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Determining concentration and required amounts

Some quick calculations will determine how to fill the quench tank as required and keep it at the proper concentration.

In this column, I will discuss how to calculate the required amounts of quenchant in a quench tank. This method is also applicable to other fluids such as coolants, cleaners, or corrosion inhibitors.

INTRODUCTION

In the heat-treating shop, we often use water soluble quenchants or cleaners to either quench our parts or to clean them. Water-based coolants are used in the machine shop. Water-based corrosion inhibitors are used throughout the manufacturing process. Based on questions that I have had recently from salespeople, and from customers, I think that a basic review of calculating concentrations and determining the amount required for make-up would be helpful.

DETERMINING CONCENTRATIONS

DETERMINING PURCHASE AMOUNTS AND INITIAL FILL

Let's assume for a minute that I have a polymer quench tank for heat treating aluminum sheet. There is the quench tank, piping to the heat exchanger, and return piping from the heat exchanger. The quench tank size is 1,600 gallons, and my governing specification requires me to use 18 percent polymer quenchant. The first thing I need to do is to sum all the fluids — the quench tank capacity, the volume in the heat exchanger, and the amount in the piping to and from the quench tank. This is accomplished by a review of the engineering drawings of the equipment and installation. For the sake of argument, the total fluid volume is 1,940 gallons. The specifications require that the concentration of the polymer quenchant for quenching aluminum sheet is 18 percent. The next question to ask is whether the concentration is by weight or volume?

Concentration by weight and concentration by volume are different calculations and can confuse things. Generally, a laboratory will use concentration by weight, and a manufacturing shop will use concentration by volume. The laboratory uses this method because it is more accurate, and the manufacturing shop uses this because it is easier.

For the purposes of this discussion, assume that the concentration required is 18 percent by volume. How do we know how much to buy to fill our quench tank?

Since the required concentration is 18 percent and our total fluid volume is 1,940 gallons, the required amount is:

$$T = V\left(\frac{\%C}{100}\right)$$

$$T = 1940\left(\frac{18}{100}\right) = 349.2\ gallons$$

In this instance, the quench tank will require a total of 349.2 gallons of polymer quenchant, and 1,590.8 gallons of water.

After filling the tank with water and polymer quenchant, you verify the concentration by measurement and adjust accordingly.

THE CONCENTRATION IS LOW

Let's assume that I have an induction hardening machine with a total fluid volume of 450 gallons, and the Quality Department has noticed that the parts are getting harder than normal after quenching. The required concentration to get good parts is 7 percent by volume. After either measuring the concentration in-house or sending a sample to the quenchant supplier laboratory, the laboratory comes back and says that the concentration is actually 4.2 percent instead of the required 7 percent. How much quenchant is needed to bring the concentration back to my required amount?

Using the previous equation, the total amount of polymer that should be present in my quench tank is:

$$T = V\left(\frac{\%C}{100}\right)$$

$$T = 450\left(\frac{7}{100}\right) = 31.5\ gallons$$

But if I really have a concentration of 4.2 percent instead of the required 7 percent, how much polymer quenchant is present? Again, a calculation is performed:

$$T = V\left(\frac{\%C}{100}\right)$$

$$T = 450\left(\frac{4.2}{100}\right) = 18.9\ gallons$$

Now the quench tank is supposed to have 31.5 gallons in the system, but only 18.9 gallons are actually present. The system needs to have 12.6 gallons (31.5-18.9 = 12.6) of polymer quenchant added to the quench tank.

THE CONCENTRATION IS HIGH

The situation when the concentration is high requires a bit more calculation to get right. Assume that I have an induction hardening system for hardening gear teeth such as in the instance above. I am supposed to have a concentration of 7 percent, but the laboratory measured a concentration 10.5 percent and my parts are not seeing the proper depth of case, and the hardness is low. The system capacity is 450 gallons. The quench tank needs to be adjusted to the proper concentration.

In this case, the calculation again, but with the existing amounts:

$$T = V\left(\frac{\%C}{100}\right)$$

$$T = 450\left(\frac{10.5}{100}\right) = 47.25\ gallons$$

From the calculations above, the proper amount of polymer quenchant in the tank should be 31.5 gallons, but there are 47.25 gallons

of polymer present. The system needs to remove 15.75 gallons (47.25-31.5 = 15.75) of polymer. It is not possible to selectively remove just the polymer from the quench tank since the polymer is thoroughly mixed in the tank. We must remove the equivalent of 15.75 gallons of polymer from the quench tank.

The equation is used again, but with just the quenchant to be removed:

$$T = V\left(\frac{\%C}{100}\right)$$

$$15.75 = V\left(\frac{10.5}{100}\right)$$

Rearranging:

$$V = \frac{T}{\left(\frac{\%C}{100}\right)}$$

$$V = \frac{15.75}{\left(\frac{10.5}{100}\right)} = \frac{15.75}{0.105} = 150\ gallons$$

We must remove 150 gallons of quenchant mixture from the 450-gallon quench tank to get the concentration right. After the 150 gallons is removed, the solution remaining still has a concentration of 10.5 percent. Verifying that the polymer remaining is right, we do the calculation again, but with the new volume:

$$T = (V_i - V_r)\left(\frac{\%C}{100}\right)$$

$$T = (450 - 150)\left(\frac{10.5}{100}\right) = 300 \times 0.105 = 31.5\ gallons$$

Now the proper amount of polymer is present in the quench tank, and 150 gallons of water is added to the system. The system is now at the required capacity of 450 gallons, at the proper concentration of 7 percent.

As always, the quench tank should be remeasured and verified that the proper concentration is present, after adjustments have been made.

CONCLUSIONS

In this article, I went over the proper method of determining the amount of quenchant required in a quench tank to achieve the proper concentration. In the event that the concentration is low in a quench tank, the proper method of determining the proper amount of polymer quenchant to the quench tank was illustrated. A method was also shown to determine the amount of quenchant to be removed from a quench tank (and then adjusted with water) when a high concentration of polymer quenchant is measured.

Should you have any questions regarding this column, or suggestions for new columns, please contact the editor or myself.

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