Frequently asked questions #5

Can tool-steels be brazed?

Tool steels are not only moderately expensive; they also possess a relatively complex metallurgy. It is these two factors, when taken in combination, that cause alarm-bells to ring in the minds of experienced brazing engineers when they hear 'brazing' and 'tool steel' mentioned in the same sentence. From this fact the message ought already to be clear…………..approach any requirement to produce brazed joints on a tool-steel with extreme caution, and if at all possible don't approach it at all!

However, for those engineers who want to satisfy themselves that trying to braze tool steels in a manner that will provide satisfactory results is rather like trying to empty a pond by bailing it out with a cup while it is raining………..please read on!

Parent materials

For convenience, when discussing the brazing of tool steels it is commonly the case that they are classified into two basic groups:

- Carbon steels
- High-speed steels

The hardness of carbon steels is derived from their relatively high carbon content, this typically falling in the range 0.65 – 1.45%. In order for such steels to achieve their optimum properties it is essential to subject them to a 'fierce' quench, and it is clear that such a procedure is likely to lead to the generation of severe stresses in the material. In these circumstances it would not be too surprising to find that if a brazed joint were present, if it were not actually torn apart during the quenching procedure it would certainly be in a highly stressed state after the hardening process had been concluded!

Tungsten and vanadium can be added to carbon steels in modest quantities to provide them with special properties. While the beneficial properties of an improvement in one or more of toughness, wear-resistance, and improved high-temperature properties are developed as a result, the resultant metallurgy of these materials renders their successful brazing a painstaking, not to mention relatively stressful, procedure.

High-speed steels are classified as a separate group even though there is a logical argument to support the view that they form part of the family of the alloy steels group. Such materials are typified by relatively high alloying additions of tungsten, molybdenum, vanadium and chromium.

Comments on brazing procedure

The logical procedure is to combine the brazing and heat-treatment processes, and this is an objective that ought to be pursued. However in many cases brazing is attempted prior to undertaking the hardening process, and this can lead to metallurgical problems.

The hardening temperature of *carbon steels* is typically in the range 760 - 815ºC. In order to ensure that the alloy in the joint is sufficiently 'solid' to have a chance of resisting deformation failure, the brazing operation will need to be carried out at a temperature which is perhaps 200ºC or more above the hardening temperature. While this would satisfy the matter of the solidification temperature of the filler material, the magnitude of the brazing temperature might well lead to undesirable metallurgical changes occurring in the steel. Clearly, the problems that arise from this approach to the joining process might well be insoluble!

The other alternative would be to employ a filler material that has a solidus temperature that is close to the hardening temperature. However the joint strength during quenching would be extremely low. Moreover, damage to the joint would probably occur unless precautions were taken to design it so that it was subjected to compression during the quenching cycle. This solution to the problem is very much easier to recommend than to achieve!

The brazing procedures that would be employed with alloy steels, (and this includes the high-speed steels), is dependent upon an understanding of the physical metallurgy of the steel, and how time and temperature affect the metallurgical phase changes that the steel experiences during the process cycle. We have already mentioned the fact that a joint can rupture due to the development of severe levels of stress in the part during the quenching stage of the hardening operation. It can also be the case that austenite-martensite transformations in certain steels may result in their first contracting, and then expanding, and then contracting again. These dimensional changes are bound to apply stress to any brazed joints in the assembly, and even if the joints remain intact it is clear that will be in a highly stressed state. Joints in this condition are prone to early failure when subjected to the stresses experienced by the part in service.

It is clear from the foregoing paragraphs why the comment "…………..approach this requirement to produce a brazed joint with extreme caution, and if at all possible don't approach it at all!"…………… was made at the beginning of this note!

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