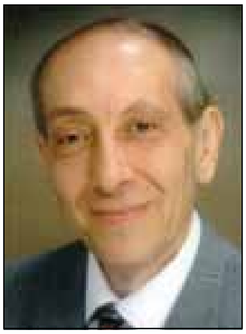
Vacuum Oil Quenching



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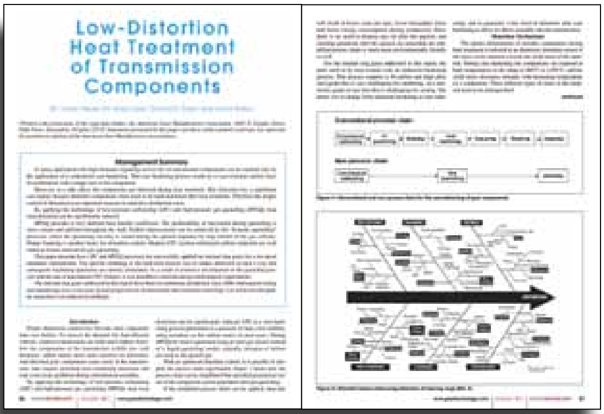

Low-Distortion Heat Treatment of Transmission Components

The October 2011 issue of Gear Technology *featured the article "Low-Distortion Heat Treatment of Transmission Components," which covered the combination of low-pressure carburizing and high pressure gas quenching in an automotive environment. Here, heat treating expert Dan Herring explains why oil quenching is an appropriate choice for many applications.*

Oil quenching is a viable alternative to high pressure gas quenching in many instances, especially for gears and other components whose cross-sectional thickness, geometry or hardenability, i.e., DI or Jominy values (*Ed.'s note: DI—ideal diameter—value; from the French phrase "diamètre idéal"*; *Jominy refers to a hardenability test for steel to determine the depth of hardening obtainable by a specified heat treatment*) indicate they are marginal candidates for gas quenching. Many components use oil quenching to achieve consistent and repeatable mechanical and metallurgical properties, as well as predictable distortion patterns. The reason oil quenching is so popular is due to its stability over a broad range of operating conditions. Oil quenching facilitates the hardening of steel by controlling heat transfer during quenching and it enhances wetting of steel during quenching to minimize the formation of undesirable thermal and transformational gradients which may lead to increased distortion and cracking. For many, the choice of oil is the result of an evaluation of a number of factors, including:

- Economics/cost (initial investment, maintenance, upkeep, life)
- Performance (cooling rate/quench severity)
- Minimization of distortion (quench system)
- Variability (controllable cooling rates)
- Environmental concerns (recycling, waste disposal, etc.)

Oil quench vacuum systems offer not only the ability to control the normal set of quench variables but, in addition, one can vary and control the pressure over the oil. This technique can extend the range of part cross-sections and materials that can be processed. In addition, the use of vacuum oil quenching has been found to reduce distortion in a wide variety of components such as gears, shafts and ball bearings. Altering pressure over the quench oil allows for a change in the boiling point of the quenchant. The position of the boiling point, i.e., "characteristic temperature," determines where and for how long the various stages of oil cooling take place. The lower pressure allows for longer "vapor blanket" stages and a somewhat long "vapor transfer" stage due to the reduced boiling point of the oil.

Distortion minimization methods have been used in combination with changes to flow characteristics (for example, some manufacturers pull oil down through the workload as opposed to pushing it upward) and oil compositions specially blended for use in vacuum having low vapor pressure oils so that they are easily de-gassed.

The design of an integral vacuum oil quench system requires considerations beyond those of atmosphere oil quenching. For example, the boiling point and vapor pressure of the base oil—as well as the accelerant additives characteristics—must be taken into consideration, along with the quench oil temperature, agitation, cleanliness, pH and viscosity. Also, the vapor pressure of the quench oil must be compatible with the selected operating vacuum level.

Finally, vacuum systems do not permit the build-up of water in the quench tanks. In a vacuum furnace system, where vacuum is used to process the work or purge the quench environment, moisture will be removed as the system is evacuated and the oil circulated. The circulated oil brings any moisture to the surface where it is vaporized and removed from the oil by the pumping system.

Reference:

1. Herring, D. H. *Oil Quenching Technology,* On-Line Exclusive, Industrial Heating, 2011.