

Best of Both Worlds in Polymer Quenching

“The success of most heat-treating processes comes down to the battle between time v. temperature...” In this white paper, Jerry Dwyer of Hubbard-Hall describes innovative heat-treating practices with organic polymer quenchants.

If you are interested in learning what these polymer quenchants can do and want to know specifically how a high-performing polymer reacts in the quenching process, read on for the details from a specific case study. Between time and temperature, you may get the best of both worlds.

The success of most heat-treating processes depends on the battle between time and temperature, better known as isothermal transformation. The delicate balance between how long it takes to quench a part and at what temperature often depends on which media is used to do the quenching.

Water and oil have been the go-to solution for quenching heat-treated parts to harden them to proper specifications for decades. Water has the highest cooling rates (between 2,000°F/sec to 10,000°F/sec), which often leads to high distortion rates in parts and more cracking because of the high residual stresses. Oil-based solutions have been used extensively in the metalworking industry on larger, thicker parts because it has three cooling speeds: slow for lower hardness and less distortion, medium for when moderate to high hardenability is needed, and high for carburized and carbo-nitriding part applications.

But with increasing concerns about environmental disposal and safety, many heat treaters have been searching for an alternative quenching technology that meets their needs. With water and oil so prevalent, industry researchers developed a hybrid of the two to create a series of polymer quenchants that serve numerous functions and also reduce some concerns.

Development of Polymer Quenchants

The polymer quenchants contain organic inhibitors and other additives that produce concentrates, which are diluted for use. The advantage of polymer solutions is that they have widely variant properties, giving heat treaters flexibility in how they use the product compared to water or oil. They are also non-flammable, which eliminates the need for operators to install needed fire suppressant equipment that might be needed with other quenching methods.

Several different types of organic polymer quenchants exist, including polyethylene glycol (PAG), sodium polyacrylate (ACR), polyvinyl pyrrolidone (PVP), and polyethyl oxazoline (PEO).

The polyalkylene glycol (PAG) polymer is one of the most widely used in the heat-treating industry and provides an ideal uniform cooling for minimizing distortion and preventing crack formation during hardening machine components and tools. Scott Papst, vice president of specialty sales and business development at Hubbard-Hall, says that many customers have inquired about adding a polymer quenching alternative to their process.

“The technology of the polymer process has grown tremendously over the years, and we wanted to make sure we had that technology in their hands,” Papst says.

Partnership with Idemitsu Grows Offerings

Hubbard-Hall, which has a line of several heat-transfer and heat-treat salts for annealing, martempering, isothermal quenching, and other applications, began to look for a partner company to supply its customers with polymer quenchants and set its sights on Idemitsu Kosan Co., a Japanese energy company that owns and operates oil platforms and refineries and manufactures numerous petroleum, oils, and petrochemical products.

“We found Idemitsu to be a wonderful partner which has a tremendous focus on advanced technology, especially when it came to heat treating,” Papst says. “We were very happy when we could put together a partnership to offer their polymer quenches to the U.S. market.”

Polymer quenches are used primarily in an “induction hardening operation.” An electric current is put through a copper coil to create a magnetic flux that heats up the target section of the part. Induction hardening uses a shorter time to harden the targeted section of the part instead of using an atmosphere furnace to heat treat the entire part.

Where salt quenches are used to heat treat an entire part, the polymer quenches can be targeted to certain areas of a parts, such as gear teeth. Greg Steiger, a senior key account manager for quench products at Idemitsu, says polymer quenches work great on parts like gears because it treats the most vital sections of the part.

“A gear has to be hardened because it needs to withstand a lot of wear-and-tear; but the teeth take the brunt of the load when the part is in use,” Steiger says. “The teeth of the gear have to be harder than the rest of the part; if the entire gear was as hard as just the teeth, then that part would fracture and shatter.”

Benefits of Inverse Solubility

Polyalkylene glycols utilize inverse solubility in water; while they are completely soluble at room temperature, they become insoluble at higher temperatures from 140°F to 195°F, depending upon chemical structure. Inverse solubility controls the cooling and quenching mechanism. The ability to vary the concentration of a polymer quench provides great flexibility of the cooling rate. The polymer separates from water as an insoluble phase, and the ensuing deposited layer becomes as an insulator that determines the rate of heat extraction from the quenched part.

“The polymer slows the cooling compared to water, and controls the heat treating process” Steiger says. “The transformation rate is much more controllable, which makes the heat treating more tailorable to the part.”

Idemitsu’s high-performance polymer quenchant is its Daphne Plastic Quench HF, which has excellent oxidation stability performance that protects the integrity of the quenchant even after contamination by metalworking fluids. Steiger says Daphne Plastic Quench HF virtually eliminates the formation of sticky films common in most quenching polymers, which reducing the amount of drag out and thus reducing consumption.

“It is formulated to provide superior biocidal protection, preventing bacterial contamination in the recirculating induction hardening systems,” he says. “It also offers outstanding rust and corrosion prevention to better protect quenched parts. It is highly resistant to degradation.”

Lower Viscosity, Improved Efficiency

The Daphne Plastic Quench HF has a viscosity (at 104°F/40°C) of 29.5 mm²/s, which bests its two top competitors at 536.1 and 301.7. The lower viscosity improves handling and production efficiency, and also reduces or eliminates sticky build-up on machines, gauges, fixtures and parts.

The product also has excellent rust preventative properties and is thermally stable. In fact, Steiger says, testing with a Tier I parts supplier who was having rust issues with a competitor’s product showed that Daphne Plastic Quench HF has stable cooling performance after six months of use, and they only recharged their system twice in a year, reducing consumption by over 66%.

Further, when a global automotive OEM switched to Daphne Plastic Quench HF from a competitor, the result was better separation from tramp oils. The previous product was causing unstable cooling performance that resulted in



cracks on the parts; it turns out the OEM was dumping machines and recharging every three months because tramp oil contamination become more than 5%.

“The actual quench oil usage by the OEM was reduced by up to 75% after just four months, and their sump life was much longer at more than six months,” Steiger says. “Lower concentrate usage and a significant reduction in residue directly correlates to improved productivity, reduced maintenance costs and lower disposal costs.”

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