WHITE PAPER

Control Plans For Polymer Quenchants

By D. Scott Mackenzie, Ph.d., Fasm Senior Research Scientist–Metallurgy Quaker Houghton Inc.

A control plan is necessary to maintain proper process control of the fluid, including concentration, pH, and corrosion.

Polymer quenchants, whether used for immersion quenching or spray applications such as induction hardening, are much more difficult to control than oil quenchants. As such, it is important to first understand the variables involved and, second, to develop a method to make sure that the process parameters on the quenchant are maintained, and the process is in control.

Concentration

This is probably the most important process parameter to control. Failure to maintain the proper polymer quenchant concentration will result in inadequate properties (excessive concentration) or high residual stress, distortion or, potentially, cracking (low concentration).

Polymer concentration can change for several reasons. First, there is drag-out of the polymer by the parts themselves. Pockets or inadequate drain time can cause a high rate of polymer withdrawal. Remember, the polymer precipitates on the hot part, so a locally higher concentration is present at the part surface. If parts are not allowed to cool, and the polymer is not allowed to go back into solution, then high rates of polymer consumption will occur.

A second source of change in polymer concentration is evaporation of water. If it is an open bath, or tank, water can evaporate from the bath. Hot parts being processed also cause evaporation of water. This results in a higher concentration of polymer in the bath, with potential low part properties.

Refractometer: As has been indicated in previous columns, the digital refractometer is a handy method of controlling concentration. It is quick and easy to perform. It the quenchant is kept clean and the water is free from contaminants like coolant, the concentration limits can be controlled by a simple Brix range. However, in most applications, this is not a good idea. Contamination or inorganic contaminants from hard water can cause a shift in concentration, resulting in the factor to decrease. This results in a lower concentration than is expected, with the potential of distortion or cracking of parts. It is always a good idea to use the proper multiplying factor when determining the concentration by refractometer.

Viscosity: This is another method of measuring concentration of a water-polymer solution. In this test, a defined amount of fluidis entered into a small flask with a very fine capillary. The time is measured for the fluid to drop through this capillary. The viscosity is then calculated. The method of kinematic viscosity is described by ASTM D445 - Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids. This method is less prone to contamination from dissolved solids. The fluid is usually centrifuged prior to measuring the viscosity to remove any debris present. The measured viscosity is then compared to a relationship between concentration and viscosity, and the concentration determined. This is a check against the refractometer, and the reference where the multiplying factor is determined.

pH

This is a measurement of the acidity of the solution, and is a measure of the health of a system. It infers the presence of adequate corrosion inhibitor. Steel parts tend to rust when solutions are at a pH of less than 7 and have a passive film at a pH greater than 8.5. Further, biological growth is stunted as the pH is increased. Contamination, especially by chloride-containing coolants or from water containing high levels of chloride, can result in the pH dropping and rust occurring. In water, when evaporation occurs, the chloride will concentrate. Should the pH drop below 8.5, then a pH booster or corrosion inhibitor should be added to increase the pH.

Quaker Houghton
Forward Together

Control Plans For Polymer Quenchants

By D. Scott Mackenzie, Ph.d., Fasm Senior Research Scientist–Metallurgy Quaker Houghton Inc.

DESCRIPTION	PURPOSE	TEST METHOD	INTERVAL	LIMITS	RESPONSE
Concentration	Maintains proper quenching characteristics	Refractometer	Daily	Depends on application	Low – Add polymer
		Viscosity	Weekly or Monthly		High – Add DI water or tap water
pH	Monitors general health of the system. Low pH indicates contamination or biological contamination	pH-meter	Monthly	pH < 8.5	Low – May indicate contamination of biologicals. Add proper inhibitor for quenchant.
				pH > 10.0	High – Add DI water or buffer
Biological Activity	Measures bacterial or fungal contamination	Microbiological Dip slide	Monthly	Bacteria > 106 CFU/ml	Dose fluid with biocide or similar per manufacturer instructions
				Fungus > 102 CFU/ml	Dose fluid with fungicide or similar per manufacturer instructions
Corrosion Inhibitor	Verifies the presence of the corrosion inhibitor	Dip slide – Nitrate/nitrite	Monthly	Depends on application	Low – Add corrosion inhibitor
		Titration – Amine	Monthly		Low – Add amine-based corrosion inhibitor
		Titration – Biostable Amine	Monthly		Low – Add biostable amine-based inhibitor

Biological Activity

Biological activity, such as fungus or bacteria, can affect the performance of the quenchant. This doesn't necessarily affect the quenchant, but affects the quench system by clogging filters and quench spray heads. It also is a stink issue, resulting in a smell like strong mildew or "locker room smell." Occasionally, when a system is started up over a long weekend, the smell of rotten eggs from the production of hydrogen sulfide in the bath can occur.

The test for biological activity is usually a simple dip slide. The slide, containing an agar-type growth medium, is washed with the fluid, and allowed to sit for three days. Bacteria growth will be evident on one side, and fungal growth is visible on the other side. The slide is observed and visually compared to a reference provided by the dip-slide manufacturer. The levels of bacterial are usually rated from 1-11, indicating bacteria or fungus in a logarithmic scale. When the bacteria exceed 6 or 106 CFU/ml, the fluid should be treated with a biocide. If the fungus count exceeds 102 CFU/ml, then it should be treated with a spectrum fungicide. The system should also be thoroughly cleaned prior to dumping and recharging to prevent contamination of the new bath.

Corrosion Inhibitor

There are two types of corrosion inhibitors commonly used in polymer quenchants: nitrite/nitrate corrosion inhibitors, and aminebased corrosion inhibitors. Both are equally effective. However, these corrosion inhibitors should not be mixed due to incompatibility. Since most machining operations contain an amine-based additive package, amine type rust inhibitors are usually recommended for polymer quenchants. This is especially true if the parts are not washed and rinsed prior to induction hardening.

Summary

A control plan is necessary for polymer quenchants to maintain proper process control of the fluid. A generic control plan is provided in Table 1. The ranges should be determined with the help of your polymer supplier.

Should you have any comments on this article, or suggestions for further columns, please contact the writer or the editor.

Quaker Houghton
Forward Together