Controlled shot peening eliminates corrosion

Shot peening has long been used to prevent stress corrosion cracking of metal parts. A new method eliminates intergranular corrosion, too.

The basic advantages of shot peening are well known. But engineering and monitoring a shot peening procedure for a particular component is a task requiring experience and background of a highly sophisticated nature. No two assignments are exactly alike.

However, this procedure is a lot cheaper and easier than redesigning a part to prevent corrosion failure of the equipment.

Metal Improvement Co., subsidiary of Curtiss-Wright Corp., Carlstadt, N.J., specializes in controlled shot peening to prevent stress corrosion cracking, intergranular corrosion and fatigue failure.

"Intergranular corrosion and stress corrosion have very different causes," states Gerald Nachman, president of Metal Improvement. "The approach to prevention of each is somewhat different.

"We peen the surface in both cases, but the peening media is different as are all the other peening factors."

Susceptibility to intergranular corrosion in alloy steels such as Type 304 stainless results from depletion of chromium at the grain boundaries at temperatures between 1000° to 1500°F.

This is referred to as sensitizing of the metal. Loss of chromium in the surface layer means loss of resistance to corrosion. Cracks originate at the susceptible grain boundaries.

What actually happens is that, in the sensitizing temperature range, one component precipitates as a carbide into the grain boundaries. The sensitizing range coincides with the service temperature range of much of today's processing equipment.

Fabrication of equipment also usually involves welding which acts to sensitize the metal in terms of intergranular corrosion.

For example, a stainless steel pressure vessel could be subject to intergranular corrosion for the reasons stated.

"To prevent this," comments Mr. Nachman, "we would peen the surface at a high intensity to greater than 100 pct coverage, thereby breaking up the surface grain boundary continuity so to speak, so that chromium carbide precipitation occurs in the surface layer and is locked in.

"But this intense peening also happens to prevent stress corrosion cracking which is an entirely different mechanism," he added.

In what ways are they different?

Stress corrosion cracking can occur in a susceptible metal or alloy and it has nothing to do with temperature sensitization.

Gerald Nachman

"Procedures must be developed for each part."

It is essentially caused by residual surface tensile stress, induced by ordinary manufacturing operations such as grinding, drilling, threading, welding, shrinkfitting and bending, plus a corrosive environment.

The surface tensile stress creates weakened grain boundaries which are where the corrosion starts. The residual surface stress causing the trouble cannot be measured or predicted in any way.

What controlled shot peening does is to change the surface tensile stress to residual compressive stress. Stress corrosion cracks cannot originate in a compressively stressed layer.

Mr. Nachman points out the differences in dealing with stress corrosion and intergranular corrosion.

"Controlled peening relates to proven procedures we use to prevent stress corrosion and fatigue failure. Breaking up a surface grain structure to prevent intergranular corrosion is a somewhat different proposition, requiring severe impacting densities."

Of course, stress corrosion and intergranular corrosion can occur together, each for its own different reason.

The result of such dual action is a more intensified corrosion problem and one that's all the more tough to solve unless one is fully aware of the origins of the different corrosion processes.

"Uniform depths of induced compressive stress can only be obtained under controlled conditions that produce uniform and consistent coverage. Procedures and test strips must be developed for each part and properly documented to insure repeatabil-

ity," Mr. Nachman says.

"The machines we have to do this work are specially designed by us and automatically assure exact repeatability of all parameters. Some machines are numerically controlled," he continues.

Actually, a peening project is an engineering assignment at Metal Improvement Co.

Tests are first run on the particular item to determine the correct intensity, shot or bead size, peening angle and distance necessary to obtain the desired surface properties.

Many test runs are made. Masking procedures are determined.

The company owns and operates its own equipment; it does not sell the equipment to customers but rather processes parts at its own locations. Metal Improvement has ten facilities in the United States and two overseas.

In addition, special equipment has been developed for controlled shot peening in the field and this is now done as a matter of course where a large installation is constructed at the job site or where equipment has been installed and shot peening is an afterthought.

Recently, Rockwell International Corp., Canoga Park, Calif., announced that they had licensed Metal Improvement Co. to use the Rockwell-patented technique for preventing intergranular corrosion in metal alloys.

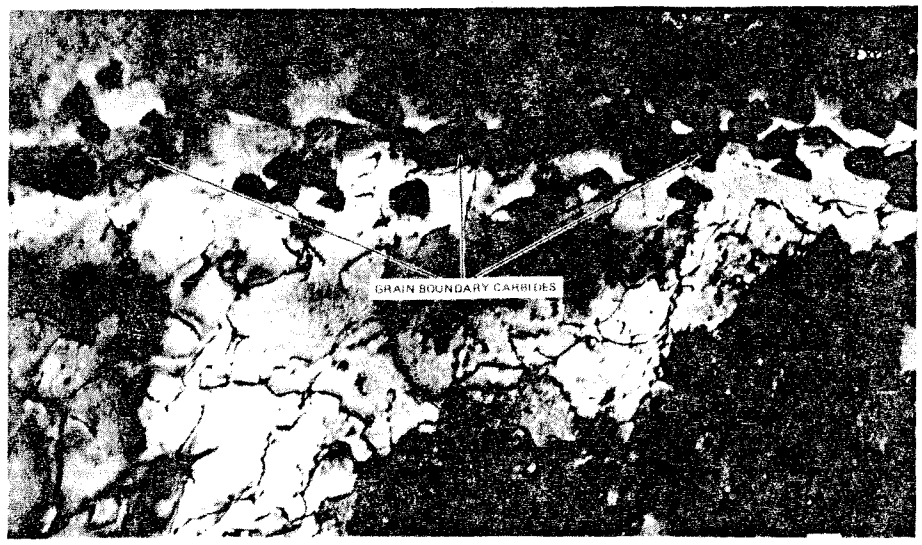
The technique, discovered by scientists at Rockwell's Atomics International Div., is an adaptation of commonly used shot peening processes which increase the fatigue life and prevent stress corrosion cracking of metal parts.

Rockwell's process prevents both types of corrosion damage.

Does shot peening really constitute a major approach to solving the corrosion problems of industry?

Controlled peening is a significant approach to the corrosion problem, but, as is obvious, corrosion is being dealt with in many other ways also.

Peening does not help prevent certain types of corrosion. Peening has its advantages; other methods have theirs. Most other methods, however, involve changing the design and/or the material of construction. Shot peening deals with a product as it is, leaving the design unchanged. It treats the surface only and is really not a very expensive approach comparatively.



Electron micrograph of unpeened Type 304 stainless steel, sensitized for 24 hours at 1250 F shows how carbide particles have been precipitated along the grain boundary.


The same surface as shown above, but after shot peening. Notice that the carbides are precipitated randomly throughout matrix without preference for grain boundaries.

To date, Metal Improvement Co. has done successful shot peening to prevent stress corrosion on the following metals: Copper silicon alloys; stainless steels 316, 321, 347; Inconel 600 and 802; pipe ID and OD; Inconel tubing straight and U-bent; also all types of bent and formed tubing up to ¾ in. diam; and high-strength steels.

Shot peening to prevent intergranular corrosion has been successful on stainless steel 304.

One example of shot peening a 220T4 aluminum casting to eliminate stress corrosion cracking shows its usefulness. A total of 12 specimens, 1 to 4 in. thick, 1 to 2 in. wide and 8 in. long were divided into two groups for accelerated tests and for standard atmosphere tests.

Specimens were shot peened all over and stressed to 90 pct of yield approximately 35,000 psi.

Results of the accelerated tests: Unpeened specimens lasted 3, 6, and 8 minutes, respectively. Peened specimens lasted 24, 41 and 280 hours; in fact the latter sample did not fail even after 280 hours.

In standard atmosphere tests, unpeened samples failed after 5 days; peened samples lasted 52 days, 142 days and one sample is still on the roof where tests were conducted. It's been there since 1956.

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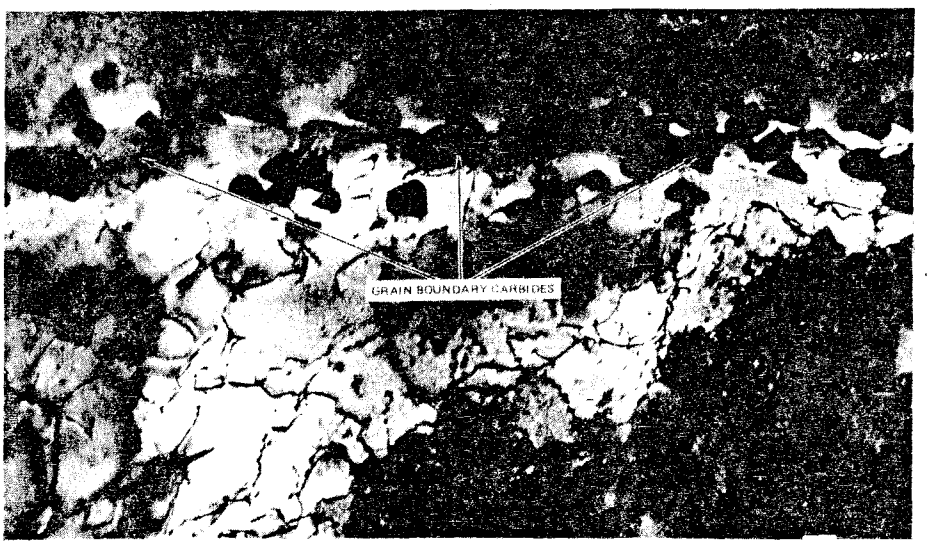

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