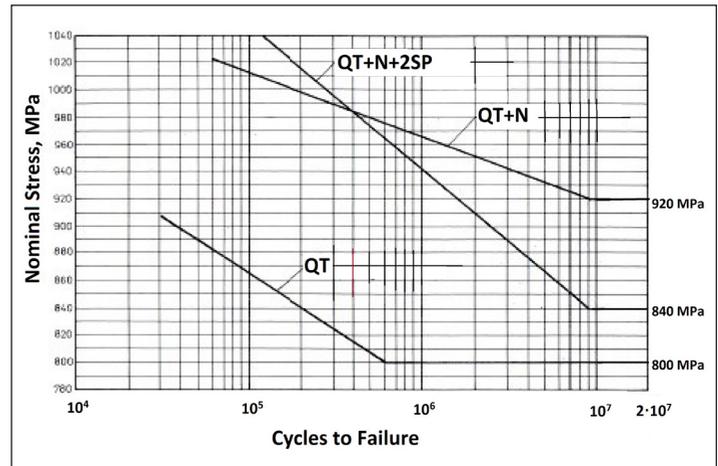


Figure 1: Comparison of fatigue strength for 41CrAlMo7 steel samples in quenched and tempered (QT), nitrided (QT+N), and nitrided with the two-step shot peening condition (QT+N+2SP). Reprinted with permission and adapted from Reference [2].

and balancing of the thermochemical treatments in combination with shot peening require careful analysis of the achievable properties.

When applying nitriding, careful analysis should also be performed for determining which method to use. Gas nitriding would result in an all-over treatment of the gear, which may be detrimental to the selected surfaces. In these situations, plasma nitriding should be used, since it offers easier local protection from nitriding by using mechanical masking (see Figure 3).

REFERENCES

1. I. Boiadjev, J. Witzig, T. Tobie, and K. Stahl, "Tooth Flank Fracture — Basic Principles and Calculation Model for a Sub-Surface-Initiated Fatigue Failure Mode of Case-Hardened Gears," *Gear Technology*, August 2015, pp. 59-64.
2. G. Mońka, J. Michalski, and J. Tacikowski, "Effect of Shot-Peening on Chosen Mechanical Properties of Nitrided Steel 41CrAlMo7," *Inzynieria Powierzchni*, No. 1 - 2014, pp. 7-13. Ed. Institute of Precision Mechanics.
3. J. Senatorski, J. Tacikowski, and W. Liliental, "Tribological Properties of Nitrided Layers, as Determined by the Cone-Three-Cylinder Wear Test," *Tribology Transactions*, Vol. 41, 1998, pp. 199-208.

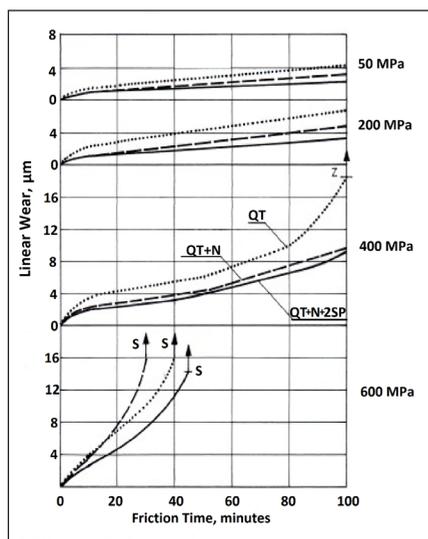


Figure 2: Comparison of linear wear (depth) versus time of test and unit load for 41CrAlMo7 steel samples in quenched and tempered, nitrided, and nitrided with the two-step shot peening condition (S = Seizure). Reprinted with permission and adapted from Reference [2].

ABOUT THE AUTHOR: Dr. Edward Rolinski received his M.S. in manufacturing technology in Warsaw, Poland, and received his doctorate for his research on phenomenon in the ion nitriding process. He has taught physical metallurgy and surface engineering and received his ScD (habilitation) for studying plasma nitriding of titanium. Rolinski is a senior scientist at Advanced Heat Treat Corp. in Monroe, Michigan, solving technical problems and developing technologies. For more information, contact him at doctorglow@ion-nitriding.com or visit www.ahtweb.com.

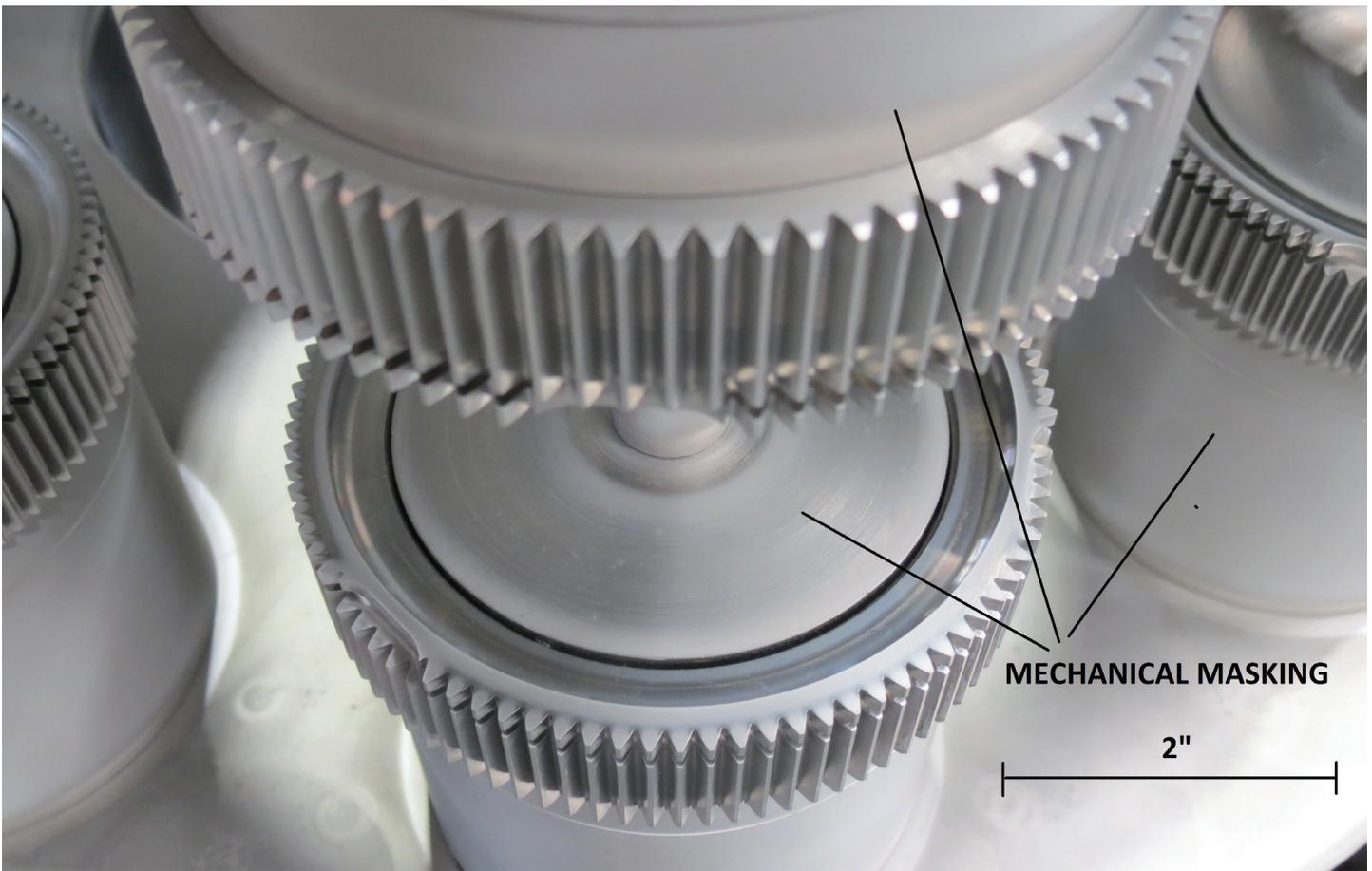


Figure 3: Small gears after plasma nitriding. Elements of masking protects selected areas from hardening. Photo courtesy of Advanced Heat Treat Corp., Waterloo, Iowa.


STDGear.com

GEARING AHEAD TO MEET INDUSTRY'S DEMAND FOR PRECISION

– SERVING –

- Aircraft • Aerospace • Actuation**
- Instrumentation • Optic**
- Robotics • Radar • Medical**
- Marine • Defense • Experimental**
- Prototype • Production**
- Hi-Performance Automotive**



Precision Gear Products (up to AGMA Q14):
 Spur Gears, Helical Gears, Worm Gears, Anti-Backlash Gears, Cluster Gears, Clutch Gears, Face Gears, Planetary Gears, Gear Assemblies, Gear Boxes, Bevel Gears, Miter Gears, Metric Gears, Internal Gears, Idler Gears, Gear Rack & Pinion, Worms, Wormshafts, Splines, Spline Shafts, Serrated Shafts.

CNC Thread Grinding

STD Precision Gear & Instrument, Inc.
 318 Manley St. • W. Bridgewater, MA 02379
(888) STD-GEAR or (508) 580-0035
 Fax (888) FAX-4STD or (508) 580-0071
 E-mail info@stdgear.com • Web site: www.stdgear.com

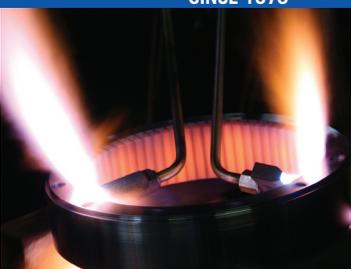


PINSON VALLEY

HEAT TREATING

ISO 9001-2000 REGISTERED SINCE 1970

Celebrating 45 Years of Service

- Anneal
- Straightening
- Quench & Temper
- Flame Hardening
- Carburize
- Solution Anneal
- Normalize
- Shot blasting
- Carbide Removal
- Cryogenics
- Stress Relieve
- Vacuum Heat Treating
- Solution Treat and Age of Aluminum/Aerospace Specifications

MEMBER






205-681-8595

PVHT.COM