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Full Length Research Paper

Metal spraying for revamping and keeping pieces

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Metal spraying for coating industrial pieces and products are applied in different industrial fields. In these recent years, many researchers have focused on developing various metal spraying methods and their relevant conditions and characteristics. Metal spaying are applied for revamping and reforming new and worn out pieces. In the surface coating by metal spraying, metal particles shoots to the considered surface to make mechanical coating. The advantages of metal sprayed coating which makes this method more desirable for designers in industrial products are, surface uniformity, good porosity for oil suction, high solidity, adhesion to the base metal, resistance against acids and resistance against impact, rust, pressure and wear. In this paper, an investigation is made on different methods of metal spraying such as hot, cold and plasma spraying methods in addition to the advantages and the shortcomings of each one. In addition, the surface preparation for products are introduced.

Key words: Metal spraying, coating, revamping, mechanical coating.

INTRODUCTION

Metal spraying was used for the first time in 1910 in Sweden. In recent times, usage of metal spraying with its developed methods is unavoidable. In the coating of surface by metal spraying, metal seeds as a single sparks are shotted to the surface with high speed so that that it makes a mechanical connection between them. This method has uses in many fields for reform and revamping pieces against the mechanical and chemical negative effects and also, for resistance against impact, pressure, corrosion, molding and wearing in different industries such as airspace, oil, petrochemical, agriculture, metallurgy, car factories (Hanada et al., 2005). The advantages of using this method are as follows:

1. Metals with high melting degrees can be used for spraying.
2. The adhesive between the coating metal and the base surface will be mechanical and very strong.
3. The variety of spraying conditions can create layers with different thickness.
4. The porosity of sprayed metal absorbs and keeps oil.
5. Different metal combinations allow making of different alloyed coating.

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METAL SPRAYING METHODS

Different methods can be used for metal spraying while considering the application of each specimen such as, hot spraying, cold spraying, plasma spraying, and Hypersonic spraying.

Hot spraying

Hot metal spraying provides significant advantages over other available coatings for specific applications that require particular performance properties. In this method, a special powder is used which makes the connection to be as a weld. This powder has special technology and is exclusive. Moreover, it is not possible to implement the hot method spraying with common powder.

Cold spraying

Generally, the main consideration regarding metal spraying is related to the cold techniques. This method was first invented by Russian researchers in the year 1990. Cold spraying involves injecting microscopic powdered particles of metal or other solids into a supersonic jet of rapidly expanding gas and shooting them at a target surface. When these particles hit the substrate, they 'splat' so hard they stick and form a coating. The surface does not get so warm because of the existence of air pressure. This method can be used when it is not necessary to warm so much the considered surface. The maximum and minimum degrees in this method are 40 and 200℃, respectively. The most important thing in this method is to carefully and completely carry out the instructions such as roughness, cleaning the compressor's air, spraying gap and hand motion velocity (Kulmala and Vuoristo, 2008; Li et al., 2008).

Plasma spraying

Plasma is a complex technology in the metal spraying. In the plasma systems, there is a durable anode and cathode. By connecting them and also using electrodes, material plasma is created. To use the plasma, anode is made as a nozzle to allow entering of the gas in the electrical arc and it exits with pressure from other side. In this process, the gas turns to the separated atoms then gets ionized and exits from the nozzle as a flame of plasma. Exited plasma has electrical current. Metal powder gets out of the of the system's exit with high speed and it is floating in the gas. At this time, the ionized gas returns to its initial condition. Much energy gets released in the returning process that melts the metal powder very quickly in about 8000 to 20000℃, and sprays it on the surface with high speed. Because of the high temperature and high thermal energy of the plasma jet, materials with high melting points can be sprayed, with plasma spraying widely applied in the production of high quality sprayed coatings (Ismagilov et al., 1999; Zhang et al., 2001).

Gases used in the plasma spraying

Many gases can be used in the plasma process such as Nitrogen, Hydrogen, Azoth, Argon or Helium. Nitrogen is used mostly in common situations and has low cost. Hydrogen creates wear and ruins the anode. Hence, if it combines with Azoth at about 10%, it would increase the temperature of plasma flame and improves the hot transition. Chemical reactions are so significant in selecting plasma gas. For example, zirconium and titanium absorb nitrogen and oxygen to become very brittle and hydrogen to become hydride. Consequently, for these metals, a pure gas is needed for plasma and for transforming powder. This pure gas can be either argon or helium (Fahim and Kobayashi, 2006; Kim et al., 2010; Zhouet al., 2007).

Material used for plasma

Plasma can be sprayed with all pure metals, metals alloys, metals oxides, cermets and carbides, and their selection depends on what is needed. Plasma powders are special and no other powder can be used in plasma machines (Tahara et al., 2006; Wan et al., 2003).

Plasma spraying method advantageous

1. Accessing the under control atmosphere for the flame is one of the advantages of the plasma method. In this method, a neutral gas has an effective role for flame to control chemical reactions such as oxidizing at the time of heating or the flow of sprayed particles.
2. Achieving the degree of 20000℃ is another characteristic of this method. This temperature is much more than the melting or evaporating of the identified materials.
3. Using plasma increases the heat transfer power very much.
4. In this method, velocity of particles increases to almost 600 m/s.

Hypersonic

In this method, the system is located at the head of spraying pyramid as shown in Figure 1. Gun is designed to give metal particles a speed that is a few times more than the sound velocity which leads to inserting this particle to the surface after shooting with an acceleration of 750 to 1000 m/s. This system in comparison with the plasma method, is simpler, cheaper, more accurate and does not need Argon gas. Its fuel is supplied by hydrogen or propane and oxygen (Wagner et al., 1984). The carrying gas of the powders is Azote. In this method, the surface has a high density and is with minimum porosity while being almost smooth (Rao et al., 1998).

METAL SPRAYING AND HEATING SYSTEM

The metal spraying technology while considering the heating system is described here (Ait-Messaoudene and Abdellah El-Hadj, 1998; Paredes et al., 2006).

Combustion

In spraying by combustibility method, the gas which has combustion ability is used as the supplier for the heat. In this process, the heat of oxygen chemical reaction is used as a one base and other gases such as acetylenes, Propane, hydrogen and other natural gases are used as the other base. These gases can produce heat at 2650 to3160℃. By considering the gun in designing process, it is possible to spray specimens with melting temperature less than 2750℃.

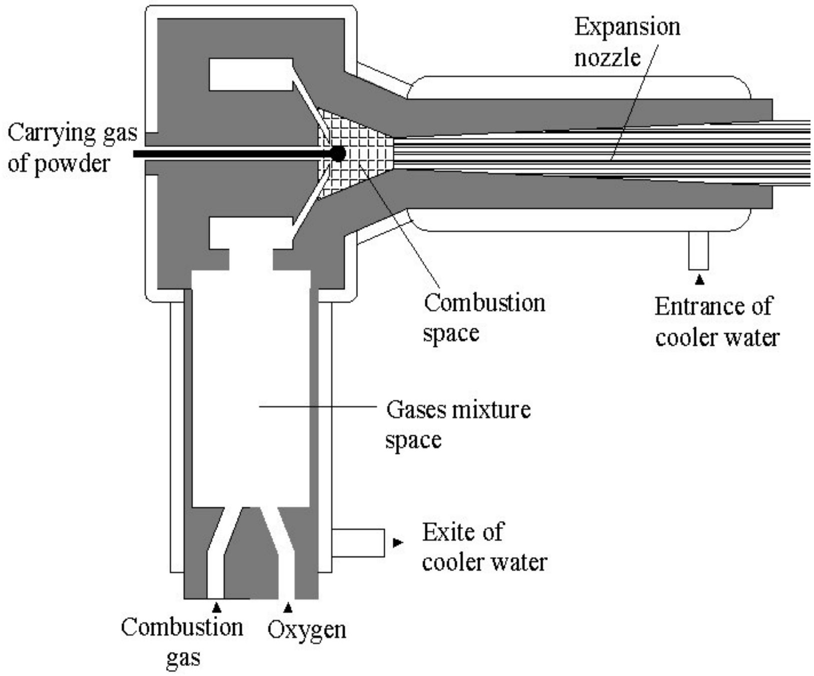

Figure 1. Spraying pistol of hypersonic system.

Combustion gas gets the particle near the melting point, and then the compressed air shoots them to the piece's surface. This method can be made as powder flame method, wiring flame, hypersonic combustion method and explosive method; some of them are explained here (Gonda et al., 1993).

Powder flame method

In this method, some predetermined powder enters to the flame and is then shot to the surface by the air jet. Some parameters have an effect on the coated layers such as the production technology of powders, flame conditions, distance of the pistol to the surface, the amount of used powder, and the experience of the operator (Ballard, 1966).

Wiring flame method

In this method, a wire passes through the pistol and at the exit of the gun, it gets melted by the oxide acetylene, and then it is shot to the surface by the air jet.

Explosive method

In this method, the gases mixture in the entrance space of the pistol explodes by the spark (Figure 2) and then, the expanded gas exits from the other space. This gun may creates so much noise and the speed of particles can exceed 1300 m/s, that results in the layer being very compressed (Gibson, 1961).

Electrical heating

In the metal spraying, some devices operate by electrical heating. They are the arc spraying and the plasma spraying devices.

The arc spraying device can be sprayed over all metals which conduct electricity and produce heat at 5000˚C. In this system, two metal wires are used. These wires at the head of pistol are contacted to each other and make the electricity arc. Produced molten, as single sparks, with high speed is shot to the surface by compressed air. One of the advantages of this method is alloying two metals at the head of the pistol and spraying the molten to the surface (Crcsswell, 1962; Ismagilov et al., 1999).

SURFACE PREPARATION

Sprayed metal connection defaults can be eliminated by cleaning and preheating the considered surface before spraying. Surface preheating (up to 175 to 200˚F) before metal spraying can avert all possible atmospheric humidity on the surface. Preheating of big rods before metal spraying can prevent creation of cracks and adhering coat to the surface effectively. Surface preparation for coating includes surface cleaning and surface roughing (Gonda et al., 1993).

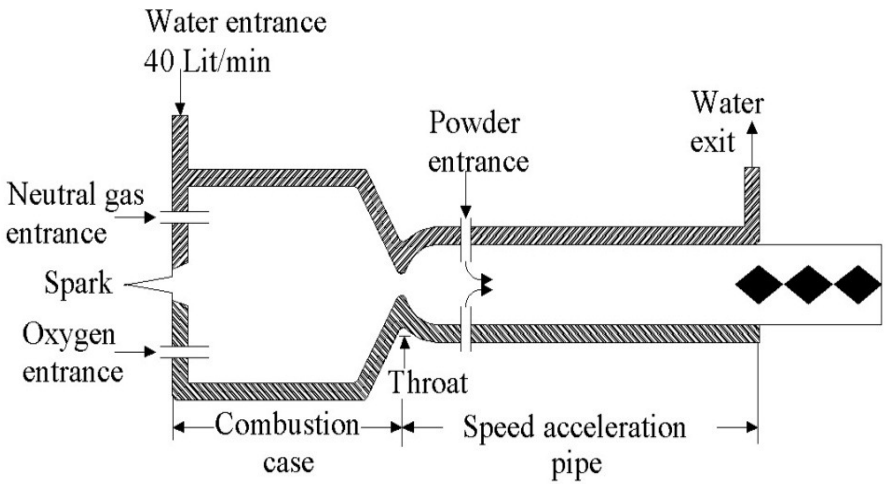

Figure 2. Schematic of hypersonic explosive gun.

Surface cleaning

Surface cleaning involves the cleaning of oil, grease and any other substance that prevents a good connection. Cast iron and other porous material should be preheated at temperatures of 500 to 800˚F to clean their surface from oil and other external substances. In some cases, chemical cleaning seems necessary. Sometimes, in order to prevent extra carbon from being preheated; cast iron is used as a flow of abrasive materials.

Surface roughing

The final stage before metal spraying is roughing the surface. Clearance and roughness of surface has a significant effect on the connection strength between the specimen surface and coating layer. Many methods are used for surface preparation. When surfaces of device parts such as shafts and other cylinder pieces need thick coating, they are readied by grooving or screwing, and then a thin Molibdenum layer is sprayed on the piece surface as glue for other metals. This coating increases shear strength up to 16000 Lb/in^2 and increases tensile strength up to 3000 Lb/in^2. In some cases when the thin coating layer is needed, the groove screwing of surface is not used. Moreover, the Molibdenum coating is used for preparing the surface. Abrading flow is usually used for preparing surface for the subsequent stages. Abrasive materials flow is used for coating of some metals such as aluminum and zinc.

CRANKSHAFT REFORMING BY METAL SPRAYING

The following instructions should be noted in order to reform crankshafts by metal spraying:

1. Cleaning of crankshaft surface.
2. The crankshaft surface must be grinded 2 mm in diameter relative to the standard diameter.
3. After grinding, the surface must be checked for the cracks. A crankshaft with crack is not proper for metal spraying.
4. To repeatedly cleans the surface from oil.
5. Heating the specimen up to about 60℃.
6. Roughening of the surface by oxide aluminum, and then preheating it to 60˚C.
7. Filling the oil holes by using wood.
8. In order to have coating with uniform thickness, rotating machine is set to 50 rpm.
9. By using a special wire, the crankshaft is sprayed 1 mm in diameter more than the main diameter. Maximum thickness spraying is 3 mm in diameter.
10- After metal spraying, grinding must be done by using the special grinding stone suitable for the metal which is sprayed.

Crankshaft must not be heated more than 150˚C otherwise the process should be stopped. Moreover, the sprayed surface is not allowed to get cold, if so the spraying process is performed again.

Conclusion

Metal spraying is very useful in different fields of industry and can be used for various pieces. This coating method has some advantages. By controlling the spraying condition, all our expectations can be achieved. In addition, it is possible to perform coating of the pieces by alloys. Another advantage of this method is the reduction in costs. Using this method is recommended for reforming and revamping mechanical pieces that must have a considered hardness, solidity, and resistance against wearing, corrosion and impact.

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