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WELDING RECOVERY METHODS OF THE PRESSURE CASTING DIES

ABSTRACT

Welding hot-work tool steels, containing 0.3-0.6% of carbon, is difficult both because of the elevated carbon content and because of significant hardening resulted from large amounts of alloying elements. A development of welding technology, i.e. better quality of electrodes, modern welding devices, improved welding technologies and better steel quality, make welding of such steel types possible today.

A development of welding technology for tool steels, especially in the case of expensive tools, such as pressure casting dies has a profound justification taking into account economical advantages and quick repair possibilities, which is a matter of principal importance in the case of a lot production of pressure castings.

INTRODUCTION

A high hardenablity of hot-work steels, which arises from the high total carbon and alloying elements content, constitutes the main problem of the process of welding these materials. After a removal of the heat source, a weld cools quickly, thus leading to quench hardening of the weld material and of a part of the weld-affected zone. High residual stresses are introduced in this way, which lead to the formation of cracks.

The forming dies undergo welding in the following cases:

- regeneration of surface cracks caused by a thermal fatigue of the forming surface
- repair of cracks or spalls caused by exploitation and reconstruction of dies
- removal of possible errors arising in the process of die machining
- changes of casting construction

An assurance of the up-to-the-end production maintenance or a desire to keep the production process going until a new die is introduced, constitute the main reasons for repair or regeneration of forming dies by means of welding methods.

WELDING PROCESSES

The TIG (Tungsten Inert Gas), MIG/MAG (Metal Inert Gas/Metal Active Gas) and typical shielded arc welding methods are the ones most often used in die regeneration.
A use of laser beam in welding technology for tool recovery is currently in a phase of laboratory research and preliminary industrial application.

The TIG method is widely used in the case of regeneration and repair of forming dies with small losses or cracks caused by exploitation. This is the cleanest process of all arc welding methods, from the metallurgical point of view comparable to arc micro-casting in backing shielding.

The MIG/MAG methods are used in the case of larger and more complicated die repairs. A reconstruction of small forming parts losses is also possible with a use of these methods. The consumable electrode is in a form of bulk wire, typically 0,5 to 4,0 mm in diameter, and it is continuously supplied by a special automatic feeding system.

The typical arc shielded welding should be applied in the case of macroscopic cracks occurring at large area.

Compared to methods presented above, laser welding has following advantages:

- avoidance of deformation in the vicinity of weld passes
- reduction of an area of the heat-affectedzone
- possibility of repair of temperature-sensitive parts
- precise laser beam positioning
- possibility of welding deep cracks
- cleaning of the fractured surface or deep cracks by local material evaporation

The literature presents the laser beam welding possibilities based on 3D system making use of CAD/CAM technology [4].

BINDING MATERIAL

Electrodes used in welding forming dies should have chemical composition similar to the composition of the substrate, because significant composition differences between the electrode material and the die material are connected with a risk of extended cracking during quenching phase.

Welds, in the case of hot-work tool steels, are characterized by high hardness, thus they are especially susceptible to fracturing, which starts at slag particles or pinholes. Therefore, an applied electrode must assure a formation of high quality weld, possibly without any pollution. At the same time the electrode manufacturing must undergo a strict control of chemical composition, in order to guarantee a repeatability of welding methods of die repair. High quality binders are required particularly in those cases when a die is to be polished or etched after welding.

One has to remember that covered electrodes must be stored in a dry box (fig. 1) because of the very good hygroscopic properties of their coatings. In addition, isolated boxes should be used to transport electrodes to the site of repair. A hydriding of the weld can be a consequence of an improper isolation of the electrodes from water vapor or of their storage in moist compartments [2].

Fig. 1. Electrodes storing

HYDROGEN DETRIMENTAL ACTION

Welds obtained during hot-work tool steel welding are particularly susceptible to the so called "cold crack", caused by a presence of hydrogen during welding. The presence of hydrogen in the weld is a result of water vapor decomposition and its absorption by a hygroscopic electrode coatings.

Weld susceptibility to cold cracking is affected by:

- residual stress
- amount of dissolved hydrogen
- weld microstructure
- steel hardness

The volume of hydrogen can be significantly limited by applying the following precautions in the welding process:

- during their transport, coated electrodes must always be stored in dry boxes or in special isolated containers
- surfaces subjected to regeneration or welding repair should be grinded to "pure" metal directly before welding starts (pollutants such as oil, grease, paint or rust constitute a source of hydrogen)
- preheating, with a use of propane torch, of the dies before their welding can cause water condensation on tool surfaces outside the heated zone [2]

CONDITIONS OF WELDING OF HOT-WORK TOOL STEELS

Having at one's disposal the best welding devices, applying a high class welding electrode, taking advantage of the best welders, may prove insufficient in terms of successful welding if one doesn't use caution during preparation of a welding place, and a welding operation itself, and if an appropriate heat treatment is not applied before and after welding.

It is extremely important to heat up the tool to 50-100°C over Ms (martensite start temperature) directly before welding. This temperature should be maintained during the entire welding process. Partial welding, allowing the a tool to cool down, is not recommended, because the risk of fracturing significantly increases.

The best way of heating and maintaining the appropriate tool temperature during welding, is an application of a special, isolated container with the heating elements installed in its walls (fig. 2).

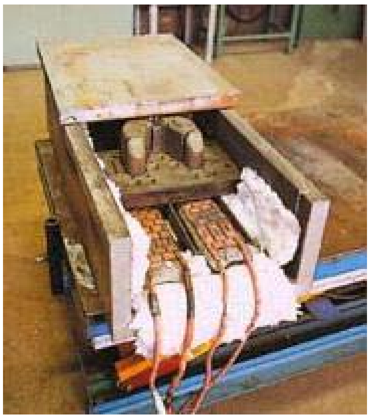

Fig. 2. Welding station

A cleaned workplace should be checked for defect presence before welding, with a use of special well penetrating substance.

Heat treatment after the repair is the next factor which affects a satisfactory final result. The tool should undergo a stress relief annealing. This operation directly after welding, is aimed at an improvement of the weld material ductility and at a reduction of the residual stresses arisen during welding. The process temperature should be selected in such a way as to equalize a hardness of the weld with that of the material. This temperature typically remains about 20°C below a prime tempering temperature for the material with lower temperability. The stress relief annealing is not necessary in the case of small repairs, but doing so can contribute to an improvement of the weld properties.

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