Research Progress of Thermal Spraying Technology

Yueyun Fang[1,a], Hao Cui[2]

[1]Guangdong University of Science & Technology, Dongguan, 523083, China;

[2]China Nuclear Industry Huaxing Construction Co. Ltd, Nanjing, 210000, China.

[a]996987541@qq.com

Abstract

Thermal spraying technology is one of the surface technologies widely used in equipment maintenance and mechanical manufacturing. Thermal spraying is a surface processing technology that uses a heat source to heat the spraying material to the molten state, atomize it by air blowing and spray it to the part surface at high speed to form the spraying layer.

Keywords

Thermal Spraying Technology; Flame Spraying Technology; Arc Spraying Technology.

1. Introduction

Thermal spraying technology can deposit ceramic coatings on metal substrates, and combine the characteristics of high temperature resistance, wear resistance and corrosion resistance of ceramics with the characteristics of strength, toughness, machinability, conductivity and thermal conductivity of metal materials to obtain ideal composite coating products. It has become an important development direction in the field of composite materials and products. Thermal spraying materials can be divided into metal materials, special metal materials, organic polymer materials, ceramic materials and biomaterials. According to the coating structure, there are nano coating materials, alloy coating materials, amorphous coating materials and composite coating materials composed of these materials. At present, in order to meet the requirements of multi-function and high performance of materials, the composite of various materials, the use of nano materials, new alloys or amorphous materials have become the main development trend of thermal spraying materials [1].

2. Classification of thermal spraying technology

According to different heat sources, traditional thermal spraying methods can be divided into combustion method and electrothermal method. The former includes flame spraying and explosion spraying, and the latter includes arc spraying and plasma spraying. In recent years, with the further improvement of people's requirements for coating performance, the majority of scientists have developed supersonic flame spraying and supersonic plasma spraying on the original basis through continuous innovation. At the same time, laser spraying, reactive thermal spraying and cold spraying have been developed.

2.1 Flame spraying technology

As a new surface protection and surface strengthening process, flame spraying technology has developed rapidly in recent 20 years and has become a very active branch in the field of metal surface engineering. Flame spraying uses the flame of combustible gases such as acetylene, propane and oxygen as the heat source to heat the spraying material to the melting or near melting state, and auxiliary gases such as nitrogen or compressed air spray it to the substrate surface to form a coating.

The basic characteristics of flame spraying technology are as follows: ① general metal and non-metal substrates can be sprayed, and the shape and size of the substrate are usually not limited, but the small holes can not be sprayed at present; ② A wide range of coating materials, metal, alloy, ceramic and composite materials can be coating materials, which can make the surface have various properties, such as corrosion resistance and wear resistance; High temperature resistance, heat insulation, etc.:

③ The porous structure of the coating has oil storage, lubrication and antifriction properties. The macro hardness of the spray coating containing hard phase can reach 450hb and the spray welding layer can reach 65hrc; ④ Flame spraying has little influence on the matrix. The heating temperature of the matrix surface is 200-250℃, and the overall temperature is about 70℃-80℃, so the matrix deformation is small and the material structure does not change.

Disadvantages of flame spraying technology: ① the bonding strength between spraying layer and substrate is low and can not bear alternating load and impact load; ② High requirements for substrate surface preparation; ③ Flame spraying process is affected by many conditions, and there is no effective detection method for coating quality [2].

2.2 Arc spraying technology

Arc spraying is a thermal spraying method that uses two sprayed wire or linear conductive materials as consumable electrodes, uses the arc energy generated between them to nearly melt the electrode material, atomizes it with high-speed compressed air and sprays it onto the substrate.

Arc spraying takes the arc as the heat source, so the sprayed materials must be conductive, usually only metal materials. Non conductive ceramic materials are difficult to be arc sprayed, which is the biggest limitation in its application. However, arc spraying has its outstanding advantages, which can be summarized as follows:

(1) The bonding strength between the obtained coating and the substrate is high, which is generally 1.5-2.5 times that of flame spraying coating. This is due to the high melting particle temperature and large deformation of spraying particles. In some cases, for example, when arc spraying aluminum on steel substrate, micro zone diffusion metallurgical bonding structure can also be produced on the interface, which greatly improves the bonding strength of the coating.

(2) High spraying efficiency. Spraying efficiency refers to the metal weight sprayed per unit time. It increases with the increase of arc current. The efficiency of arc spraying can be 2-6 times higher than that of wire flame spraying.

(3) High energy utilization. The energy utilization rate of plasma spraying is 4%-12%, that of flame spraying is 5% - 13%, and that of arc spraying is as high as 57%-67%.

(4) Good economic benefits. Compared with all other thermal spraying methods, arc spraying has the lowest cost, simple equipment and less than 1/3 of the investment cost of plasma spraying method. Due to the high energy utilization rate and the fact that China's electric energy is much cheaper than oxygen, acetylene and other raw materials, its operation cost can reach only 1/10 of that of flame spraying.

(5) Easy to realize automation.

(6) Safety. The safety is greatly improved by using electricity and compressed air without flammable gases such as oxygen and acetylene.

2.3 Plasma spraying technology

In the conventional state, the atom is electrically neutral, and the gas is also non-conductive at room temperature. However, if the outside world gives gas molecules or atomic molecules considerable energy by changing conditions, it will cause electrons to separate from the atom and become free electrons with positive charge. This is the so-called phenomenon of ionization of gas, This is the generation principle of plasma and plasma arc in plasma spraying.

Plasma spraying is a technology of material surface strengthening and surface modification, which can make the substrate surface have the properties of wear resistance, corrosion resistance, high temperature oxidation resistance, electrical insulation, heat insulation, radiation protection, wear reduction and sealing. Plasma spraying is realized by plasma spray gun. The nozzle and electrode of the spray gun are respectively connected with the positive and negative poles of the power supply. Working gas is introduced between the nozzle and electrode. The arc is ignited with the help of high-frequency spark. The arc heats and ionizes the gas to generate plasma arc. The gas thermal expansion

is ejected from the nozzle to generate plasma flow, and the powder is sent to the plasma jet by the powder supply pipe, It is heated to the molten state, accelerated by the plasma jet and sprayed to the surface of the pretreated substrate at a certain speed to form a coating [3].

3. Application of thermal spraying technology

Thermal spraying technology can spray most solid engineering materials such as various metals and alloys, ceramics, plastics and non metals, so it can be made into functional coatings with various properties, with flexible construction, strong adaptability, wide application range and outstanding economic benefits, especially for improving product quality, prolonging product life, improving product structure, saving energy and precious metal materials It plays an important role in improving work efficiency and reducing cost. Thermal spraying technology plays an important role in the field of mechanical damage repair of various metal or non-metal parts. At present, it is mainly used in the following aspects:

(1) Manufacturing new parts, such as manufacturing stamping plastic and leather product molds by arc spraying, plasma spraying ceramic nozzles or refractory metal nozzles, radar fairing, high-temperature furnace components, and engine parts of fiber-reinforced titanium composites.

(2) Modification of materials in terms of material modification, the treatment of ordinary materials with thermal spraying technology can change the chemical composition and microstructure of the surface as needed, so as to strengthen some properties of the surface.

(3) Core repair in the field of core repair, thermal spraying technology can not only restore the size of parts, but also strengthen the surface performance of parts and double their service life, which is of great economic significance.

(4) Prepare specific functional coatings, such as wear-resistant coating, corrosion-resistant coating, high temperature resistant coating, shielding coating, insulating spraying layer, oxidation-resistant coating, etc., so as to improve the surface properties of materials.

References

[1] Kan G, Wen L. Thermal Spraying Technology [J]. Powder Metallurgy Technology, 1985.

[2] Heimann R B. Thermal spraying of biomaterials [J]. Surface & Coatings Technology, 2006, 201(5): 2012-2019.

[3] Wang Y, Khor K A, Cheang P. Thermal Spraying of Functionally Graded Calcium Phosphate Coatings for Biomedical Implants [J]. Journal of Thermal Spray Technology, 1998, 7(1):50-57.