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Analysis of Material Characteristics of Cast Metal Molds and Related Heat Treatment Process

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Abstract: *This paper focuses on the analysis of the classification and characteristics of casting metal mold materials, and systematically studies the material heat treatment process and related processing technology of casting metal molds, providing horizontal reference for the integrative improvement of the thermal processing technology level of metal molds and the comprehensive utilization rate of metallic materials.*

Keywords: *cast metal; mold material; heat treatment; processing technology*

1. Introduction

Mold is the core basic equipment for production process parts. The use of batch metal molds can significantly improve the production speed and production efficiency of material processing. Therefore, in the application process of casting metal molds, the reasonable selection of casting materials is very important, especially the need to clarify the performance and level of different processing and manufacturing materials, which is the key to comprehensively improve the quality and efficiency of material processing. Hence, this article has launched a related discussion.

2. Classification and characteristics of casting metal mold materials

2.1 Carbon steel

Carbon steel is one of the unique metal materials in our country, and it is also a metal material with high output in our country. Its collection and processing costs are low, and the material sources are relatively abundant. So it has been widely cited in the manufacturing processing and parts processing and other fields[1]. The material characteristics of carbon steel are as follows: First, the plasticity is strong. The carbon content in the product parts of carbon steel does not exceed 0.6%. Therefore, the proportion of metal materials has a large room for improvement, and it can strengthen the shape of the carbon steel well and be forged into any desired shape in combination with the actual production requirements during the processing process. Second, the softening characteristics of the material are relatively high. During the annealing operation in the process of material processing, the carbon steel can show high softening characteristics, so the plasticity of the softened material can be significantly enhanced, which is the basis for the subsequent operation. The process and operation links provide a good technical guarantee [2]. Third, the cutting type is strong. Compared with the traditional processing metal materials, the hardness of carbon steel is low. It can be directly cut in the form of direct physical processing to obtain the expected mold shape. At the same time, the investment cost of carbon steel is low, and the source of materials is very wide, which can also significantly reduce the actual processing and production costs of production enterprises.

2.2 High carbon and high chromium steel

When the carbon element content of high-carbon and high-chromium steel exceeds 0.6%, and the content of chromium element is also more than 12%[3], there are following characteristics in this kind of steel. The first is the higher hardness. The entry of elements makes the hardness of carbon steel significantly improved. When the content of chromium element is between 12% and 15%, its hardness parameters can reach the peak value. The excellent material properties can effectively resist the corrosion of external oxidation while obtaining higher hardness. The second is better wear resistance. Compared with the wear resistance of carbon steel, high carbon steel cannot leave any metal traces on the basis of

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severe external friction, which can significantly improve the aesthetics of the mold. The third is poor plasticity. In the process of shaping, the difficulty coefficient is significantly higher than that of carbon steel, and the manufacturing difficulty of the mold is relatively high. Fourth, the hardenability is strong. After the quenching operation is completed in the processing process, the high-carbon and high-chromium steel will be rapidly cooled in a short period of time, and the material will undergo secondary hardening, which effectively improves the hardness of the mold.

2.3 High-speed steel

High-speed steel is a new material obtained by changing material parameters on the basis of traditional carbon steel. By adding molybdenum element appropriately, the material properties can be effectively transformed. It has the following characteristics: First, the thermo-plasticity is high. Similar to the properties of carbon steel, high-speed steel in a high temperature environment can have good ductility, so designers can combine different model shapes to reshape its parametric structure, and its process flow and requirements are relatively simple [4]. Second, its toughness is better. Since molybdenum element itself has good ductility effect, high-speed steel can form good mold plastic parameters after adding molybdenum element, which is a good processing parameter material, and its toughness is stronger, more suitable for making molds of various metal materials. The third is high quenching hardness. During the quenching process, this type of material can be cooled in a short time, significantly reducing errors caused by the quenching process.

2.4 Super-hard high-speed steel

Super-hard high-speed steel is also a material obtained after deep processing on the basis of high-speed steel. This material has the following material characteristics: First, the hardness parameter is very high. In order to produce ultra-hard high-speed steel, it is mainly because the daily materials cannot meet the requirements of cutting, such materials must be produced to meet the hardness requirements of other materials. Second, the plasticity is poor. Due to the high hardness of the material, it is difficult to bend it by conventional operating procedures. Third, the production process and processing time are long. When comprehensively selecting super-hard high-speed steel as the actual production material of the mold, it is necessary to use other processing means and processing equipment to shape the mold, so it consumes a high cost of time. At the same time, due to the low toughness of the material, it is more difficult to form, and it has only been promoted in a small range in the actual production and application process.

2.5 Matrix steel

The matrix steel is also a material added with corresponding auxiliary elements during the processing of high-speed steel to optimize the stamping performance and produced after deep processing. Its material properties have the following characteristics: First, the toughness is relatively centered. The toughness properties of such materials are between high-speed steel and super-hard high-speed steel, and they are mold manufacturing materials with relatively moderate toughness [5]. The second is the low cost of its core. Compared with the traditional super-hard high-speed steel, the matrix steel has a good super-hard high-speed hardness index, but in the actual processing process, the material processing cost and equipment maintenance cost are lower than super-hard high-speed steel. Under suitable working conditions, its material properties can adapt to the specific environment in which super-hard high-speed steel is used. The third is its high quenching hardness. During the quenching process of the material, the material can undergo secondary hardening in a short time. Such material properties combine the common performance advantages of high-speed steel and super-hard high-speed steel, which is a new type of mold manufacturing material.

2.6 Alloy material

Alloy material effectively realizes the composite working process of various materials, making it an integrated processing material. This alloy material has the following characteristics: First, the hardness of the material is high. The alloy material combines the excellent individuality indicators of the alloy product, and its material hardness is much higher than the die rigidity. Second, the durability of the material is high. The hardness of the alloy material is relatively large, and it is difficult to leave traces when other materials are in contact with the surface. It is one of the materials with strong durability and is suitable for various industrial processing and mold forming processes. Third, the mass of the product is low. The mass of traditional metal materials is high, and the transportation cost is relatively large in

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the actual handling process. However, when the alloy material is used, the mass is relatively small, which is convenient for the actual handling and deep processing of the material.

3. Thermo-mechanical coupling process of casting metal mold material processing

During the solidification process of the casting, the generation of thermal stress is closely related to the cooling rate. During this process, the boundary changes of the casting/mold can affect the shape of the boundary heat transfer, which in turn affects the effect of comprehensive heat transfer. There is an obvious correlation. The above two aspects together constitute the thermo-mechanical coupling effect of the solidification process of the casting. Therefore, in the process of hardware analysis, it is necessary to start from the two parts of thermal analysis and stress analysis. The process flow is suitable as shown in Figure 1.

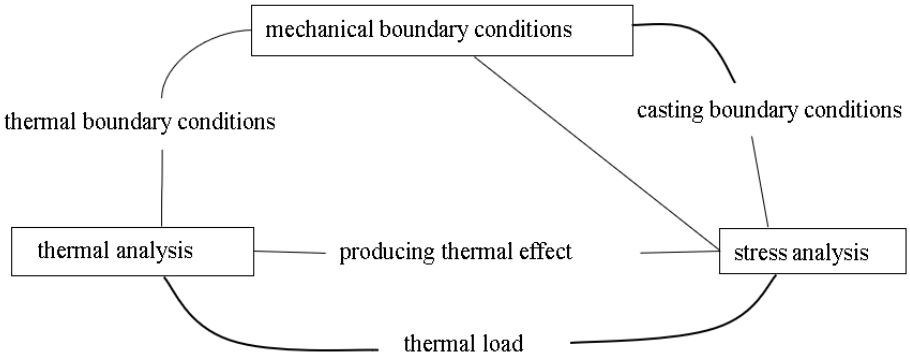

Figure 1 Process diagram of thermal-mechanical coupling

4. Heat treatment process of casting metal mold materials

With the continuous increase of industrial operating costs, the processing and manufacturing costs of metal molds in our country at this stage are relatively high, especially when making parts with high precision, there are higher requirements for the precision of molds. In this process, heat treatment technology is the key to realizing deep processing of materials. It can not only improve the comprehensive quality and comprehensive accuracy of the mold, but also protect the mold itself, effectively prolonging the service life of the mold. According to the parameters of the heat treatment process and heat treatment process requirements, which can be divided into vacuum heat treatment process, cryogenic heat treatment process, quenching heat treatment process, chemical heat treatment process and other processes. Its practical methods and principles are as follows:

4.1 Vacuum heat treatment process

The vacuum heat treatment process needs to be processed and handled under vacuum conditions. The vacuum conditions can avoid the influence of air pollution and air parameters, maximize the cleanliness and parameter requirements of the processing process, and comprehensively improve the manufacturing and processing accuracy of the mold. Especially when the relevant technical operations are carried out in a vacuum state, the surface of the mold will not be disturbed by external factors, so that it still maintains a high activity, promotes the content of other elements in the mold to remain unchanged, and comprehensively improves the mechanical parameter performance of the mold. At the same time, the mold hardness parameter can also be increased by increasing the environmental vacuum degree. In the actual case practice process, the toughness of the material can be significantly improved by vacuum quenching operation, and the service life of the material can also be significantly improved.

4.2 Cryogenic treatment process

Compared with the traditional vacuum heat treatment process, the cryogenic treatment process can also effectively improve the mechanical properties and material strength parameters of the mold material. In the practice of quenching materials, a suitable operating environment is required to carry out advanced

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treatment of materials. After being placed in the constructed cryogenic environment, the material on the surface of the mold can be rapidly cooled in the cold environment, and at the same time, a corresponding protective film will be formed on the surface of the mold as the temperature decreases to significantly improve the wear resistance of the mold and temper resistance.

4.3 Die quenching process

In the process of thermal processing and heat treatment of the mold, sometimes it is necessary to perform a rapid cooling process on the metal material, especially in the quenching process, it is necessary to quickly remove the impurities of the material to ensure the purity and stability of the metal mold material. At the same time, the process of mold quenching can also significantly reduce the carbon content in the mold, so that the mold material can arbitrarily change the shape parameters in real time according to the parameter requirements, and improve the comprehensive performance and shape parameters of the mold material. In particular, the wear resistance of the metal mold produced by the quenching process can be significantly improved, and its operating life has been extended accordingly, which is the key to the current process heat treatment technology.

4.4 Chemical heat treatment process

The process of chemical heat treatment is achieved by fully replacing the metal elements in the material by chemical methods. The replacement process can continue and significantly improve the surface parameter performance of the metal mold. At present, the widely used processes in the chemical heat treatment process mainly include high-frequency nitriding and ion nitriding process, etc. Among them, the ion nitriding process can effectively improve the quality of the surface infiltration layer of the material on the basis of significantly reducing the nitriding time, and is the mainstream of the current method application.

5. Conclusion

This paper systematically sorts out the relevant technical content of the heat treatment process of casting metal mold materials, and deeply discusses the relevant technical principles of thermal-mechanical coupling, which provides reference for horizontal technical practice and product research and development, and promotes the healthy and stable development of the industry.

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