RECONDITIONING OF DIE CAST MOULDS FOR NON FERROUS MATERIALS BY USING MODERN METHODS

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ABSTRACT: 1 In the life of die casting moulds can be effective increased by timely repair of damaged active surfaces of the moulds. During the production with the die casting moulds, due to heat and the shock, the surface of the mould starts being wounded (the pins will be broken and the profile zone will be waste and crack).The causes that the moulds will be damaged is: incorrect parameters of the die casting machine, incorrect temperature of aluminium alloy, incorrect design of the mould, operators fault, etc..
KEYWORDS: die casting tools, injection moulding tools, laser-beam welding, filler material, nonconventional reconditioning

1. INTRODUCTION

There are many procedure with which to extend the service life of mould and with we find it out to increase the life cycle, including utilization of new wear resistant mould materials, reduction of the intensity of wear by optimizing mould geometries, reduction of molten metal corrosion and erosion to the mould by coatings and the improvement of the toughness of existing moulds with heat treatments, etc. While there are a variety of measures to prevent moulds from failure, moulds will finally reach the end of life phase [1]. Welding is the best known technology for repairing damaged moulds so that they may be put into operation again [12].

In the most welding technologies, three of the most frequently used operation for the repair of moulds are TIG Welding, Plasma arc welding (PAW) and laser-beam welding.

-TIG welding (Gas Tungsten Arc Welding) is a fairly mature technologies and is widely applied in industry to obtaining a best performance from repaired the moulds. The process is often optimized in terms of welding procedure, material and filler wire, etc

TIG welding is an autogenous process, where the heat is generated by the arc between the non-consumable tungsten electrode and the mould.

-Plasma arc welding advances the GTAW process, as the plasma is forced through a fine-bore copper nozzle at high velocities and at a temperature of about 19.000-20.000°C. Compared to GTAW, Plasma Arc Welding has a stable arc that is more tolerant to arc length changes and penetrates weld materials more deeply and uniformly due to the constricted orifice.

-Laser welding is characterised by its concentrated density of energy and accuracy allowing narrow, high quality and deep weld beads.

Due to its advantages over traditional welding techniques, laser repair technology has been widely adopted for the restoration of moulds as well as other components.

Apart from these main stream welding techniques, other processes like the electro spark process and cold spray are adopted for the repair of moulds.

In general the die casting moulds can be classified with reference to their application, the degree of atomisation, operating temperature, the material from what he made, etc[18].

The mould life depends on a lot of factors, which, however, are not completely known for all moulds. It often happens that mould damage occurs well before the stated and right fully expected time.

Taking into consideration of the costs involved to produce a new mould, it is necessary to think through it of the possibility in repairing moulds without significant loss of quality. Therefore, if the operation life of moulds could be successfully extended by a regular maintenance of mould parts (fixed side and mobile side), the final price of moulds would be significantly improved.

In die casting processes of aluminium alloys, these tools are subjected to strong thermo-mechanical loads which can lead to damage of the moulds surface in the form of wear or fatigue cracks.

Choosing a welding process

We are haven't many welding processes from which to choose a process that we will repair by welding of moulds [2]. It should be taken into account that the welding positions used may be different, workpieces

may have a difficult access and various shapes. Consequently, manual welding seems to be the most appropriate one to be applied. The most frequently used processes are TIG (Tungsten Inert Gas) welding and less frequently manual metal-arc welding [11]. Plasma arc welding and laser-beam welding may be applied but very rarely since they are still being developed and introduced into practice because they are more suitable than TIG welding.

Manual metal-arc welding is applied more rarely in spite of a wide selection of covered electrodes for repair welding offered by manufacturers of filler electrodes. It is applied on moulds only that the mould is larger or the mould containing larger defects [17].

Surface preparation of the die casting mold before the welding operation

Surface preparation plays a decisive role in the welding process [4]. Recommend always removing any trace of dirt and rust before starting to weld, and avoiding welding in the vicinity of sharp corners (figure 1). When repairing cracks, it is necessary to grinding the defective area. The minimum recommended angle is 25-35° and the joint groove has to be 1-2 mm larger than the diametric section of the electrode to be used. We also recommend testing with penetrating fluid or magnetic testing on the whole area to be welded, in order to locate possible surface defects, which have to be removed by grinding .

Figure 1.Cracks on de die casting mold

In this prepared mould surface we were gradually coating the filler material in the form of wire with Bazic Laser B47 E-7018 marking [19]. We were coating two times and produced individual samples for proposed testing. The chemical composition of the used electrode is shown in Table 1.

Table 1. Chemical composition of the used filler material – Bazic Laser B47

Wire	Chemical composition %				
Bazic Laser B47 E-7018	C 0,5	Mn 1,5	Si 0,6	Cr 6	Mo 0,5

Is very important that the chemical composition of the filler material tally with the chemical composition of the mould material.

The filler materials that can we used take different forms, covered electrodes, bare rods, wires and a powder [7]. The nature of the filler material added depends mainly on the welding process can be used.

Prior to repair welding, the filler material to be applied should be adequately prepared. Bare rods and wires for TIG welding should be clean down with a grinding paper and with any solution where as covered electrodes, cored wires, and metal powder should be dried at a suitable temperature. Filler wire is available in most common tool steel and mould steel equivalents [17]. There are copper alloys available for application on both copper nickel and beryllium copper alloys in the small sizes of filler wire, and of course aluminium wire is available too. The coatings were created by the laser beam used the metal wire with the defocused laser and with slanting wire feeding to the coating processes (figure 2) Produced clad was separated so it could be evaluated.

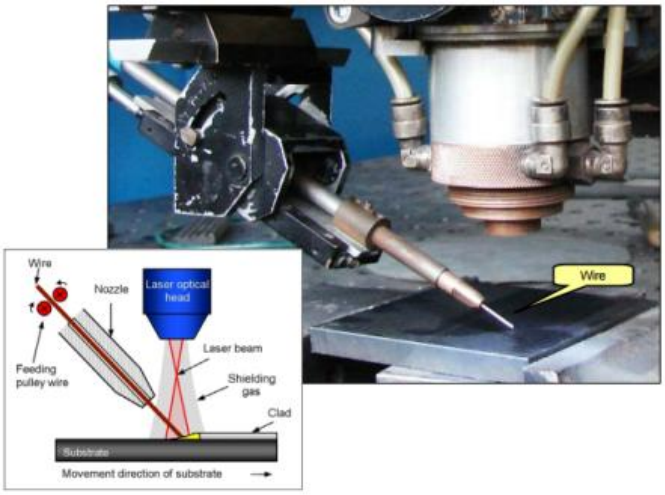

Figure 2. Welding with Laser

Milling process

After the welding process if we have problem with the welded zone (the weld is very thick), it is necessary to use rough milling (figure 3).

Figure 3. Milled surface on the mold

Surface finishing using EDM

Electrical discharge machining (EDM) is a procedure whose principle of action is an electric discharge that generates a spark between the casting mould being processed and an electrode(figure 4). Consequently the electro erosion process can only then useful on electricity conducting materials.

One of the most conditions for electric discharge is a fixed breach gap, which constitutes the distance between the casting mould being processed and the electrode (negative of die, which is made of graphite/cooper etc) [5]. When the spark occurs in the breach gap electricity conducting gases, soot and minute particles of material are generated, which need to be removed from the vicinity [14]. For this purpose a dielectric liquid such as oil, petroleum, diesel fuel or distilled water, is used.

Figure 4. Electrical discharge (EDM) used by die casting mold

Surface finishing using acid

When the surface of the mold is not polished correctly, after the few cast shot on the active zone of the mould remain stuck thin layer of aluminium alloy (figure 5).

Figure 5. Using Acid on the mould.

Polishing

Draw polishing has been used for decades to help with release of castings and help the aluminium alloy to flow better over flat surfaces (figure 6).

Figure 6. Polishing surface of the mold.

PVD Coatings in Aluminium Die Casting Dies

A primary need for die casting moulds manufacturers is to identify the best combination of the mould chemical composition together with thermal and surface treatments in order to achieve the best thermo-mechanical shock and wear resistance [15]. It is well known that mechanical and thermal stresses act in different combinations for the die casting moulds (figure 7). Therefore, in general, difficult operating conditions, these mechanical parts should be able to cope with two opposite industrial needs: the good product quality, as far as tolerances and surface roughness are concerned, and the long life of the mould parts in contact with the component to be manufactured .

Figure 7. The die casting mould after the reconditioning.

The use of PVD (Physical Vapour Deposition) coatings revealed to be of particular interest since the wear resistance can be fully supplied by the external layer and thus the steel can be treated in its best structural condition.

2. FAILURE FOR DIES AND MOLDS

During the die casting operation the moulds that are subjected to thermal loads, i.e., they are heated and cooled. As these moulds are not subjected to a uniform thermal load across the entire cross section, periodical stresses occur. Because of the loads, the moulds will start to worn out, break, and get cracks which will gradually propagate during tool operation [12,18]. How a partially damaged mould can be repaired is a very difficult question. Welding is the only operation fit for repair of moulds and thus to increase their service life.

The catastrophic failure of moulds are attributed to faulty design, force majore, improper and inapposite storage during transportation. Faulty design is one of the important aspects what may drive into a catastrophic failure.

Often, the moulds failure just takes place due to inapposite storage during the handling time of the manufacturing. Improper location of storage may caused of chemical reactions due to other stored items leading to oxidation and corrosion of surfaces of the moulds. Improper handling during transportation of moulds from one station to another may cause damage to the moulds [3]. These errors can accidently occur due to extreme thermal shock, extreme mechanical strain, operators fault and errors during transportation.

Because on the die casting mold we have (crack, plus/minus of material etc.) the parts will be scrap or is it necessary to rework (figure 8).

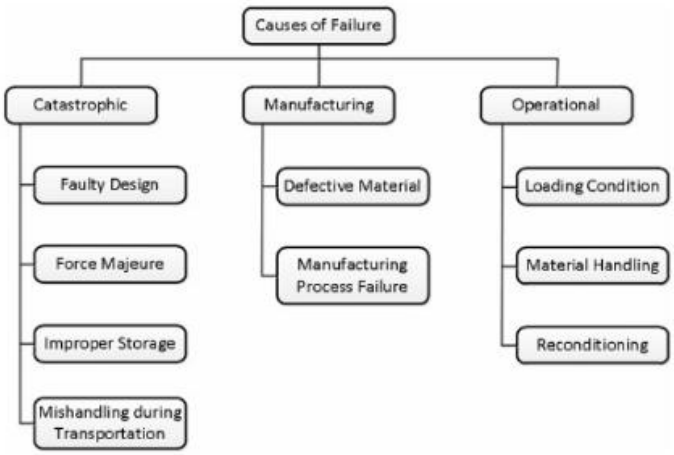

Figure 8. Causes of failure.

The most important mould failures are classified under two categories: washout and thermal fatigue. Washout damages are a direct result of the flow of the aluminium melt impinging on and rubbing against the mould cavity surfaces (figure 9-10). Corrosion is attributed to friction wear that is caused when the melt solidifies around the core surfaces, and when the casting is ejected. Thermal fatigue, the most influential failure mode in die-casting, reveals itself in two ways: heat checks and stress cracks. Thermal fatigue cracks occur as the die cavity surfaces are placed under tension when the cold (~24-26°C) water-based release agent impinges on the hot surfaces previously exposed to the aluminium melt. The cooling effect of the die lubricant spray on the underlying hot material causes a tensile stress in the hot die surface, causing surface cracks. This cycle is repeated each time a casting is made.

These defects are then reflected on casting parts as defects-fins, marks or burr (figure 11-12-13). If these defects are in acceptable tolerances for the final product the die casting die is good even thought the surface has cracks or is eroded [12,18]. If these defects are too extensive, each casting must be refurbished, or the mould must be replaced by a new one or the mould must be repaired by welding. The optimal choice depends on the series of castings to be produced, deadlines, costs of the new mould and/or mould repair, costs of workers, equipment, and production space.

Figure 9. Worn, break and cracks on the mold.

Figure 10. Minus of material on the mold.

Figure 11. Burrs and shrinkage on the parts(defect)

Figure 12. Plus of material(rework by grinding).

Figure 13. Lamination and Cold Flow on the parts(rework by Sand Blasting).

3. CASE STUDY

Using laser welding as the remanufacturing process, the welding characteristics are studied based on which laser welding process is selected.

The mould life is defined as the length of time during which the mould will operate without any unexpected interventions [8]. It is most often measured with the number of products manufactured by the mould.

An appropriate welding operation is the selection of a similar filler material and a suitable preheating temperature and an appropriate post weld heat treatment operation make it possible to repair the majority of moulds and recondition them for further use, ensuring almost the same life as that of a new tool.

By the repair of cracks on the mould using a special filler material ant the absence of caulk, you increase the surface quality and thus the failure risk of the component (figure 14). A lower supply of your end costumers due to poor cast parts batches or processing errors can be circumvented by our repair of cast parts by the use of laser welding [6].

Before the welding process

Before welding, a groove should be prepared (cleaned) and a mould heated onto a proper temperature.

In preparing the groove care should be taken of its shape and position [17]. The groove should not show sharp angles or sharp transitions. The root of preparation should be rounded. The location of groove should be adapted, if possible, to the type of load applied to the tool during its operation. It is recommended that the groove is affected, via the weld metal, by pure compression stresses, but not by shear, tensile, or combined stresses. The preheating temperature is determined in accordance with the parent metal.

Figure 14. Broken corner on the mould (before reconditioning)

During welding process

During the welding process it is very important to strictly stick to the technology prescribed. Very important elements are the interpass temperature, the welding sequence, and other additional measures, including cleaning of weld beads [9]. Cleaning accessories such as brushes and hammers should be correctly chosen, i.e., be made of suitable materials.

To exacting repair welding operations it is recommended to apply multiple-bead welding and weld -bead forging.

After welding process

For a tool postweld heat treatment is very important. It is selected in dependence of the type of tool material and the type of filler material (figure 15).

Figure 15. After reconditioning

4. CONCLUSION

On the active parts on the die casting mould, due to improper use, it appears defects.

Laser repair welding of damaged die casting mould is appropriate technology for elimination of surface irregularities as cracks.

The following conclusions can be summarized:

- The crack growth rate for particular location and mould could be predicted to be between upper and lower trend line.
- If crack grows at faster rates than indicated with upper trend line, two or more adjacent cracks joined and merged and caused the removal of surface material in-between the cracks.
- With the proper laser repair of damaged mould, the mould life could be extended for the same period or even more, and repair could be done several times.
- If repair is not done correctly, the extending of the mould lifetime is very short.

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