Introduction

Metal parts often require heat treatment to obtain improved mechanical properties. A common method used is induction hardening, in which induced heat is combined with rapid cooling (also known as quenching) to increase the hardness and durability of the steel.

Heating by induction is preferred because only the part to be hardened is heated. This is a flame-free, non-contact process that quickly produces intense, localized and controllable heat. Metal induction is used to harden numerous components such as gears, power/transmission parts, crankshafts, driveshafts, torsion bars, valves, rock drills and slewing rings.

Application

Induction heating tools usually treat one workpiece at the time. The metal part is placed inside a coil (inductor) which generates a magnetic field that results in an induced alternating current in the workpiece. The coil does not touch the piece, and heat is only generated by the induced current flowing into the surface of the workpiece.

The necessary cooling is achieved by quenching. Rapid quenching is performed by spraying the workpiece with a suitable liquid medium. The quenched metal undergoes a martensitic transformation (creation of a very hard form of steel crystalline structure), increasing the hardness and brittleness of the part.

There are a number of quenchants that are used with induction heating and they are selected according to the materials being processed. Polyalkylene Glycol (PAG) is commonly preferred because it exhibits inverse solubility in water, providing great flexibility of cooling rate.

The efficiency of the quenching system is dependent on the percentage of PAG in the water. The greater the polymer concentration, the slower the quenching action and the lower the heat removal rate. Since cooling the heated workpieces causes the water to evaporate, the concentration of the quenchant must be constantly monitored. In-line measurement of the quenchant concentration is necessary for automated control to maintain the polymer concentration at the desired level and to optimize the hardening process.
Instrumentation and installation

The K-Patents Sanitary Process Refractometer PR-43-AC is installed directly in the pipe before the induction tool to monitor in real-time the concentration of quenchant. Alternatively, the refractometer can be installed in a circulation line from the quenchant storage tank.

The measurement signal by the refractometer is used to ensure the quenchant has the correct concentration before it enters the sprayer. When the concentration levels are correct, the surface properties of the finished parts are within the specifications.

The refractometer’s signal can also be connected to a process controller for continuous monitoring of the system and automated control over the concentration replenishment process.

Traditionally, handheld or laboratory Brix refractometers indicating sucrose content on a Brix scale (symbol °Bx), have been used for monitoring PAG quenchant concentrations. The K-Patents refractometer provides this same measurement capability in real-time.

The Brix reading can be converted into the quenchant concentration using a specific conversion factor for the quenchant being measured. The factor is typically from 2 to 2.5 for new PAG solutions and is typically provided by the manufacturer of the quenchant.

The K-Patents refractometer is factory calibrated and delivered for PAG applications with a Brix calibration, which is identical to the typical hand-held or lab refractometer. The measured values can be displayed either using sucrose Brix scale or the specific quenchant concentration scale, where the Brix values are multiplied by the conversion factor for the quenchant (see Technical Note 7.01.01 PR-23 Calibration for PAG Quenchants).

Due to its unique digital sensing technology, the measurement by the K-Patents refractometer is not influenced by suspended particles or bubbles.

<table>
<thead>
<tr>
<th>Instrumentation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-Patents Sanitary Compact Refractometer PR-43-AC for hygienic installations in small pipe line sizes of 2.5 inch and smaller. The PR-43-AC refractometer is installed in the pipe bend. It is angle mounted on the outer corner of the pipe bend directly, or by a flow cell using a 3A Sanitary clamp, I-clamp or Varinline® connection.</td>
<td></td>
</tr>
</tbody>
</table>

| User Interface | Selectable multichannel MI, compact CI or a web-based WI user interface options allow the user to select the most preferred way to access and use the refractometer measurement and diagnostics data. |

| Measurement range | Refractive Index (nD) 1.3200 – 1.5300, corresponding to 0-100 Brix. |