Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(6):2136-2139

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Research on functional gradient mold coating optimized preparation by electroplating and arc spray

C. S. Liu and B. H. He

Department of Mechanical Engineering, Zhejiang Industry Polytechnic College, Shaoxing, China

---

ABSTRACT

Functional gradient tool (FGM) is an important developing direction of modern precision mould, it can effectively improve the performance and reduce the cost of die mould. On the base of the previous experiments, using electroforming and arc spray characteristics, through interactive experiment and analysis methods, to optimize the combination of two processes, complete the Ni-Zn metal alloy system structure / function gradient mold coating preparation, and complete analysis of coating micro structure. Experimental results and analysis show that, by melting casting and machining technology of arc spraying rapid manufacturing function gradient material mould is feasible, and can greatly improve the performance, reduce the cost of gradient mould precision, which will provide new ideas and methods to provide good for the preparation of functional gradient die precision.

Key words: functionally graded mold; optimized combination; Ni-NiAl-ZnAl-Zn coating

---

INTRODUCTION

In recent years, the development of the mold industry set forth stricter requirements for the research and development of new types of die materials. From the perspective of mold working conditions and failure modes analysis, the force condition, wear and heat condition of mold are all uneven when it's in use. Therefore, it is difficult to meet the performance requirements on high precision molds. Thus, gradient material mold made of advanced material of which the physical, chemical, and biological properties can change in one direction when its single or composite performance vary continuously in order to adapt to different environments and achieve special purpose has become an inevitable trend in the development[1-3].

The concept of functionally graded materials was put forward by the Japanese materials scientist Masayuki Niino [4]. To obtain functionally graded material, two kind of materials of different properties are first chosen according to certain requirements on final application; then advanced material composition technology is adopted to make the composition and structure in a continuous gradient change with no obvious interface in it, thus the properties and functions of the new type of composite material is also in gradient change along the thickness direction[5]. The manufacturing of FGM is a process based on functionally graded materials, which includes designing and manufacturing of qualified molds and which takes the work environment and failure mode into comprehensive consideration[6,7].

EXPERIMENTAL SECTION

This experimental principle of this study is to prepare FGM layer through electroforming, then thicken the working layer by arc-spray[8]. The die is designed according to the gradient of the material to conduct an overall backing reinforcement, for the mold that requires frequent heating and cooling, complex hot and cold pipes are laid surface-shaped along the profile structure in the process of backing-cavity. The microstructure diagram of the mold is as shown in Figure 1.

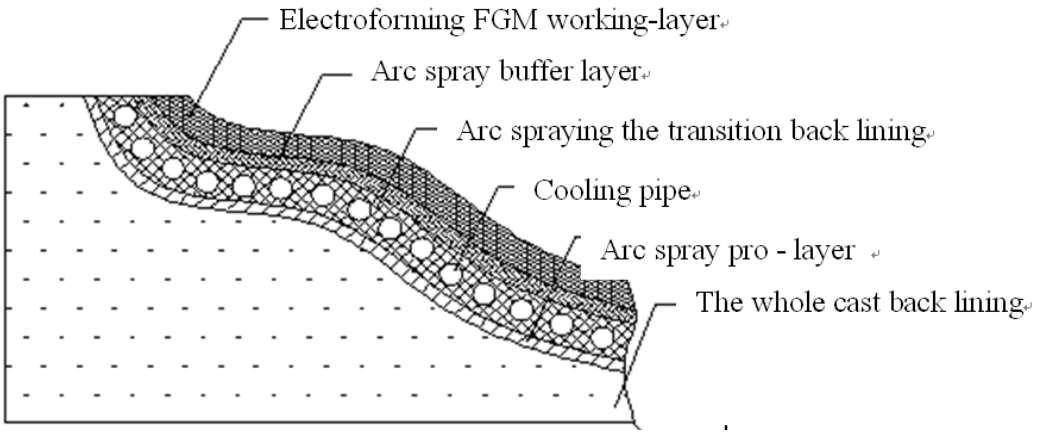


Figure 1: FGM die cross-section structure diagram

1. EXPERIMENTAL PRINCIPLE

3.1 Granular computing

Nickle was first deposited to form the FGM working layer of an injection mold through electro-forming precision finishing technology.

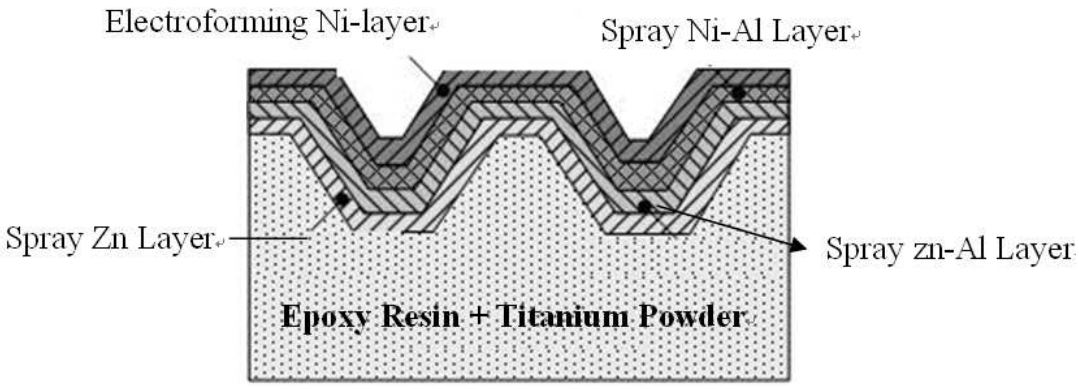


Figure 2 : Composition Distribution Diagram of FGM cross-section

As the electroforming deposition speed is slow, whereas the arc spraying is of low cost and high deposition efficiency, the spray transition back-lining method was adopted when the nickel layer obtained a certain thickness[9]. Arc spray method formed rapid reinforcement while producing gradient material transition according to the design requirements on gradient material distribution, followed by spraying NiAl, ZnAl, Zn successively to form the internal transition back lining. Finally, the whole back lining is reinforced by casting epoxy Resin + Iron powder to form the final mold. The mold components distribution as shown in Figure 2.

3.2 Analysis on FGM mold manufacturing test process

FGM mold manufacturing process (Figure 3) mainly includes the following steps: Preparation of the original mold for electro-forming, deposition of FGM working layer through electroforming, spraying transition back lining on the FGM working layer, casting the whole back lining on the transition back lining, removing the original mold to get the FGM mold.

3.3 Experiment

Original Mold Surface Treatment

Physical sample was used as the original model for electroforming deposition in the experiment. As a non-metallic original model was used as the physical sample, the conductive treatment was executed prior to electroforming process. The process was as follows:

① Degreasing

② Sensitization

③ Electroless silver plating

Nickel electroforming process
FGM spray forming
Electroforming layer should first be Sand blasted to improve its adhesion to arc spray layer. The arc spraying process parameters of different wires are as shown in Table 1.

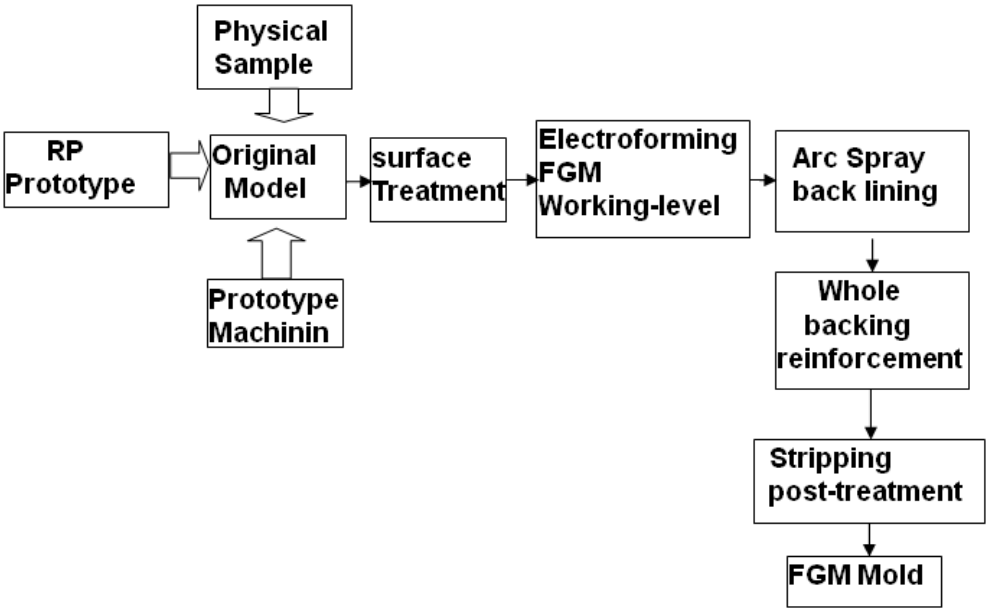


Figure 3: FGM mold forming process

Table 1: Arc-spray process parameters of the gradient layer

Coating	Wire (φ2mm)	Arc voltage (V)	Arc current (A)	Compressed (MPa)	Spray distance (mm)
NiAl Coating	NiAl	33	220	0.6	150
ZnAl Coating	ZnAl	28	200	0.6	150

Backing reinforcement
As the strength of deposition layer obtained through arc spraying is limited, an extra back lining process is required to strengthen the rigidity and strength.

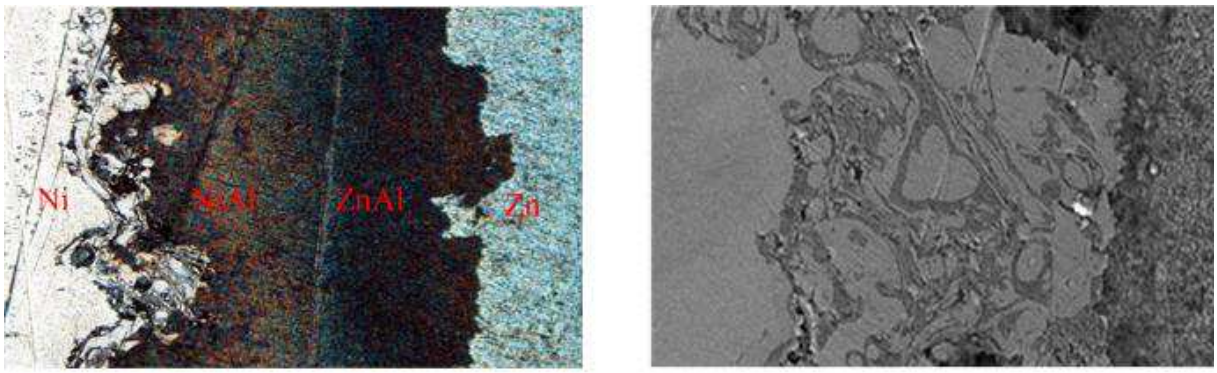
Figure 4: FGM mold cavity

Stripping and post-treatment
Stripping processes are generally carried out after backing reinforcement mainly to prevent mold cavity damage that would cause by external forces when stripping. As there are nodulation and dendritic deposits formation on the

face and side electroforming layer after stripping, mold machining is required according to the mold size. The FGM mold eventually obtained is as shown in Figure 4.

2. EXPERIMENTAL ANALYSIS

Through microscope, the microstructure of FGM working-level cross-section was obtained as shown in Figure 5. It can be seen from Figure 5 (a) that the FGM gradient layer can be divided into four layers from left to right respectively: electroforming Ni layer, arc spray NiAl, ZnAl, Zn layer, which are in gradient change, fully meeting the initial design requirements. The microstructure of electroforming layer is dense, and the arc spray NiAl is flattened after hitting the uneven surface of electroforming nickel layer (Figure 5 (b)), and is closely combined in the surface. As the flying particles is of high speed and mall size, the flattened particles are fully deformed and its thickness is reduced, thus compacted transaction layer of low porosity is formed. As the composition and structure of the FGM mold material are in gradient distribution, there is no obvious interface between two neighboring layers, thus the cohesive bond strength of each gradient layer is greatly increased, which prevent the delamination caused by over stress concentration that might occur at the interface when composite different materials, and make the mold adaptable to different working conditions and improve its service life.



(a)Metallographic **(b)Cross-section morphology**

Figure 5 :FGM cross-section micro-structure diagram

CONCLUSION

Based on the designing theory of FGM, the rapid manufacturing processes of FGM mold was studied in this paper. An FGM mold with nickel electroforming working level, arc spray transition back lining layer and overall back lining layer was. designed and prepared According to the FGM preparation process, mold cavity surface of high coping precision can be produceed through electroforming processing technology, and as level-gradient components are used, the micro-structure of the FGM layer are in regular gradient changes, forming Ni-NiAl -ZnAl-Zn system organizational structure, which can improve the adhesion of interface between different materials while enhancing overall performance of mold. The adoption of arc spray electroforming combing electroforming composite processing technology makes it possible to produce FGM mold not only of comprehensive strength and rigidity, but also of comprehensive performance and working layer that are in gradient change. And this technology provides a fast and economical method to produce mold of high-use performance and long-life.

REFERENCES

[1] Miel, Rhoda. *Plastics News,*Vol. 26 Issue 11, p0014-0014,5 May,**2013.**
[2] Geihe, Benedict; Lenz, Martin; Rumpf, Martin; Schultz, Rüdiger. *Mathematical Programming.* Vol. 141 Issue 1/2, p383-403. 21p. 2013.
[3] Cooper A G, Kang S, Kietzman J W.*Materials & design*, pp. 83-89, **2005.**
[4] Seng Dewen. *Applied Mechanics and Materials*, v. 189, p. 482-485, **2012**.
[5] Adewale, Adeniyi J.; Dinu, Irma; Yasui, Yutaka. *Journal of Computational & Graphical Statistics.*, Vol. 19 Issue 1, p140-153,**2010.**
[6] Steven Ashley. *Mechanical Engineering*,pp.82-87. **2007.**
[7] SENG Dewen, LI Zhongxue. *Journal of Liaoning Technical University*, Vol.27(1), pp.9-12, **2008**.
[8] Gansert R: *NSF Design and Manufacturing Grantees Conference*, *Seattle Washington USA*, **1997.**