



## THERMOCHEMICAL SURFACE TECHNOLOGIES APPLICABLE TO GEARS

Comparing wear resistance of nitrided and carburized cases formed on the same steel can help designers choose which method to use.

### HARDENING OF THE GEAR SURFACES

Wear of the nitrided layer at 50 MPa is limited only to the compound layer (6  $\mu\text{m}$ ) and exceeds this depth at higher loads. As shown in the graphs, despite the lower case depth, tribological performance of the nitrided case is similar to the performance of the much deeper carburized case. Remember that the nitriding process represents a low-temperature (350-650°C) thermochemical treatment technology that is widely applied in the industry to various products mainly made of steel, both to single units as well as bulk or serial production, and its popularity is permanently growing. It is a cost-effective alternative to widespread high-temperature (800-950°C) thermochemical treatment methods, such as carburizing or carbonitriding. Low temperatures of the nitriding process make it possible to reduce deformation and undesired changes of workpiece dimensions, as compared to carburizing or carbonitriding. Therefore, final machining costs of nitrided gears might be reduced. Also, service temperature of the nitrided layer can be higher than that of the carburized case. 

has a profound effect on their performance. Reduction in friction, enhancing rolling contact fatigue resistance, and other tribological properties of the surface can be utilized by application of various surface techniques available to the manufacturing industry. For surfaces hardened by a diffusion process, what really matters is the depth of the hardened layer and its hardness and resulting tribological performance. Two leading methods used to produce hard layers in gears made of low alloy carbon steels are carburizing and nitriding. Both methods produce surfaces of significant hardness and may be applied to finished products if their control is at a sufficiently high level. Nitriding is often used as an alternative process to carburizing. Therefore, comparing the wear resistance of nitrided and carburized cases formed on the same steel could be important to designers to determine which method to use. A good example for this purpose is the SAE 5120 (European equivalent 18HGT) steel, which can be either carburized or nitrided. A typical carburized case is a few times thicker than the nitrided case to allow for grinding stock removal, and its surface hardness is slightly lower (see Table 1).

It might be interesting to see if tribological performance of those layers is much different. This was done by applying the “Cone-Three-Cylinder Test” [1]. Such characterization of the wear phenomenon also allows an evaluation of its progress with time using this method. Three-dimensional graphs showing tribological behavior of the SAE 5120 steel after nitriding and after carburizing are shown in Figures 1 and 2. Both graphs show characteristic linear wear up to 200 MPa of unit load and accelerated wear at 400 and 600 MPa. Unit loads of 600 MPa cause seizure (S) of both nitrided and carburized cases.

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### REFERENCES

1. J. Senatorski, J. Tacikowski, and E. Rolinski, Nitrided and Nitrocarburized Layers and Their Tribological Characteristics, ASM Metals Handbook, Chapter in Vol. 18, in preparation.

Type of Treatment	Temperature, °C	Time, Hours	Media	Prior/Post Quenching & Tempering Temperature, °C	Thickness of compound layer/case, mm	Hardness Surface/Core, HV
N	530	6	Controlled $\text{NH}_3+\text{N}_2$	860/600 3 hours	0.006/ 0.16	826/268
C	930	6	Liquid carbon compound	Quenching after carburizing/temper at 180°	0.000/ 0.95	745/460

Table 1: Details of nitriding (N) and carburizing (C) processes applied to the samples. Adopted from Reference [1]

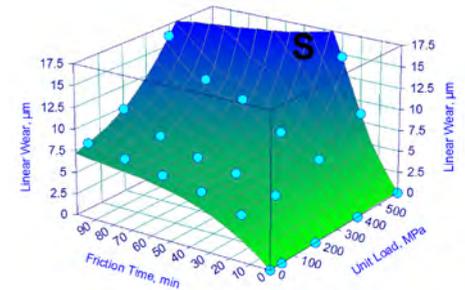


Figure 1: Linear wear depth versus time of friction at different unit loads of the nitrided layer produced in SAE 5120 steel (equivalent to 18HGT steel) by controlled gas nitriding at 530°C for six hours. Linear wear at 50-200 MPa was 5.8-11.6  $\mu\text{m}$ , and wear intensity was 0.024-0.072  $\mu\text{m}/\text{min}$ . S = Seizure. Adopted from Reference [1]

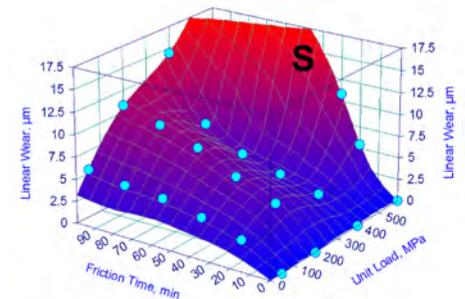


Figure 2: Linear wear depth versus time of friction at different unit loads of the carburized layer produced in SAE 5120 steel (equivalent to 18HGT steel) by gas carburizing at 930°C for six hours, quenching and tempering at 180°C. Linear wear at 50-200 MPa was 5.4-10.8  $\mu\text{m}$ , and wear intensity was 0.0375-0.083  $\mu\text{m}/\text{minute}$ . S = Seizure. Adopted from Reference [1]

**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.