



Canadian Welding Association

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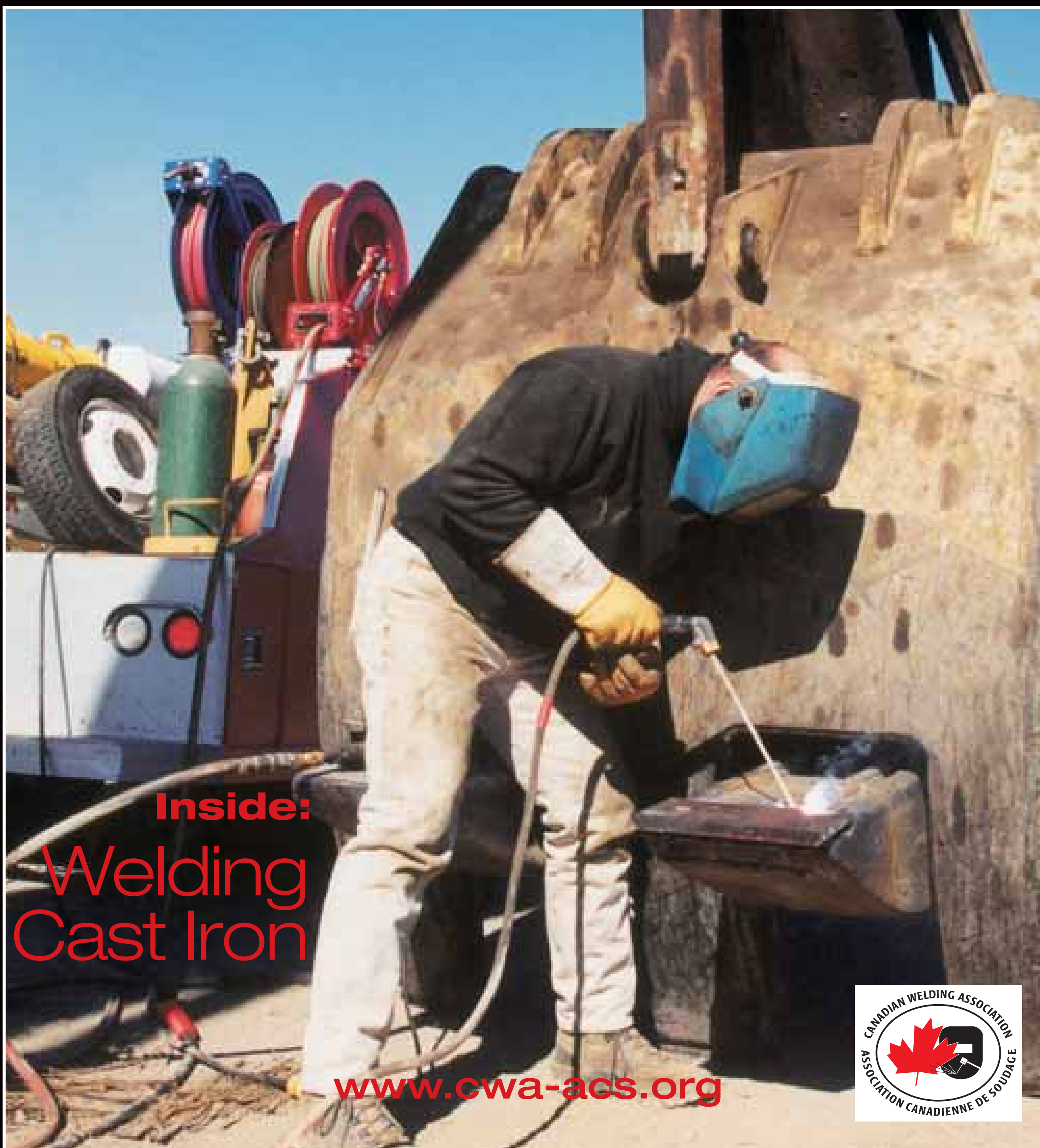

Inside:

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Considering a Repair Weld?

By Dave Jauhal

In addition to all of the factors normally associated with creating a successful weld, there are often many sometimes-obscure factors to be considered and overcome in creating a successful repair weld.

Many factors required by a finished component's end use will create additional and unique considerations. Other considerations may seem like common sense, but are often overlooked.

Determine the Initial Cause of Failure

Ask yourself: What caused the failure that has necessitated a repair weld?

This seems obvious, but in many cases it is overlooked in the haste of attempting to return a component to service. Often we are asked the percentage of success anticipated from a repair weld. Our first query in return is checking to see if the cause of the failure has been determined and rectified; if it has not been, further component failure is generally inevitable. Typical causes of failure in the manufacturing industry that we may encounter on any given day range from the very simple and straightforward to the complicated.

Fully automated MIG weld refurbishment of internal pipe thread

Weld restoration of D-2 metal-stamping punch

Some simple root-cause examples include:

- accidentally driving a towmotor into a machine tool;
- mishandling of machine tools as they are being relocated;
- machining errors (too much material removed from the manufacture of a component for a multitude of reasons).

Breakdowns become a bit more complicated as:

- older machines are upgraded with more-efficient hydraulics and electronics; often the existing cast iron, steel or aluminum structures were not designed to cope with the increased loads from increased output demands;
- seal and bearing failures cause damage to shafts and housings;
- malfunctioning sensors allow more than one metal blank into a press die.

Repair-weld solutions can become increasingly complicated in wear, impact, high/low temperature and corrosive environments. Such examples include:

- parting line edge wear on plastic injection moulds;
- pump and valve component wear (erosion, cavitation, corrosion and impact);
- scoring, chipping and cracking of tool-steel components.

Whatever the weld-repair requirement may be, the solution must begin with determining the root cause that requires weld-repair consideration as a viable option.

The next consideration prior to embarking on a repair weld is identification of the base material. Again, this seems obvious, but in reality the material is often mistakenly identified, which greatly diminishes the success of a weld repair. There are many methods of determining what the material may be or, at the very least, finding clues to what type of material it is. Without a good idea of what the base material is or knowledge of the root cause of failure, your decision about how to create an effective weld procedure will be a gamble. Luckily, in the manufacturing industry, most metal- or plastic-forming tool steel or iron is identified, with the name of the material scribed, machined, stamped or cast into it (very common examples include D-2, A-2, H-13, P-20, M-2, GM 190, and GM 246.) If you're not able to locate positive identification on the component to be welded, other methods to identify the base material include:

Chemical Analysis:

Remove a small amount of material (drill cuttings) from the component and send it to a laboratory for chemical analysis. In our opinion, for any major repair, this is a must and the cost is a bargain. It usually takes a couple of days to get results. Have them compare the analysis with a known standard, if possible.

Drawing Specifications:

Check with original engineering drawing specifications, if possible. Always verify a drawing specification with a second method of identification if there is any doubt at all.

Magnetism:

Is the material magnetic?

A non-magnetic material could be:

— an austenitic stainless steel
— a manganese steel
— an aluminum alloy
— a magnesium alloy
— a copper or copper alloy

Hardness:

A hard steel generally indicates that it has been and can be subjected to heat treatment. Generally, a higher carbon content will also be present.

Micro TIG repair using 0.007" wire on an H13 injection mould block

Weight:

A lighter weight may indicate, for example, magnesium rather than aluminum, or cast iron rather than steel.

Spark test:

By grinding an area of the material, one may be able to determine from the sparks what family of material it belongs to. To aid determination, compare the sparks with those of known materials and/or a spark chart identifying different configurations of sparks to base materials.

Colour:

Colour can be an additional clue in identifying the group to which a material belongs (e.g., copper, brass, bronze, aluminum alloy, stainless steel).

Without base-material identification, a successful weld repair is unlikely.

Considering a Weld Procedure

A successful repair-weld procedure must first address the peculiarities of the component's end use, coupled with the amount of time available to complete a repair. Because the majority of incidents in manufacturing that necessitate a weld repair are not planned, time is always of the essence, and is often a major detriment reducing the full benefit of a weld repair.

Time issues often compromise proper preheat and post-weld cooling and/or heat treatment. Daily, we ship hot weld-repaired components to customers who insist on having them back immediately. The components are insulated and plastered with warning labels emphasizing the benefits of slow cooling and the negative repercussions of rushing the process.

There are many other issues that will compromise a weld repair that are dictated by the component's end use. Distortion control is often critical. It doesn't matter how good the weld is, if the welded part becomes distorted and cannot be put back in service. Distortion can be caused by such simple errors as overheating a tool-steel component and causing it to grow in size. If the component is a metal punch, it will no longer fit the die and will, therefore, not function without being completely reworked.

Another example could be distortion of a shaft repair weld. The weld may be sound, but if the shaft becomes unacceptably distorted and cannot be straightened, the weld is of no value.

Preheat, Interpass Temperature and Post-heat Are Also Dictated by End Use

Preheat is useful when welding heavy aluminum components, in order to slow heat conductivity surrounding the weld puddle. However, too much preheat will soften and weaken the aluminum. Preheat and accurate interpass temperatures are necessary when welding hardened tool steel. Most repair situations, however, require that the welded component be returned to service immediately without time for post-weld heat treatment.

Therefore, care must be taken in the weld procedure not to exceed draw temperatures critical to the component's end use, while at the same time, minimizing the heat-affected zone. On plastic injection-mould tool-steel components, critical end-use considerations not normally associated with weld procedures may often include discolouration of a polished mould. (To restore a mirror finish on some plastic mould surfaces can take days.) Therefore, optimum welding preheat and interpass temperatures are compromised in favour of lower heats, in order to avoid the hours of polishing that would be required subsequent to the welding. Obviously, any weld process that created the possibility of spatter at all would also not be an option. Weld sink lines adjacent to welds on moulds are almost always not tolerable on surfaces where the actual parting line is located. It is not uncommon for a tolerance of 0.005" of welding sink to be unacceptable for the end use of an injection-mould component. This often dictates weld processes such as micro GTAW or laser welding.

Chemical etching or photo etching of moulds (chemically inducing a pattern that will be transferred to the end product) will determine both the heat treatment and the filler material. If an incorrect welding procedure will not allow the final etching of the weld to match and blend into the surrounding areas, the weld becomes unacceptable to the component's end use, no matter how sound the weld is.

In addition to base-metal-material considerations, filler metals can be considered and chosen to enhance the repair weld. Selection of an appropriate filler metal can make the repaired component better than new. Filler-metal selection allows the component to be harder or softer, more wear-resistant, more heat-resistant, more impact-resistant, or more corrosion-resistant in exactly the areas where these enhanced characteristics may be required. For example, one could utilize a low-alloy steel to repair cracking problem areas on a tool steel, but use a hard-steel alloy on the wear edges.

Choose a filler material by determining (i) how to best correct the initial cause of failure and prevent or delay failure from recurring, and (ii) compatibility with the base material. Another post-weld consideration when selecting a filler wire could be the anodizing of an aluminum weld. In this case, filler wires with a high silicon content do not lend themselves well to the anodizing process.

Colour match can also be paramount for the weld repair on items such as a newly manufactured component. You wouldn't want a mis-machined area that required a repair to be obvious. This can often be controlled by correct filler-metal selection.

Many of the ferrous and non-ferrous materials utilized in modern manufacturing were not designed with the intent of welding them. However, if you have them positively identified, many of the manufacturers of the materials offer welding recommendations.

The Internet has become an indispensable tool to this end. Simply by entering the proprietary name of the material into a search engine, within minutes you can often find welding-procedure guidelines. Weld-filler-wire manufacturers are also an indispensable source of direction. By knowing the cause of failure and the base material, the filler-wire manufacturer can often offer general guidelines for a weld procedure. These two information sources can be very helpful when determining a weld procedure for a base material that is not commonly welded to a particular standard (e.g., tool steel).

If the base material is more common (e.g., low-carbon steel, low-alloy steels, austenitic stainless steels, and common grades of aluminum), then welding guidelines from organizations such as the Canadian Welding Bureau, American Welding Society, or American Society of Mechanical Engineers could be utilized to formulate a welding procedure, obtain a prequalified weld procedure, and evaluate welder competency.

Post-weld inspection is always recommended prior to re-installing a repaired component. It should begin with visual examination at the very least. It's sometimes a good idea to have an outside inspection company (third-party verification) do a final inspection, especially if there are safety issues. The type of inspection should be linked to the component's end use (e.g., hardness testing of cutting and forming edges of tool-steel punch and die components, or pressure-testing repaired water cooling lines in injection-mould components).

Conclusion

The best weld repair is one that best addresses the many considerations of the final function of a weld-refurbished component, often within a restricted amount of time.

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