HOT SEAT

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Different methods of aqueous polymer concentration control

The Multiplying Factor and Delta methods are similar, effective techniques for controlling concentration of polymer quenchants by considering the level of contamination.

In this article, I will discuss the two different methods for controlling the concentration of polymer quenchants. This is applicable to either induction spray or flood type of agitation, or traditional quenching by immersion of parts.

The handheld refractometer (Figure 1) is commonly used for concentration control of polymer quenchants. The ease of use and the speed of obtaining the percent product in solution are the reasons for its popularity in the heat-treating industry. Specimens can be readily obtained and tested, and the concentration of a solution determined very rapidly. The refractometer is a good tool for the user, but the limitations of this device must be understood.

Figure 1: Typical handheld refractometers used.

The refractometer is based upon the refractive index of a solution and most handheld equipment uses distilled water as zero (refractive index = 1.3330). The scale is different for each type or model of refractometer. The most common scales are zero to 10, zero to 30, and zero to 50. There are also two types of temperature compensation, one that has automatic temperature compensation in the 60 to 100°F (15.6 to 37.8°C) range, and those that have a correction thermometer on the side of the unit.

There are two different methods to control the concentration of a polymer quenchant. First, there is the Multiplying Factor Method and, second, there is the Delta Method. Both methods are acceptable, and the ultimate choice is often a matter of which manufacturer of polymer quenchant is chosen.

MULTIPLYING FACTOR METHOD

In this method, the concentration of the product is first determined by kinematic viscosity, C_v. Kinematic viscosity is used because it is less affected by contamination. The sample is usually centrifuged prior to measuring viscosity to reduce large particulate and help reduce the contamination prior to determining viscosity. The solution is then measured by a handheld refractometer, and a refractometer reading, *R*, in °Brix is obtained. The concentration by kinematic viscosity, C_v, is divided by the refractometer reading in °Brix:

$$F = \frac{C_v}{R}$$

The multiplying factor, *F*, is then used to determine concentration at the side of the quench tank using a handheld refractometer:

$$C_R = FR$$

Where C_R is the concentration by refractometer, %; F is the multiplying factor; and *R* is the refractometer reading in °Brix.

Very clean systems see little change in their factor, while systems with high levels of contamination see major changes to this factor. The factor usually goes down as other dissolved solids add to the reading. Some contaminants have a minimal effect, such as carbon fines and most other solid, non-soluble materials. Other materials such as salts, liquids soluble in aqueous solutions, oils, and dissolvable solids

Figure 2: Typical contaminated polymer quenchant.

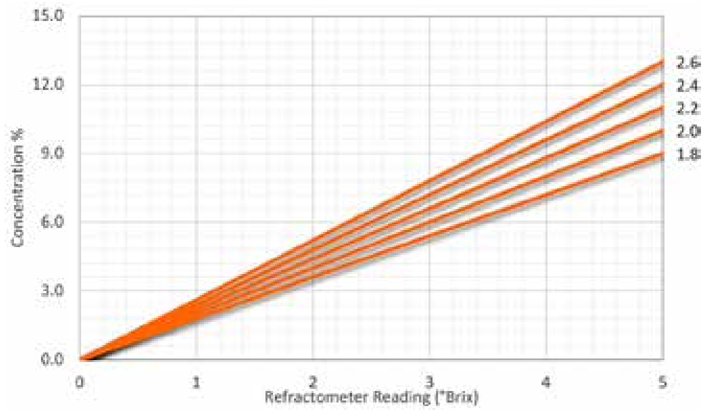

Figure 3: Typical refractometer versus % concentration based on different multiplying factors.

A good rule of thumb is that the difference in concentration be approximately one half of the factor for new quenchant.

can have a major effect on the multiplying factor.

Since the refractometer reads solids in solution it cannot differentiate between contaminate and the quench additive, therefore part of the reading will be the contaminant. It is important that the polymer quenchant be kept clean, and not contaminated with coolant, cleaners, and forming compounds (Figure 2).

Based on the results of the factor determination, graphs are put together to help the operator determine the concentration of the polymer solution based on different multiplying factors (Figure 3). When the factor exceeds a given value, the polymer is recommended to be discarded. This value depends on the amount of contamination or degradation of polymer. For PAG type quenchants, a factor of 1.5 is often used as the threshold for contamination, if the quenchant has a factor of 2.0 when new. For a PVP-type quenchant, with a new factor of 5.5, a factor of 4.5 may be used to determine if the bath is due to be dumped and recharged. However, while these factors are recommendations, they depend on the individual user's process conditions and tolerance for variation. The customer and manufacturer need to work together to establish proper and practical thresholds.

DELTA METHOD

In the Delta method, concentration is determined using the refractometer, but a fixed factor is used. The concentration is measured by handheld refractometer and the °Brix reading is multiplied by a fixed factor. This factor depends on the polymer quenchant and can vary from 2.0 for a PAG to 5.5 for a PVP-type polymer. Concentration is also measured by kinematic viscosity. The difference or "delta" between the concentration by kinematic viscosity, C_v and the concentration by refractometer, C_R, is then determined:

$$\Delta C = C_R - C_v$$

$$\Delta C = F_N R - C_v$$

Where F_N is the factor for a new solution of quenchant; R is the refractometer reading in °Brix, and C_v is the concentration by kinematic viscosity. When the difference in concentration between that determined by refractometer, and the concentration determined by kinematic viscosity is greater than some value, then the bath is recommended to be discarded and recharged.

One problem with this method is that the difference in concentration, ΔC, varies with use concentration. For instance, the difference in concentration for induction hardening is more critical than for immersion quenching of large parts. The difference in concentration must be determined for each application. A good rule of thumb is that the difference in concentration be approximately one half of the factor for new quenchant. Alternatively, the difference in concentration between the concentration by viscosity and the concentration determined by a fixed factor and refractometer should be no greater than 25 percent for a PAG type quenchant, and 10 percent for a PVP type quenchant. While this is conservative, and is applicable to new quenchants, it should be determined for each process, and levels of contamination expected for each process. Again, it is necessary for the customer and manufacturer to work together to establish the proper criteria for bath maintenance.

CONCLUSIONS

The two methods described here for controlling the concentration of polymer quenchants are similar, in that the methods look at the level of contamination or degradation of a polymer to determine effective concentration of the bath. Each is an effective method of controlling the concentration of a polymer quenchant.

Should there be any questions regarding this article, or suggestions for future articles, please contact the author or the editor.

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