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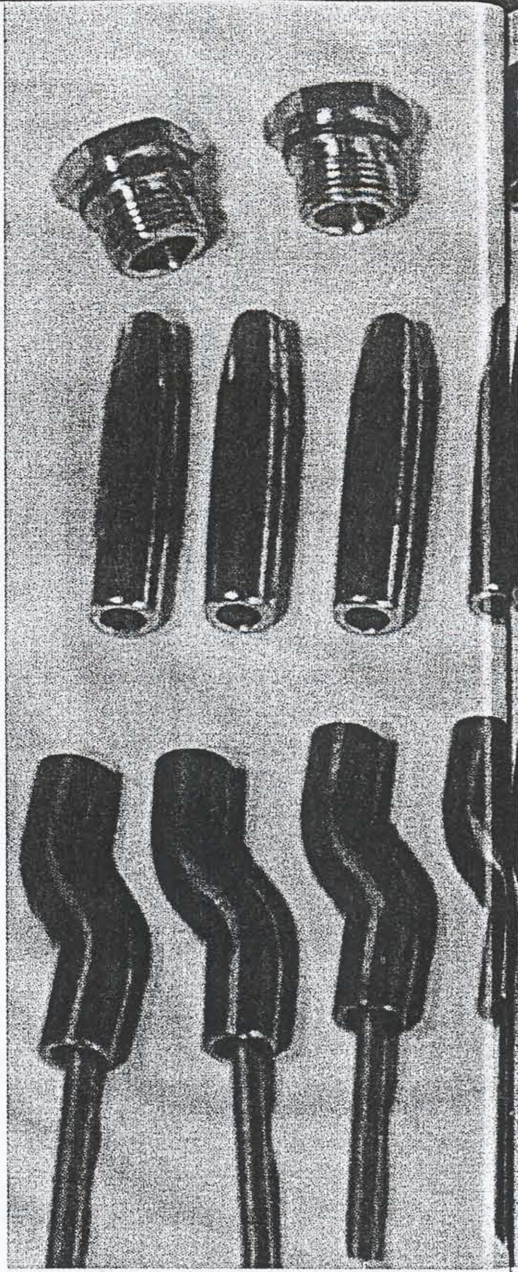
PRACTICAL WELDING TODAY®

CRYOGENIC TREATMENT for SPOT WELDING TOOLING



Finding appropriate applications through time and testing

Cryogenics is the science of subjecting materials to temperatures below 70 degrees F. There are two forms of cryogenics: shallow and deep. Shallow cryogenics typically subjects materials to temperatures no lower than -110 degrees F. Deep cryogenics normally subjects materials to temperatures as low as -430 degrees F, depending on the application. Deep cryogenics is used to effect crystal restructuring and molecular enhancement of materials.

This article addresses deep cryogenics and how it improves the physical properties of metal, primarily copper alloys, used in resistance welding tips and tooling.

The normal cryogenic process as it is practiced today normally takes 30 to 40 hours, including heating at the end of the process. However, many cryogenics processing machines, as well as practitioners, may not heat the material at all.

The use of cryogenics on spot weld tips and tooling is not new. In the late 1970s and 1980s, when this application was first introduced to the resistance welding community and the majority of development work was performed, the results were sometimes extraordinary and other times disappointing and very inconsistent.

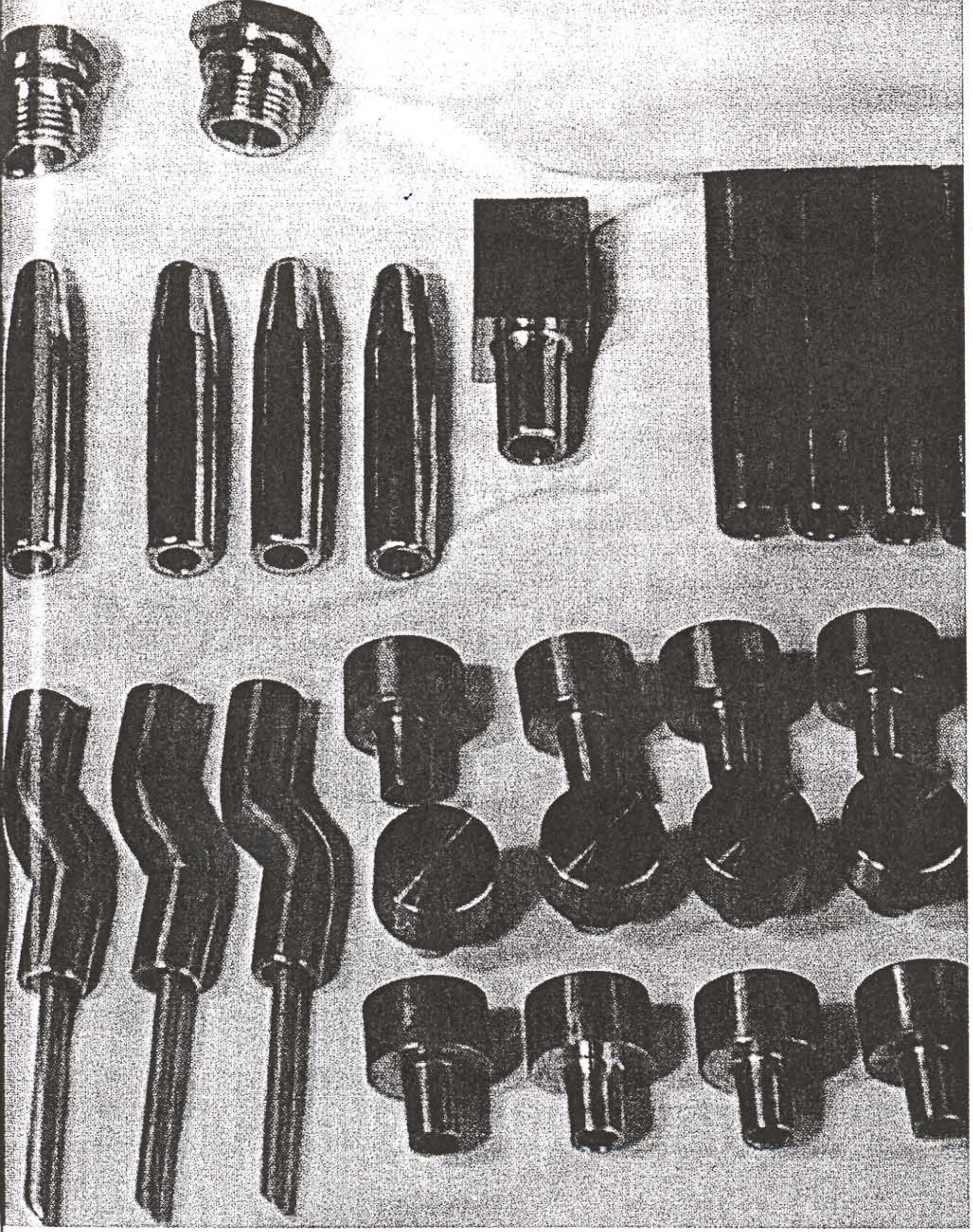
Since then, refinements to the process, the development of microprocessor-controlled cryogenics processors, advanced thermocouple design, and computer software with next-generation cryogenics chambers have helped make results more consistent and reliable.

For instance, microprocessor controls enable the temperature of the material treated to be lowered slowly and precisely to -300 degrees F (at which it is held for up to 40 hours) and then slowly and precisely raised to between 300 and 400 degrees F and returned to ambient temperature. The complete process can take up to 40 hours, which generally includes the heating time.

One of the vital factors in the cryogenic process is precise temperature control during the critical phases of lowering it to -300 degrees F. Before microprocessor controls, nitrogen or helium was introduced manually by opening and closing a valve. This led to an inconsistent temperature decrease rate, which led to inconsistent results.

In effect, two identical parts treated at different times would not be altered in the same way. The reason for these inconsistent results was that lowering the temperature too quickly did not allow for the complete restructuring of the part's molecular structure.

For instance, a portion of a part might



Deep cryogenics can improve the physical properties of metal, especially copper alloys used in resistance welding tips and tooling, by effecting the crystal restructuring and molecular enhancement of materials.

have a completely restructured crystal grain, while another portion of the same part might have only a 70 percent restructured crystal grain. This resulted in varying physical properties within the same part, and sometimes the part performed worse than if it had not been treated at all.

This is the main reason that some people had negative opinions about cryogenics. Sometimes it worked, and sometimes it did not. Now, however, microprocessor controls enable a cryogenics machine to control the temperature to 1/10 of 1 degree F, thereby providing the necessary rate of temperature descent/ascent to achieve consistent, repeatable results.

Because of their physical, thermal, and electrical properties, the copper-based spot welding caps, tips, and tooling used today can benefit from cryogenic processing. Cryogenic processing of copper-based alloys for spot welding increases density, electrical conductivity, thermal conductivity, and toughness. It also refines and realigns the micrograin structure of the tooling.

How the Process Works

Tooling is arranged in the processor to allow the cooling agent to circulate around the parts. Parts may be wrapped in aluminum to allow for a more consistent and uniform penetration of coldness, and release of heat and coldness.

Once the parts are placed in the cryogenic chamber, the operator selects the load variables from the microprocessor control and pushes the start button. The microprocessor takes over and controls the flow of the cooling agent into the chamber where the liquid is contained, and the boil-off vapor is spread throughout the chamber. This is referred to as a dry process because the parts being treated do not come into contact with liquid nitrogen or helium. The parts are cooled with gas. Nitrogen gas has zero humidity and therefore is dry.

Some cryogenic processors actually submerge or dip the parts being treated directly into liquid nitrogen or liquid helium from ambient room temperature. The result is a part that is thermally shocked, causing microfractures and material stress. This is another reason that cryogenics sometimes has gotten a reputation for inconsistent results.

Effect on Material Structure

Cryogenics is not a substitute for heat treating; instead, it simply adds the finishing touch to the heat-treating process. It completes the austenite-to-martensite conversion in tool steel and precipitates a fine molecular crystal lattice structure in the nickel and chromium of the copper-based spot welding alloys.

In addition, cryogenics allows the copper matrix to reorganize into a more uniform and compact micrograin structure, which has a homogenizing and stress-relieving effect. Scientists speculate that the increase in electrical and thermal conductivity is due to the realignment and uniformity of the copper matrix.

While at cryogenic temperatures, the

electrons of the copper and alloying material slow down. This allows the material to eliminate microvoids and microcavities and return to the natural, uniform crystalline structure while forming much stronger molecular bonds.

The process also can be used to release or relieve internal stresses caused by casting, extruding, forging, stamping, cold heading, machining, etc. The changes resulting from one treatment are permanent and penetrate completely through the materials, so these properties cannot wear off or be broken down. If metal with an applied coating undergoes cryogenic processing, the molecular bonds between the base material and the coating are strengthened, helping to make the coating tougher.

Evaluation Procedures

Follow these steps to evaluate cryogenics or any process that extends electrode/tip life:

1. Document the number of welds that a specific spot weld application gets before the electrodes/tips need to be dressed.

2. Document the amount of material that is removed during dressing to return the electrode/tip to acceptable weld face specifications.

3. Document how many dressings an electrode/tip lasts before it has to be discarded. Then, repeat the same procedure with an electrode/tip that has been cryogenically treated. Do not assume that the electrode/tip that has been cryogenically treated needs the same amount of material removed as the untreated one. The amount of material that needs to be removed from a treated tip is usually less than one-half that of an untreated tip.

4. Subtract the total number of welds performed by the untreated electrode/tip from the number of welds performed by the cryogenically treated tip.

The cryogenically treated electrode/tip will offer more savings in changeover times and extended electrode life if it has more dressings per life and makes more welds per dressing than the untreated electrode/tip.

Even wear on treated caps, tips, and tooling allows the user to remove less material while dressing them to specifications. In one case involving Resistance Welder Manufacturers' Association (RWMA) Class III material, average life per tip increased from five days to 22 days. The user removed 0.003 to 0.005 inch of material per dressing, compared to 0.008 to 0.010 inch before treatment. The average dressings per tip increased from five to 10.

In another case, a fabricator of stainless steel assemblies in York, Pennsylvania, used a very small-diameter RWMA Class II chrome copper electrode and achieved 90 to 100 welds per electrode. After cryogenic treatment, the number of welds per electrode increased to 420 to 450.

Of course, every application is unique, and the benefits for each one are application-specific. This means that no blanket predictions can be made or previous results used to guarantee the same results for every operation. Each one has to be tested.

Evaluating Applications

Cryogenic treatment of spot welding caps, tips, or tooling must be performed by a reputable processor and the benefits of a specific application evaluated. The evaluation process is very critical. If the user puts the treated items into general stores and does not monitor and track the test items closely, failure and bad data are guaranteed.

The dry cryogenics process is good for preliminary testing because it has the smallest chance of thermally shocking the material being treated. While the material reaches deep cryogenic temperatures, it never contacts the liquid nitrogen directly.

The parts, tooling, and welding machine to be tested determine the type of test to use. For instance, a treated welding electrode and an untreated welding electrode can be tracked for life and their life spans and wear compared to evaluate the benefit, if any, of treating the part with cryogenics.

Cryogenic Processing as an Option

Cryogenic processing is emerging as a new science, with more and more equipment and service providers entering the marketplace. For some spot welding applications, the process can help improve tooling performance. With the proper investment in time and testing, cryogenic processing can be a potential cost-saving treatment. ●