Weld Repair of Tools and Dies: 10 Popular Q&As

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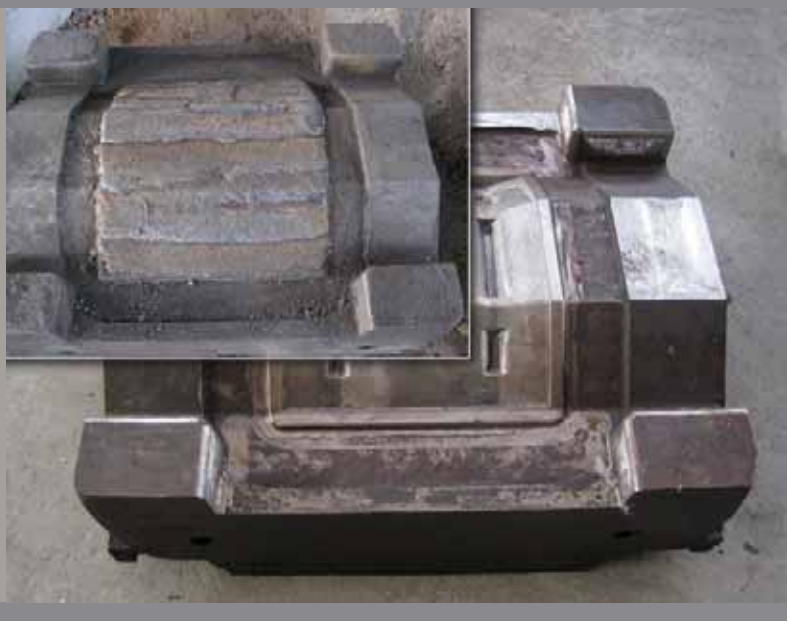

Forging die weld-repaired with Postalloy 2235 as a buildup material and 2747 as a hardfacing material

The basics of tool-and-die repair are covered in this article in Q&A format. The use of buildup products to fill a worn die, the subsequent hardfacing of a new die cavity and the thermal treatments required are all considered.

Of all hardfacing applications, tool-and-die repairs are one of the most metallurgically challenging. What makes it so challenging is the metallurgy of the base materials and their compatibility with the hardfacing products, as well as the post-weld heat treatments required.

This article will attempt to answer some of the major questions regarding the repair of forging dies and will deal only with iron-based products. References will use the term "dies" for brevity's sake, but it actually refers to tooling and die repair. The following is a list of 10 frequently asked questions and answers. Further questions can be directed to the author.

Question 1: Do tool-and-die steels have categories like other steels?

Yes, they do. The categories are shown in (Table 1). There are many grades within each category that pertain to a specific application, and there are specific chemistry ranges that also apply to each alloy.

Question 2: What is meant by quenched-and-tempered steel?

Practically all steels used in the forging industry are quenched and tempered. Low- and medium-carbon alloys are brought up to a solution-anneal temperature (1800˚F) and then quenched in water, air or other cooling medium to achieve maximum hardness. Steel is rarely used in this condition because it is too brittle. Therefore, it must be reheated to about 1000˚F for various times to achieve a lower hardness but a much tougher alloy. The reheating procedure is called tempering and allows the part to be used to its maximum effectiveness. It should be noted that the tempering process is not a hardening process but a softening process. Hardnesses can drop up to 50% after tempering, but this is rather unusual. Most only drop 4-8 points of Rockwell C hardness.

Question 3: After weld repair of a worn die, does it require a quench and temper also?

For the most part, many do. Hardfacing products with similar chemistries as the die are chosen to allow them to respond to the quench-and-temper properties associated with the parent base metal or die. In some cases the die owner chooses to have the hardfacing applied directly to the die, however, followed by a tempering cycle. This procedure compromises the parent die material because the tempering is a softening process, and the resultant die will be softer than the original. This may also increase the wear rate of the die.

Question 4: Why are some weld repairs not as hard as the original die?

There are several answers to this question, but the most prevalent is that machine shops have a limit on hardness allowed for machineability. Fortunately, technology has produced cemented carbides, cermets and ceramic inserts that easily machine up to 60 R_c hardness. The technology can have a tremendous effect on die life, forging production and success. Increasing the machineability

Type	Letter designation
Air-hardening TS	A
High-carbon, high-chromium TS	D
Hot-work TS	H
Low-alloy, special-purpose TS	L
High-speed TS	M,T
Oil-hardening TS	O
Low-carbon mold TS	P
hock-resisting TS	S

Table 1. A guideline to the various tool-steel types available. A vast range of chemistries are available in each category.

threshold will allow for the use of more efficient and harder hardfacing alloys, which will positively affect all forging operations.

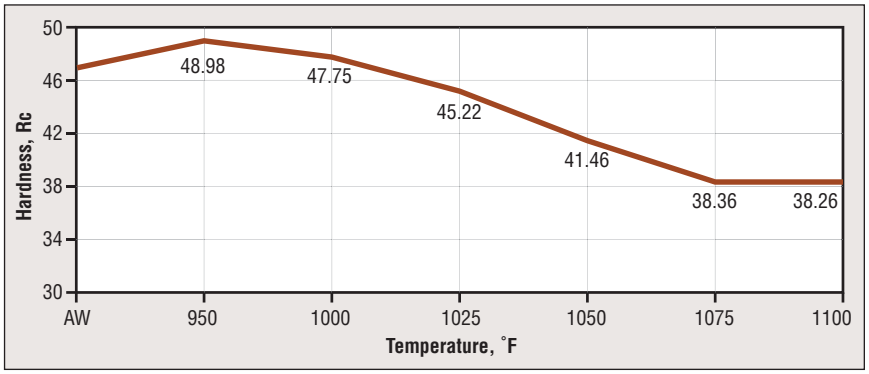

Figure 1. A tempering curve for Postalloy 2245 FCG. The rise in hardness at the 950˚F data point is due to a slight precipitation of carbides during initial stages of tempering.

Question 5: Is the hardness of a hardfacing product a good indicator of wear resistance?

Yes, but only in rare occasions in which the electrode or wire are similar in metallurgical structure. For example, Postalloy 2742 and 2747 have respective hardness values of 42 R_c and 47 R_c. In this case, the increased hardness of 2747 (47R_c) will most likely wear better. When comparing 2898 to 2826, where hardness values are nearly equal, however, the abrasion resistance of 2826 is 3-5 times better than for 2898. Consequently, hardness is rarely a good indicator of wear resistance. One must rely on chemistry and microstructure for a more accurate appraisal of the impact on die life. Our company, for example, employs two metallurgical engineers to help asses die life and product selection.

Question 6: Is it possible to predict hardness levels of a hardfacing repair weld during the tempering cycle?

Yes, we publish tempering curves for each of our forging repair products (Figure 1). These curves serve as a guideline rather than an exact prediction of the actual hardness achieved. It may take a few adjustments from one type of die to another because the size of the die has an effect.

Question 7: Is hardness alone the only measurable hardfacing attribute to base product selections?

Unfortunately, it is. I say unfortunately because many dies fail from exceeding the yield strength of the deposit, and hardness can only be directly related to its ultimate or tensile strength, which is far beyond the yield strength. However, knowing the hardfacing deposit hardness infers a higher yield strength. Figure 2 shows the stress versus strain of a typical hardfacing deposit. Note the difference between the yield and tensile strengths. The yield strength is where the deposit deforms and loses its dimensions. The tensile strength is where the deposit experiences its greatest pressure, and fracture is soon to follow.

Question 8: Does the old, worn hardfacing deposit have to be removed before a new product can be deposited?

Yes, it should be. There are often minute cracks that can harbor debris and contribute to porosity, bonding issues and even cracking. It is a misconception that the welding arc will destroy everything within its path. It won't, and a wise maintenance shop will clean all areas to be welded with a grinder. There is also a process – called carbon diffusion – that takes place in the old weld deposit whenever heat is applied from a welding arc. The process can eventually lead to severe cracking and spalling.

Question 9: Do all dies fail in the same way?

Not at all. That's what makes decisions regarding repair so difficult. The first criterion is heat. Hot forging dies wear because of heat, corrosion, fatigue and high contact forces called galling. Cold forging dies do not have to contend with heat and fail by cracking, galling and fatigue. Each failure should be examined closely by trained personnel to determine the cause of failure, the correct hardfacing product to use and the procedures to accomplish the task. Postle Industries, Inc. has a metallurgical staff that can aid in product and procedure solutions.

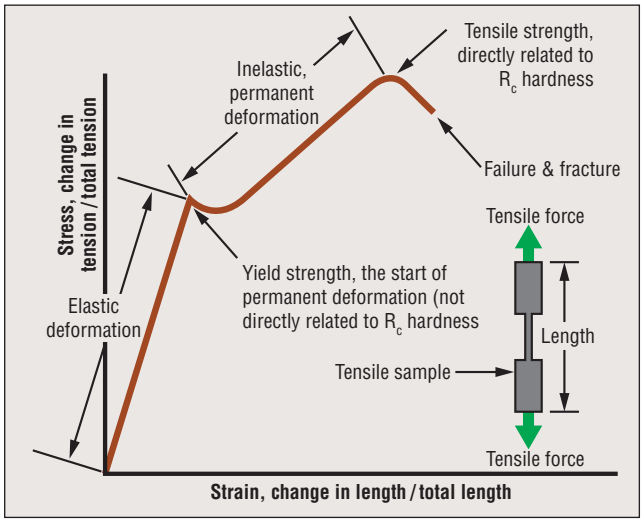

Figure 2. A typical stress-versus-strain graph for tool steels. Note the yield strength is far below the tensile strength. Yield strengths do not correlate directly to hardness data.

Crankshaft forging die showing gouged and repaired weld with Postalloy 2235 buildup and 2755 hardfacing material

Another forging die weld-repaired with Postalloy 2235 buildup material and 2747 hardfacing

Question 10: What are the major differences between buildup products and hardfacing products?

Buildup alloys are those products used as a base for the final hardfacing products. Technically speaking, a buildup product is a hardfacing product whose chemistries are far more complex than mild steel, which is sometimes erroneously used as a buildup deposit. While the buildup products are not usually the same chemistry as the base material, they are formulated to yield sufficient strength to support the final hardfacing deposit in service.

Choosing mild- or low-alloy joining products as the buildup can cause serious failures in service. Forging forces impacting a low hardness buildup can sag and deform the buildup and force the hardfacing to crack and spall. Buildup products do not come directly into contact with the forging dies, while hardfacing products do, which dictates that their chemistries require content adjustments.

Summary

The 10 questions just presented represent only a small portion of topics and issues surrounding tool-and-die repair through hardfacing. Many applications outside tool-and-die repair do not encounter post-welding heating to the extent seen in the forging industry. This fact presents challenges to the maintenance shop and requires a good understanding of hardfacing products as well as the effects that heat treating will generate within these unique products.

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