Heat treatment process and analysis of metal materials

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Abstract. With the rapid development of China's economy and society, the application range of metal materials has gradually been widely used in all walks of life. Whether in industry, agriculture, medical industry, etc., they all play a very important role. China's demand for metal materials is increasing day by day, and there is an urgent need for more and better quality metal materials to be consumed in the market. However, China is very scarce in metal materials research teams, talents, complete preparation processes and excellent equipment. It is necessary to strengthen the introduction of talent teams and excellent technology and strengthen the country's team building and mature guidelines system. Among the processing technologies of metal heat treatment, the heat treatment of metal is a fundamental processing technology. China has thrived in recent years and has already possessed complete equipment and facilities, scientific and excellent processing technology, and sound processing technology. In this way, metal materials with excellent properties can be produced, and the heat treatment process can significantly improve the strength, corrosion resistance, and fatigue strength of the metal and reduce the cost of processing. The impact on the environment cannot be ignored in the development process of metal materials. The processing of metal materials should not damage the environment but lose more for less. Therefore, improving metal material processing technology has become an urgent matter. This article will deeply analyze the performance of metal materials after heat treatment, the method of heat treatment processing technology and the innovation of metal heat treatment, and put forward relevant opinions for the heat treatment process of metal materials.

Keywords: Heat treatment process; Heat treatment of metal materials; Metal materials; Performance.

1. Content related to metal materials

1.1. The meaning and type classification of metal materials

The development of human civilization and the progress of society have an irreplaceable role and significance. Metal materials refer to the general designation of metal elements or materials whose main structural characteristics are metal elements. Metal materials mainly include pure metals, alloys, intermetallic compounds and unique metal materials. Metal materials are most commonly divided into three types: nonferrous metals, special metals and ferrous metals. Ferrous metals are also known as iron and steel materials, including more than 90% of pure iron used in industry, cast iron with a carbon content of 2% to 4%, carbon steel with no more than 2%, and various application ranges. High-temperature resistant steel, stainless steel, precision alloy, structural frame steel, etc. First, nonferrous metals are alloys composed of nonferrous metals as the primary matrix, adding other elements into the metal materials. The principal metals of nonferrous metals include metal elements such as Cu, Al, and Zn. Nonferrous metals are one of the earliest metal materials used in human history. According to the application, they are divided into five categories: light metals, density less than 4500 kg/m3 (0.53~4.5g/cm3), such as Al, Mg, K, Na, Ca, etc.; heavy metals: density more fabulous than 4500 kg/m3 (4.5g/cm3), such as Cu, Co, Zn, Pb, etc.; precious metals: more expensive than ordinary metals, less crustal content, stable chemical properties, challenging to purify Such as Au, Ag, etc.; semi-metals: properties between metals and non-metals, such as Si, As, etc.; Rare metals: less in the earth's crust, challenging to extract from raw metals, such as Li, Ti, etc. Unique metal materials refer to materials with special properties, made by unique forming methods or through composition design, such as iron-based austenitic heat-resistant steel, nickel-based alloys, cobalt-based alloys, etc.

1.2. Main properties of metal materials

The properties of metal materials determine the range of applications of metal materials in the field. Chinese researchers need to discover and transform the properties of metals. The basic properties of metal materials are broadly divided into two major categories: craftsmanship and usability. Usability refers to the performance exhibited by commonly used metal materials when used or processed; manufacturability refers to the performance of metal materials to adapt to various hot and cold processes during processing, and manufacturability is also the metal material in the industry. A measure of the ease with which the processing method used produces a finished product. Mechanical properties mainly include several aspects: strength, plasticity, stiffness, toughness, hardness, fatigue strength and corrosion resistance. Strength refers to the resistance of metal materials to deformation or fracture under external force; plasticity refers to the ability of metal materials to undergo plastic deformation before fracture; stiffness refers to the ability of materials or structures to resist elastic deformation under force. The characterization of the difficulty of elastic deformation of the structure; toughness: the ability of the material to absorb energy during plastic deformation and rupture; fatigue strength: the maximum stress that the material will not be damaged under the action of infinite alternating loads; the resistance of metal materials The ability of the surrounding medium to corrode and damage is called corrosion resistance.

1.3. Application fields of metal materials

The properties of metal materials determine the role played by the metal in various fields. The subdivision of metal materials has mechanical, physical, chemical, etc. properties. The mechanical properties mainly include strength, plasticity, hardness, toughness, fatigue strength, etc. For example, the operation of the internal gear of the machine needs sufficient strength, stiffness, hardness and fatigue strength to ensure the regular operation of the machine; the physical properties must ensure that the metal material itself Some properties: density, melting point, electrical conductivity, thermal conductivity, etc., for example, the copper wire in the wire has not only good electrical conductivity but also has excellent ductility; metals also have chemical properties, among which corrosion resistance and oxidation resistance are metals The critical chemical properties of the material, for example the aluminum alloy material used to build the ship has excellent corrosion resistance and oxidation resistance to ensure the service life of the ship. The different properties of metals have determined the different fields of metal applications.

2. Processing technology of heat treatment of metal materials

2.1. Processing significance of heat treatment of metal materials

Heat treatment of metal materials refers to heating metals at high temperatures, and different metals can be obtained at different temperatures and states. These metals can obtain different shapes and properties at different temperatures, and the metals after heat treatment have different properties. Better adapt to and achieve the performance that can be achieved for the metal, as well as the processing technology to remove stress from the metal. Therefore, the heat treatment process of metal materials not only strengthens the current target requirements in the industry but also strengthens the full utilization of metal materials in industries and other fields and promotes the rapid development of various fields.

2.2. Classification of metal material heat treatment processing technology

The processing technology classification of metal material heat treatment mainly includes annealing, normalizing, quenching, tempering, quenching and tempering, aging, cold treatment, flame heating surface quenching, induction heating surface quenching, etc. Each different processing technology corresponds to different purposes. To achieve the expected processing performance, different types of metal material heat treatment processes can be used in the industry for heat

treatment processing. The most essential heat treatment process in life and production: normalizing, annealing, tempering and quenching.

2.3. The purpose and principles of the four heat treatment processes

The process of metal heat treatment mainly includes four heat treatment methods: annealing, normalizing, tempering, and quenching, which are also called "four fires" in metal materials science. By cooperating among these four heat treatment methods for metals, desired metal materials with different properties can be obtained. If according to the order of heat treatment processing:

The "first fire" process of metal heat treatment - the normalizing process of normalizing is to heat the metal workpiece to a suitable temperature and then cool it in the air. When it returns to room temperature, the process of normalizing is to obtain More refined organizational grains. The finer the grains, the stronger the mutual restraint effect, the effective area of the grain boundaries will be significantly increased, and the resistance to the plastic deformation of the metal will be more excellent, thereby improving the strength and hardness of the workpiece. ; The primary purpose of normalizing is to eliminate the overheated coarse-grained structure and Widmansite inside the workpiece. It can also eliminate the reticular secondary cementite and refine the pearlite, improving its mechanical properties and conducive to subsequent processing. Spheroidizing annealing can eliminate free cementite at grain boundaries to improve deep drawing performance.

The "second fire" process of metal heat treatment - the annealing process is to heat the metal material to the predetermined temperature slowly, keep it for a sufficient period, and then cool it at a more appropriate speed. The annealing process in the heat treatment process The purpose is to reduce the hardness, improve the machining performance of the workpiece, reduce the residual stress in the workpiece, thereby stabilizing the size and reducing the possibility of cracks and cracks in the workpiece, and refine the grain of the structure to adjust the entire structure. Annealing can be further classified into spheroidizing annealing and stress relief annealing;

The "third fire" process of metal heat treatment - quenching. Quenching is a process that heats steel above the critical temperature and then holds it for a certain period to make it austenitized to be greater than the critical cooling rate. A large number of austenitic The body can quickly transform into hard martensite. The purpose of quenching is to improve the wear resistance of the workpiece and maintain high strength and hardness, improve the workpiece's toughness and elasticity and enhance its corrosion resistance and oxidation resistance. For the quenching process in order to get more excellent performance, on the one hand, it is necessary to ensure that its cooling rate is more significant than its critical cooling rate so as to ensure that austenite is transformed into a large amount of martensite; on the other hand, the cooling rate should be slowed down as much as possible to reduce internal stress and avoid cracks in the workpiece and cracking defects. However, the change in its internal structure is also different under different quenching temperatures. When fully quenched, the structure in the quenched structure of steel is mainly composed of a large amount of martensite, while in the case of incomplete quenching, hypo eutectoid The microstructure of the steel is composed of martensite and ferrite. When the carbon content in austenite is more significant than 0.5%, the structure of the quenched microstructure is martensite and retained austenite. The structure obtained by hypereutectoid steel is the structure of martensite and cementite, and the quenching process used in hypereutectoid steel is incomplete quenching, which is abnormal because such a process cannot achieve the highest requirements in the industry. Hardness. It will be a regular process if the hypereutectoid steel adopts incomplete quenching. This process can make the steel obtain the highest hardness and wear resistance. It is heated at a suitable temperature, and the martensite obtained after quenching is fine. Suppose the heating temperature is too high during processing. In that case, the steel structure will form coarse acicular martensite, which will cause the material to become brittle and may even cause cracks in the steel to affect the properties of the steel.

The "fourth fire" process of metal heat treatment - tempering. Tempering is a heat treatment in which the quenched steel parts are heated to the specified tempering temperature. Then after a certain period of heat preservation, they are air-cooled to room temperature. Operation tempering will cause

the decomposition of martensite and retained austenite. The primary purpose of tempering is to reduce or eliminate the internal stress of the workpiece structure to prevent cracking and obtain the required mechanical properties. After quenching, the hardness is high, and the brittleness is high. Tempering can adjust the hardness and toughness and stabilize the size.

3. Main steps of the metal material heat treatment process

3.1. What is the heat treatment process of metal materials?

The heat treatment process of metal materials is widely distributed in various fields of people's lives and work and has an irreplaceable role. The heat treatment process of metal materials is mainly to put the metal workpiece in the medium and heat it to a suitable temperature. After being kept at this temperature for a certain period of time, it is cooled at different cooling rates to control the performance of the workpiece by changing the surface or internal structure of the metal material. The heat treatment process of metal materials is widely distributed in mechanical manufacturing and is significant. Compared with other processes, the heat treatment process generally does not change the shape of the workpiece and its internal chemical composition. Its main change feature is to improve the workpiece. The overall quality of the interior is not visible to the naked eye. The heat treatment process can be roughly divided into overall, surface, and chemical heat treatment. The effects and expectations of each heat treatment process are different, and the production and processing are determined according to the needs.

3.2. Process flow of metal material heat treatment process

When metal materials are heat treated, three main elements must be grasped: heating, insulation and cooling. The interrelationship between the three elements requires supporting use. The first step in heat treatment of metal materials is heating. When heating metal, the heating temperature and heating time of the metal must be considered to ensure that the metal can be fully heated to the predetermined time. Taking steel as an example, the annealing process must be performed first, and the steel parts must be annealed first. After heat treatment reaches Ac3+30~50 degrees or Ac1+30~50 degrees or reaches a temperature below Ac1, then slowly cool the furnace temperature to complete annealing. After completion, the steel piece is heated to above Ac3, and after heat preservation, it is cooled at a cooling rate slightly higher than that of annealing; normalizing is completed. After completion, the steel is heated to the phase transformation temperature Ac3 or Ac1 or above. After a period of heat preservation, it is quickly cooled in water, oil or air to complete the quenching process.

Then, reheat the quenched steel parts to a temperature below the Ac1 temperature. After insulation, cooling in water, air or oil is called tempering. Try to avoid temperatures between 230~280℃ for steel and 400~450℃ for stainless steel. Tempering avoids brittleness and reduces performance. Finally, cold-treat the quenched steel and cool it to a low enough temperature in a low-temperature medium. When the temperature is uniform, take it out to room temperature. There will be various processing technology defects in the production and processing technology, and the temperature control cannot meet the ideal requirements, resulting in losses. The performance of the workpiece cannot reach the expected level, and cracks and cracks may even occur, causing economic losses.

4. The status of metal material heat treatment processing technology

The heat treatment process of metal materials plays an incomparable role in the industry. Most of the metal parts in the industry need to be strengthened and improved by heat treatment, and the hardness and strength of the metal parts are strengthened by quenching. After heat treatment, the metal parts The cutting performance of parts is better, it is easier to cut and process in the industry and reduce the processing time of industrial metal materials, improve the fatigue strength and increase the service life of metal parts, and add rare metals to change the corrosion resistance and resistance of metal parts The abrasiveness meets the processing and needs of modern industrial parts, greatly

enhancing the quality and production efficiency of industrial products. Improving the quality and performance of metal parts has not only changed China's industrial status and development level but also greatly enabled China to provide strong support for manufacturing industries such as industry.

5. Introduction of innovative technology for heat treatment of metal materials

5.1. New surface strengthening technology and promotion of nitrogen-based atmosphere heat treatment technology

The surface treatment methods of the original tools are limited to relatively backward methods such as oxynitridation and steam treatment. The old methods generally can only increase the service life of the processing tool by 30% to 50%, making the service life of the tool relatively low. With the vigorous development of China's industry since the 1980s, China has successively independently developed, researched and introduced various new technologies from overseas, such as QPQ salt bath composite treatment technology and PVD titanium oxide physical coating technology, etc. The former method can significantly increase the tool's service life by 2~3 times, and its advantages are low cost, which is suitable for promotion and use in China. The latter can even increase the service life of the tool by 3~5 times, and is more suitable for processing some more precise parts. Brand new The advanced heat treatment process technology has greatly enhanced China's production efficiency.

5.2. Controlled atmosphere heat treatment technology

The primary function of controlled atmosphere heat treatment is to prevent oxidation and decarburization, achieve precise control of nitriding and carburizing, and effectively inhibit and improve the deformation and cracking of parts during heat treatment. The concentration of infiltrating elements can be controlled more precisely to improve the performance and quality of the parts, and the controllable atmosphere heat treatment technology can be well controlled to reduce the difficulty of operation.

5.3. Vacuum heat treatment technology

The working environment of the salt bath quenching technology is limited by the times and has become a product of the era. The vacuum heat treatment technology can be promoted and further developed and improved in China. The vacuum heat treatment technology has no decarburization and no oxidation; It has the advantages of no pollution, excellent surface quality after quenching and a high degree of automation. Technologies such as vacuum annealing, vacuum degassing, vacuum oil quenching and vacuum tempering are widely used in industry. In recent years, the perfection and forming of vacuum heat treatment technology have greatly improved the development of modern industry and have obtained more excellent protection for improving the quality and performance of workpieces.

5.4. Induction heat treatment and ion nitriding heat treatment technology

The birth of induction heat treatment and ion nitriding heat treatment technology shows the advantages of future heat treatment technology. Induction heat treatment technology is widely distributed in the automobile industry, mechanical engineering industry and petrochemical industry due to its advantages of high efficiency, clean energy saving, and flexible use. The use of induction heat treatment technology can enable many processes to be built into fully automatic production lines, reduce labor intensity, beautify the working environment, and improve the quality of parts and work efficiency, making induction heat treatment and nitriding heat treatment technology have higher application value.

6. Conclusion

To sum up, the heat treatment process of metal materials has been developed in the direction of cleanness, high efficiency, excellent properties and easy operation. The process of heat treatment of metal materials is undergoing innovation, and new technologies will replace old ones. In terms of industrial demand, we will continue to strive to improve the performance and quality of parts, and various new technologies will provide strong support for the development of China's industrial undertakings. Relevant researchers should vigorously develop and improve the existing heat treatment process, improve the performance and cutting process of metal materials, With the continuous improvement of China's scientific and technological level, more and more new heat treatment technologies are emerging, surface strengthening technology and promotion The development of new technologies such as nitrogen-based atmosphere heat treatment technology, controllable atmosphere heat treatment technology, and vacuum heat treatment technology will add a lot of color to China's industrial development, and provide an incomparably important role for the development of metal material heat treatment.

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