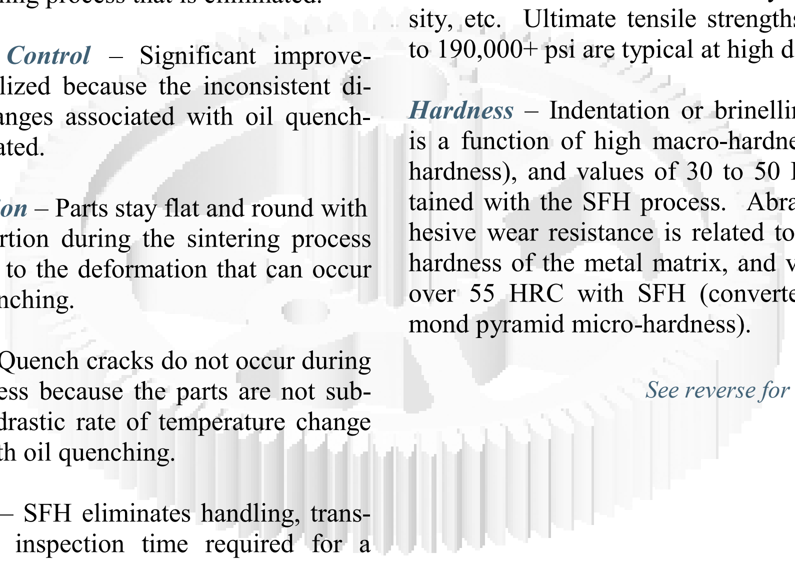
GKN SINTER METALS

Techical Sheet

Achieving High Strength and Hardness with Sinter Furnace Hardening (SFH)

Gears manufactured by P/M processes are used in applications that demand increasingly higher levels of strength and hardness. These properties usually are achieved by a heat-treatment process consisting of heating the component to a high temperature, and then quenching it in oil (as is done with wrought steels).

In addition to standard heat-treat processes, however, GKN Sinter Metals offers its customers sinter furnace hardening (SFH). SFH involves selective alloying of the P/M materials so that a strong, hard microstructure is developed during a fast cooling stage in the sintering process. This requires an optimum combination of alloys, along with a fast-cool sintering furnace.



Benefits of Sinter Furnace Hardening

Cost Saving – A saving is obtained when the additional cost of alloying is less than the quench-hardening process that is eliminated.

Dimensional Control – Significant improvements are realized because the inconsistent dimensional changes associated with oil quenching are eliminated.

Shape Retention – Parts stay flat and round with minimal distortion during the sintering process … in contrast to the deformation that can occur during oil quenching.

No Defects – Quench cracks do not occur during the SFH process because the parts are not subjected to the drastic rate of temperature change that occurs with oil quenching.

Time Saving – SFH eliminates handling, transportation and inspection time required for a separate quench-hardening process.

Readily Impregnated – Since there is no entrapped quench oil, the gear can be impregnated with lubricating oil or plastic resin.

Improved Appearance – Gears produced with the SFH process have cleaner and more uniformly colored surfaces than those obtained from the oil- quenching process.

Mechanical Properties

Strength – Very high strength is achievable with the SFH process. The specific strength that can be obtained is a function of alloy content, density, etc. Ultimate tensile strengths of 150,000 to 190,000+ psi are typical at high densities.

Hardness – Indentation or brinelling resistance is a function of high macro-hardness (apparent hardness), and values of 30 to 50 HRC are obtained with the SFH process. Abrasive and adhesive wear resistance is related to high micro-hardness of the metal matrix, and values can be over 55 HRC with SFH (converted from diamond pyramid micro-hardness).

See reverse for more →

For further information on using P/M Technologies for your gear applications, call 1-248-371-0800; e-mail: info@gknsintermetals.com

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Metallurgy of Sinter Furnace Hardening

The P/M process involves heating powder compacts to a high temperature for consolidation, a step known as sintering. At the sintering temperature, the microstructure of plain carbon P/M steel is in the form of *austenite*. Slow cool from this temperature in conventional sintering furnaces produces the relatively soft microstructures of *ferrite* and *pearlite*. Some improvement in strength and hardness can be achieved by adding certain alloying elements, but major gains are not attainable.

To obtain exceptionally high strength and hardness for wear resistance, it is necessary either to oil quench the material – which is impractical in sintering furnaces – or accelerate the cooling rate within the sintering furnace. The resulting fast-cooled microstructure is known as *martensite*, which has a very high strength and hardness. A typical martensite microstructure of a sinter furnace hardened alloy P/M steel is shown in the photomicrograph (at right). Magnification is 400X.

Typical P/M gear applications using sinter furnace hardening

TTT Schematic Diagrams

Figure 1

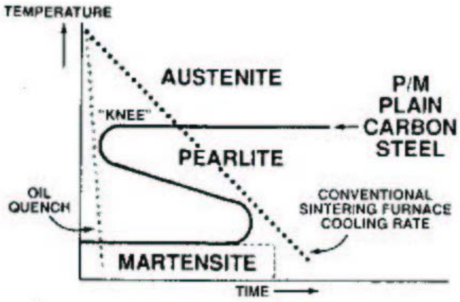
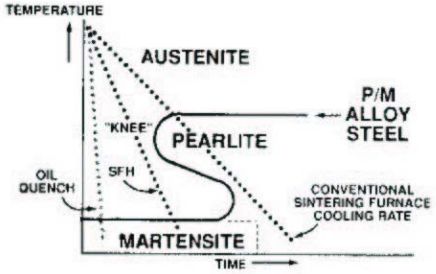


Figure 2



The SFH process can be illustrated with Time-Temperature-Transformation (TTT) diagrams, which show the changes in microstructure as a result of altering the material composition and the cooling rate of the sintering furnace (see Figures 1 and 2 at left).

Figure 1 shows why conventional sintering furnaces cannot achieve a martensitic microstructure with plain carbon jP/M steel. However, the very fast cooling rate associated with oil quenching does achieve this microstructure.

Figure 2 shows that by selective alloying of the P/M steel, the critical "knee" area of the transformation curve is moved to the right and the accelerated cooling rate of the sintering furnace permits formation of a martensitic structure—or SFH line. The resulting martensite is then tempered to optimize hardness and toughness in the same way as for oil-quenched parts.