ORIGINAL RESEARCH ARTICLE

Rocess Design of Fiber Reinforced Magnesium Matrix Composites

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ABSTRACT

This paper chooses magnesium as the matrix of composite materials, selects carbon fiber as reinforcement, and designs the composite scheme according to the structure and performance of Mg-based composites. The performance characteristics and application prospect of fiber-reinforced magnesium matrix composites are introduced. Wait. In this paper, the process of preparing carbon fiber magnesium matrix composites by compression casting method and spray deposition method is designed. The process flow chart of these two design schemes is determined by analyzing the principle of these two kinds of preparation methods, and the specific problems of the process are analyzed and summarized.

KEYWORDS: fiber reinforced; magnesium base; extrusion casting method; spray deposition method; process flow

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Preface

Although the traditional magnesium metal and its alloys have good strength, stiffness, toughness, but its corrosion resistance, oxidation resistance and plasticity and other aspects are unsatisfactory. And in the composite through the material, it shows good chemical properties, wear resistance to fatigue, high temperature and a series of excellent performance by aerospace, automotive, machinery and electronics and other high-tech areas of attention [1]. Since the 1980s, magnesium matrix composites have become one of the hotspots of metal matrix composites [2-3].

1. Performance characteristics of fiber reinforced magnesium matrix composites

Compared with the traditional metal materials, metal matrix composite material has a high specific strength, than the rigidity, high temperature, thermal expansion coefficient is small, chemical stability, wear resistance and fatigue resistance and excellent damping performance and many other excellent performance features [4] [11], it is due to its simple preparation process, micro-organization uniformity, material properties of the same nature and other advantages are now moving in the direction of industrial production and application of continuous development, including aluminum-based composite materials the fastest [5]. On the other hand, because magnesium has a lower density than aluminum, has better specific strength, specific stiffness, and has good electromagnetic shielding and damping performance [6], magnesium-based composite material has become another strong competitive of the light metal-based composite materials, the current magnesium-based composite materials used in automobile manufacturing, aerospace, electronic technology and other fields of the ideal material [7].

At present, the composite material for magnesium metal is fiber, whisker and granule [8]. The composite of magnesium metal with carbon and graphite fibers can obtain a magnesium matrix composite material with high specific strength, high specific modulus and good thermal stability [9]. The properties of the composites depend on the type and properties of the carbon fibers, the content, the distribution and the state of the interface with the matrix. Compared with the modulus and thermal stability, the graphite fiber reinforced magnesium matrix composite material is the highest of all kinds of materials when the graphite fiber content is about 50%, the coefficient of thermal expansion of the graphite fiber reinforced magnesium composite is zero, which can be divided into continuous carbon fiber reinforced magnesium and discontinuous carbon fiber reinforced magnesium composite material according to the fiber state. Continuous long fibers can be laid according to design requirements for anisotropic materials. The performance of unidirectional fiber-reinforced magnesium-based composites in the fiber direction is higher than that in the direction perpendicular to the fiber [10] [29].

2. Application background

In the current engineering metal, magnesium alloy density is small but high strength, good rigidity, and the stiff ness of its magnesium alloy increases with the thickness of the ratio increased, so the magnesium alloy made of good rigidity of the overall component design is very favorable. Moreover, the toughness of magnesium alloy is good, it is suitable for the impact of the parts - the wheel; its excellent shock absorption performance, is to avoid vibration, noise caused by fatigue and other occasions ideal materials. On the other hand, the magnesium alloy has a low heat capacity, a high solidifi cation rate, a good die-casting performance, and excellent machinability [12].

However, magnesium metal is very lively, easy with the role of oxygen in the air spontaneous combustion, and the metal surface is easy to oxidation, the formation of loose magnesium oxide, cannot eff ectively block the invasion of oxygen, thereby accelerating the oxidation of magnesium metal is oxygen, leading to its corrosion Poor performance. In addition, magnesium metal room temperature plastic poor. Magnesium is a dense hexagonal crystal structure, which has only one slip surface and three slip lines at room temperature, so its plastic deformation mainly depends on the coordinated action of slip and twins, but the slip in the magnesium crystal only occurs In the sliding surface and the direction of the tilt of some of the crystal, so the process of slipping will be greatly limited, and in this orientation is diffi cult to occur under the twins, so the crystal will soon appear brittle fracture. When the temperature exceeds 250 ° C, the additional slip surface in the magnesium crystal starts to function and the plastic deformation ability becomes stronger.

So the researchers for the advantages and disadvantages of magnesium metal analysis began to study the magnesium metal material composite, in order to achieve the purpose of improving the performance of the metal, and fiber-reinforced magnesium matrix composite material is a good way to improve one.

3. Material composite system selection

3.1. Substrate material selection

At present, aluminum-based composite materials with its high specific strength, high modulus, wear resistance, corrosion resistance and many other excellent performance has been rapid development, and widely used in automotive, aerospace, electronics and optics Equipment and sporting goods and other fi elds. In this paper, the choice of matrix material, taking into account the lower density of magnesium (1.74g / cm3), only aluminum 2/3, with a higher specifi c strength, specific stiffness, and has good damping performance and electromagnetic shielding Performance, while the magnesium-based composite material reinforced carbon fi ber has a good high temperature, corrosion resistance, insoluble and other characteristics, so the composite material will have a high specifi c strength, than the rigidity, high temperature, thermal expansion coeffi cient, chemical stability , Wear resistance to fatigue and excellent damping shock absorption properties and other properties [7].

In general, the properties of the composites depend on the interaction between the substrate and the reinforcement material and the material. Therefore, in order to obtain a magnesium matrix composite with excellent properties, it is necessary to control the composition, Process and parameter control to take into account, to fi nd the best conditions in order to fi nd a comprehensive performance, to adapt to the process of industrialization, the industrialization of new composite materials. On the other hand, due to the current aluminum-based composite material preparation process has matured, has developed a number of methods for synthesis preparation, and magnesium melting point and aluminum similar to the magnesium-based composite material preparation process and aluminum-based composite material similar, so In the process design can refer to the aluminum composite materials production process, and to improve to adapt to the magnesium-based composite materials. Therefore, this design selects magnesium as material for composite material matrix.

3.2. The choice of reinforcement

The selection of the enhanced phase is basically the same as that of the aluminum matrix composite material. Generally, the physical and chemical compatibility is good, the wettability is good and the load bearing capacity is strong, so as to avoid the interface reaction between the strengthening phase and the matrix. Generally, the enhanced phase of the common magnesium matrix composites is fi ber reinforced whisker enhancement and particle enhancement. Particles or whiskers and other non-continuous materials to enhance the metal-based composite materials to the same, is conducive to structural design, secondary molding and so on. However, it is emphasized that in recent years, the rapid development of high-performance fi ber-reinforced lightweight magnesium-based composite materials, in the low density, high specifi c stiff ness and high specifi c strength and so on more prominent advantages, making it a lightweight, high-performance structure Materials, strong competitors, is gradually becoming the most promising modern high-tech composite materials [5]. In this paper, carbon fiber commonly used in fiber reinforced magnesium matrix composites is introduced, and the preparation process of carbon fiber reinforced magnesium matrix composites is discussed, and the development prospect of the preparation process is prospected.

For the carbon fiber reinforced body, the quality of light, high strength, high modulus, high temperature, good rigidity, but long fiber reinforced metal matrix composite performance is good, but the cost is expensive, and the material itself anisotropy [13]. While the short fiber can be a good way to make up for this, so this article selected short carbon fiber as a composite material reinforcement.

4. The design of the design content and the expected objectives

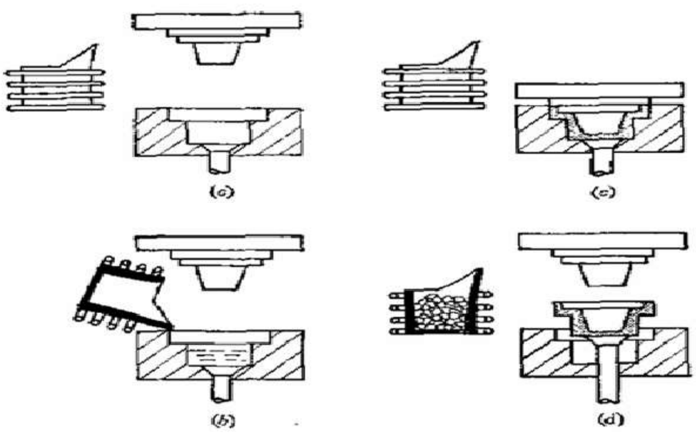
In this paper, carbon fiber reinforced magnesium matrix composites were prepared by extrusion casting method and spray deposition method. According to the interaction between matrix and reinforcement, the deficiency of magnesium itself and the possible problems caused by material composites were selected. Through the design process, in the previous experience on the basis of improvement, as far as possible the process is simple, the effect is obvious. The goal is to be able to change in the original preparation method, combined with the literature knowledge, add their own ideas, simulate the production process, and get more excellent composite materials.

5. Process Design of Carbon Fiber Reinforced Magnesium Matrix Composites by Extrusion Casting

5.1. Process experiment principle and process flow chart design

Magnesium matrix composite materials are mainly prepared by mixing casting method, extrusion casting method, powder metallurgy method, and melt infiltration method. At the same time, mechanical alloy method, melt infiltration method, self-propagating high-temperature synthesis method and other new technology, has also been widely used [4]. For the carbon fiber reinforcement, the material obtained by the extrusion casting method is superior in performance. Since the ratio between the substrate and the reinforcement can be controlled during the preparation process, the distribution of the reinforcement is uniform and the production process can be made simple, cost reduction. Squeeze casting the usual process is: melting, mixing, clamping, pressure, pressure, pressure relief, and sub-mold, blank stripping, resetting and other processes to be squeezed casting finished products. The finished product can be tested by using the Archimedes method to test the porosity of the specimen, and the fracture toughness is measured by the three-point bending method and the bending strength. The microstructures of the samples were observed by scanning electron microscopy (SEM), and the micro hardness of the samples after polishing was tested by MH-5 micro hardness tester [14].

The design of the specific program is: the use of 200 mesh magnesium powder and short carbon fiber powder, because in the extrusion casting method carbon fiber wetting is good, not easy to produce pores, so no carbon fiber surface modification. This design uses VV type extrusion casting machine [15]. First, the matrix and the reinforcing powder are respectively ground, and then the magnesium powder is melted in the furnace of the inner wall under the protection of the inert gas under the argon gas. The temperature is raised to 650 ° C until the magnesium powder melts into the liquid state. Add the carbon fiber, and stirring mixing, in addition, the mold should be preheated in advance, and then set the extrusion process parameters, to mold, filling, pressure, pressure, pressure relief, sub-mold, blank stripping, To obtain a molded body. The process is simple as follows:



(a) casting preparation; (b) pouring; (c) mold clamping; (d) open picking

5.2. Advantages of Squeeze Casting

Squeeze casting is a pressurized casting process, the key is low speed (0.05-1.50 m / s) and high pressure, so that the metal liquid is smoother fi lling and fi lling solidifi cation. From the formal extrusion casting both casting and forging characteristics, but compared to the traditional pressure casting, extrusion casting without pouring riser system, fi lling a smooth, can eliminate the porosity of castings and other defects, casting tissue density, mechanical properties get improved. Due to the need for riser and fi nal cleaning, so the liquid metal or alloy utilization is high, the process is simplifi ed. Compared with the forging process, the extrusion casting productivity is high, the forming energy is low, the parts are of high precision and the mechanical strength is close to each other, but the mechanical properties in the longitudinal and transverse directions are even more than that of the forging [16]. Specifi c advantages are mainly refl ected in the following aspects:

(1) To avoid and reduce defects such as pores. Since the molten metal is smoothed at a relatively low speed during the extrusion casting process, the eddy current formed by the flow of molten metal is reduced, thereby reducing the possibility of entrapment of gas from the outside of the mold cavity during the casting process. Metal in the crystallization process, but also by the high pressure to help solidify, you can squeeze out the solid body of the gas and crush the formation of bubbles, thereby reducing or even eliminate the pores, bubbles and loose and other defects.

(2) To improve the mechanical properties of the casting. Due to the timely application of high pressure in the solidifi cation process of the metal crystal and the amount of plastic deformation of the solidifi ed body, the dense cast of the dendritic crystal is obtained by pressing the casting, and fi ner crystals can be obtained in the semi-solid extrusion casting process.

(3) A wider range of applications, more energy conservation. Due to both casting and forging caused squeeze casting, the advantages of both applications will expand. Compared to forging, extrusion casting requires less mechanical pressure, less energy consumption; and compared to die casting, extrusion casting on the castings on the effective pressure increases, to avoid excessive pressure loss. The extrusion casting process produces near net forming castings and provides high surface roughness. This reduces the follow-up process of the workpiece, saves energy and money for continued processing, and shortens the product's production cycle.

(4) Suitable for large-scale production. Extrusion casting method is more suitable for the formation of small and medium-sized castings, and due to the role of mechanical pressure, extrusion casting metal solution in the solidifi cation process and always maintain contact with the mold cavity surface, heat transfer effi ciency is higher, casting solidifi cation time shorter , To a certain extent, improve the production effi ciency [16] [17].

5.3. Process parameters of the extrusion casting method

5.3.1 Specifi c pressure

The pressure, also known as extrusion pressure, refers directly or indirectly to the metal surface on the mechanical pressure [18]. Its role is to ensure that the metal liquid and the mold wall contact, so that the metal liquid in the role of isostatic pressing crystallization, fi lling and solidifi cation, and the elimination of castings pores, shrinkage and shrinkage and other casting defects, in order to get better Internal structure and high mechanical properties, and the pressure on the physical and mechanical properties of castings, casting defects, organization, melting point and phase balance have a direct impact, so the design process must be reasonable to choose the pressure to ensure the quality of fi nished products The If the pressure is too small, the casting surface and the internal quality cannot meet the technical indicators, than the pressure is too large, the performance improvement is not very obvious, but also easy to mold damage, and require greater clamping force of the equipment. In general, the choice of specifi c pressure should ensure that the quality of castings as far as possible under the premise of low value. For the solid ingots prepared in this experiment, the specifi c pressure decreases with increasing diameters, which increases with the increase of casting height [16]. Taking into account the fl uctuations in the parameters of the process, the actual production of the pressure used, generally should be higher than the experimental value, the experiment set to 500MPa.

5.3.2 Pressure time

The pressure time is the residence time of the molten metal before the pressure in the cavity. Studies have shown that the molten metal in the cavity is cooled to below the liquidus temperature to provide optimum pressure when pressurized. In general, before the pressure may stay as short as possible as well. The longer the residence time before pressing, the greater the required pressure will extend the pressure time and also reduce the mechanical properties of the casting.

5.3.3 Pressing speed

The pressing speed refers to the speed of movement of the extrusion punch after exposure to the metal level, which determines the fi lling speed of the molten metal. The pressure is too slow, the liquid metal free crust is too thick and aff ects the pressure eff ect; too fast (such as over 0.8m / s) is easy to make liquid metal eddy current formation and into the gas, increase the liquid metal splash, Forming a cloak, and even crack. To ensure the quality, punch the appropriate speed when squeezed, small castings for 0.2-0.4m / s; large castings 0.1m / s. General pressure is faster and better. When the pressing speed is fast, the punch can quickly apply pressure to the metal for easy forming, solidifi cation and plastic deformation.

5.3.4 Holding time

The holding time, that is, the time to keep the pressure generally lasts until the casting is completely solidified. Therefore, the holding time is related to the material, shape and section thickness of the casting. The holding time is too short, will make the part of the heart of the part has not yet fully solidifi ed when the pressure relief, resulting in the system cannot get inside the shrinkage, shrinkage; too long, make stripping diffi cult to reduce the mold life Production cycle. Pressure holding time is to ensure formation and complete solidifi cation of the premise, the holding time need to be short.

5.3.5 Metal pouring temperature

This can improve the internal quality of the castings and the working life of the molds. The casting temperature of the cast molds is lower than that of sand casting and metal casting. Generally, the casting temperature of the metal during casting is 50-100 degrees higher than the liquidus temperature of the metal. [16] [17]

5.3.6 Others

The mass ratio of magnesium powder and short carbon fi ber is 30: 1. The raw material is milled for 1 hour, the stove heating rate is lower than 5 ℃ / min, the speed of the mixer is 50r / min, the raw material is mixed for 1 hour.

5.4. Precautions

(1) Extrusion casting mainly used metal type (individual use of mud, such as casting wok). Commonly used heat-resistant mold steel, such as 3Cr2W8V, 4W2CrSiV, etc. [18].

(2) The lubrication of the mold. After the solidifi cation of the casting punch can be successfully drawn from the casting, casting and concave from the same should be smooth, reduce the friction between casting and casting, casting and extrusion before the need for mold and Punch working surface brushing lubricant. In general will choose to use water colloidal graphite, silicon paint (white paint), graphite and oil or lard mixture.

(3) In the design of the mold, set the overfl ow device, so that excess metal in the extrusion casting molding into the place, to ensure that the casting size will not be too much due to casting metal and deviations [19].

6. Process Design of Carbon Fiber Reinforced Magnesium Matrix Composites by Spray Deposition

6.1. Process experiment principle and process flow chart design

Spray deposition method is developed in the past 30 years using rapid solidifi cation, the method of direct preparation of metal materials or semi-finished products of an advanced forming technology, mainly by the molten metal gas atomization, atomization droplet deposition and other continuous process, It is the preparation of particles, whiskers or fi ber reinforced metal matrix composite material is more mature a process [20].

The principle of the spray deposition method is to atomize the liquid pure magnesium or magnesium alloy under high pressure inert gas injection to form a molten pure magnesium or a magnesium alloy jet stream while spraying the enhanced particles into a molten pure magnesium or a magnesium alloy jet, Solid two-phase mixed and co-deposited to the pretreated substrate, the fi nal solidifi cation of the particles to enhance the magnesium-based composite materials [13]. Here, for the short carbon fi ber reinforcements, the short carbon fi bers can be granulated in advance and sprayed into the pure magnesium jet after reaching a certain size. The process of the spray deposition process can be divided into fi ve stages: the metal release stage, the gas atomization stage, the injection stage, the deposition stage and the solidifi cation phase of the deposition body [21].

The advantages and disadvantages of the composite properties depend on the binding of the reinforcement to the matrix and the distribution of the reinforcement. One of the major factors determining the binding and distribution is the wettability. Only when the metal melt and the reinforcement between the good wetting (contact angle is less than 90 degrees) when the metal melt can spontaneously penetrate into the gap between the reinforcement, the matrix metal and the reinforcement can be achieved between the good combination [twenty one].

However, for carbon / magnesium composites, the wettability between the matrix metal and the reinforcement is poor, and the reinforcing fibers are very fine, especially carbon fibers, and a bundle of fibers consists of hundreds or even thousands of single fibers. Metal needs to penetrate into the fiber, usually a few microns in the gap, poor wetting is difficult to achieve. Studies have shown that the addition of alloying elements and increasing the temperature of the liquid metal will increase the wettability of the reinforcement and the matrix, but the practice will increase the cost or sacrifice the performance of the composite material, and the wetting effect is not very obvious. In view of this phenomenon, the carbon fiber surface modification is particularly important.

At present, the common surface treatment methods of carbon fiber are surface coating treatment (including vapor deposition treatment, polymer coating), oxidation treatment (including gas phase oxidation, liquid oxidation, electrochemical oxidation), plasma treatment and other methods [9], and sol-gel method [31].

The method utilizes the conductivity of the carbon fiber, and the carbon electrode immersed in the electrolyte with the carbon fiber as the anode acts as the cathode. The oxygen anion in the electrolyte moves to the anode carbon fiber under the action of the electric field and discharges the new ecological oxygen on the surface thereof Oxidation, the formation of hydroxyl, carboxyl, carbonyl and other oxygen-containing functional groups. At the same time, carbon fiber will be subject to a certain degree of etching [9].

Different types of electrolytes, oxidation etching process is also different. If the electrolyte belongs to the acid, the oxygen atom formed by the electrolysis of the water molecule is adsorbed by the unsaturated carbon atoms on the surface of the fiber and the carbon atoms of the adjacent adsorbed oxygen atoms interact to produce a carbon atom to produce carbon, thereby causing the graphite crystallites to be Etching, edge and angular increase in the number of activated carbon atoms, so that an increase in the surface energy of an important factor, the reaction is:

C (solid) + H_2O → C (solid) O (adsorption) + 2H + + 2e

2C (solid) O (adsorption) → CO_2 + C (solid)

If the electrolyte is a base, OH- is adsorbed by the activated carbon atom on the surface of the carbon fiber and interacts with the carbon atoms adjacent to each other to produce O_2, thereby increasing the number of surface active carbon atoms. The reaction is:

C (solid) + OH- → C (solid) OH (adsorption) + e

4C (solid) OH (adsorption) → 4C (solid) + $2H_2O$ + O_2

The specifi c design of this design is: fi rst short carbon fi ber particles, and then the surface of the electrochemical oxidation, making the treated carbon fiber surface and magnesium good wetting. The molten metal or alloy stream is atomized into a fine dispersion of the droplet jet under the action of a high-speed inert gas (argon or nitrogen); the atomized droplet jet accelerates under high velocity air flow and performs a strong heat exchange with the gas stream ; The treated carbon fi ber particles are injected into the liquid particles; the raw material; before reaching the deposition surface, the droplets smaller than a certain critical size solidify into solid particles, the larger size is still liquid, and the middle size of the molten droplets A certain proportion of liquid semi-solidifi ed particles; these large and small solidifi cation of diff erent degrees of melting droplets hit the deposited surface at high speed and deposited on the deposition surface, spread, accumulate, fuse to form a thin semi-liquid layer after the sequence of solidifi cation crystallization, Become a large piece of dense metal body - sediment [21].

6.2. Characteristics of spray deposition technology

For example, at room temperature and 650 ° C, alloys such as IN 718 and Waspaloy use spray deposition + HIP

Static pressure), spray deposition + ring roll or spray deposition + HIP + ring rolling treatment method Spray deposition and traditional manufacturing process of tensile strength can be compared with the traditional forging [22]:

材料		IN718			U720			Waspaloy		
工艺		$\sigma_{0.2}$ /MPa	σ_b /MPa	δ /%	$\sigma_{0.2}$ /MPa	σ_b /MPa	δ /%	$\sigma_{0.2}$ /MPa	σ_b /MPa	δ /%
20℃	1	1 150	1 350	6	1 100 ~1 250	1 150 ~1 650	8	1 120	1 330	6.6
	2	1 140	1 370	8	1 200	1 550	9	1 100	1 330	8
650℃	1	930	1 060	6.7	1 080	1 360	9	860	1 180	7
	2	950	1 100	9.3	1 100	1 450	11	850	1 190	9

***Note: 1 is the casting and forging process; 2 is the spray deposition process

It is easy to see that the material properties obtained by the spray deposition process are significantly superior to the traditional casting and forging process. Spray deposition process has the following performance:

(1) Good economy. Spray deposition technology is a near forming technique. Simple process, short production cycle, high production efficiency and low cost.

(2) Cooling speed. The cooling rate of metal particles in flight is 102 ~ 104K / s, and the velocity after deposition is 101 ~ 102K / s. This is slightly lower than the traditional powder atomization process, but several orders of magnitude higher than the casting process.

(3) Low oxygen content. The whole process is carried out in an inert or semi-inert atmosphere, the direct production of liquid metal close to the final product, eliminating the powder metallurgy process to be experienced powder preparation, storage, transportation, screening and other processes, the possibility of oxidation small.

(4) The composition of uniform, small organization. The cooling rate of the spray deposition process is large, and a large number of fine nuclei are produced in the droplets, and it is too late to grow in a short time. At the same time, the diffusion and segregation processes of the solute atoms are suppressed, so that the material inherits the composition of the metal liquid is uniform and the segregation is small, so that the billet with uniform composition and fine organization can be obtained.

(5) Diversity. The spray deposition process can not only produce products of various shapes and sizes, but also produce metal matrix composites (particle reinforced, short fiber reinforced, layered composites, etc.). For different products do not need to make too much improvement on the equipment, versatility is better [23] [24].

6.3. Condition calculation and analysis

The atomization spray deposition process is a complex statistical process, and many work attempts to incorporate the most important material parameters such as alloy composition, coagulation interval, melt viscosity and purity, and process parameters such as melt overheating temperature, metal and gas Mass flow rate, deposition distance, and surface condition of the depositor are linked by a certain model to predict the physical and thermal states of the particles and deposits. EJ Lavernia [25] after calculating the size distribution, temperature, velocity and cooling rate of atomized droplets, it is suggested that the optimum deposition distance is the percentage of the liquid phase contained in the droplet impact deposition surface at 15-30% between. Singer [26] made a special analysis of critical deposition conditions, treating sediments as a statistical process, that either the velocity of the atomized particles or the number of particles per unit volume is a function of time and location, the jet process can be considered irrelevant to time. Singer's critical conditions are:

$q / \rho V < 4 [(T - T1) h + H]$

Where

q is the heat transfer rate per unit area

p - Jet density, i.e. the mass of the metal in the unit volume jet

V - The rate at which the deposited particles are perpendicular to the deposition surface

h - The specific heat of the metal

H - Melting latent heat

T - The temperature at which the particles reach the deposited surface

T1 - metal solidus temperature

Where ρV is the rate at which the metal is deposited on the deposited surface, and maintaining a high value of ρV is favorable for deposition. And the q value is constantly changing during the deposition process. The high q value is favorable for improving the transition of the liquid metal into the preform and the metallurgical advantage of rapid solidification, but the deposition is close to the critical condition. With the deposition progress, although the q value is rapidly decreasing, the cooling rate can reach 104 ~ 106 KS-1 [27] due to the forced convection cooling of the deposited surface by the cooler jet.

6.4. Influencing factors

Figure 4 summarizes the main basic processes involved in the spray deposition process and its influencing factors. Obviously these basic processes are controlled by different influencing factors, but are interrelated. The results of the previous process are often used as initial conditions or boundary conditions for the next process to have a direct or indirect effect on the final structure and properties of the deposited material [30]. The main influence parameters discussed in this paper are: atomization cone flow rate mmax, atomization cone width d, spray distance h, sedimentor radius r, sedimentor angular velocity ω and sedimentor reciprocating velocity V effect on tube sputter deposition [28].

6.4.1 Atomization cone flow rate mmax

For the different atomization cone flow rate mmax, the tube deposition model shows the middle bulge, both sides of the edge of the flat slope, consistent with the Gaussian distribution. At a certain point in the axial direction of the depositor, the atomization cone flow rate mmax is proportional to the thickness of the single layer deposition. However, an excessively large atomization cone flow rate can cause a large amount of droplets to be over speed, resulting in low metal productivity. Here are two empirical formulas:

(1) The atomization cone flow rate mmax reflects the mass distribution of the metal droplets in the atomization cone. In the spray deposition process, it is assumed that the main atomization flow rate of the atomization cone is independent of the time, the main atomization flow rate m and the central main atomization flow rate mmax have the following empirical relationship:

$$m = m_{\max} \cdot \exp\left[-\ln 2 \cdot \left(\frac{r}{r_{0.5}} \right)^k \right]$$

Where, r0.5 is half of width for atomization cone.

(2) The spatial distribution equation of atomization rate of atomization cone:

$$m(r,h) = m_{\max} \cdot \left(\frac{h_0}{h} \right)^2 \mathrm{exp}\left[-a_0 \cdot \left(\frac{h_0}{h} \right)^k r^k \right]$$

6.4.2 Atomization cone width d

The width of the atomization cone d, that is, the width of the spiral contour, that is, the atomization cone diameter at the injection height h, has a direct effect on the spray deposition forming model and the single layer deposition thickness. When the atomization cone width d becomes larger, the deposition thickness increases signifi cantly. At the same time, the atomization cone width d is aff ected by the atomization cone fl ow rate mmax and the spray distance h. When the atomization cone fl ow rate mmax increases, that is, the spatial distribution of the atomization cone velocity increases and it will increase accordingly; when the spray distance h increases, the atomization cone width d will be correspondingly increased.

6.4.3 Sedder radius r

In the case of other relevant parameters, with the increase of the radius r of the depositor, the spray deposition shape is gentler; at the same time, the thickness of the single layer deposition tends to decrease. The increase in the radius of the depositor increases its surface area, and the total amount of metal injected in the same time is the same. When these metals are distributed to the smaller surface of the depositor, a thicker deposition thickness is obtained. Thus, when the radius of the depositor is small, a thicker deposition layer will be obtained; a thinner deposition layer will be obtained when the stack radius is large.

6.4.4 Sediment rotation speed ω

In the jet deposition process, when the settler rotation speed ω becomes smaller, the spray deposition model will become steep and its monolayer deposition thickness will increase. When the sedimentation speed ω reaches a certain value, the depositor when the rotational speed ω increases again, the change of the spray deposition forming model and the single layer deposition thickness will not be obvious.

6.4.5 Sedimentor reciprocating speed v

In the spray deposition process, with the increase of the reciprocating velocity V of the depositor, the spray deposition model will become gentle and the thickness of the deposited layer will decrease. When the reciprocating speed of the depositor is faster, the area of the atomization cone swept on the surface of the sedimentator is large in the unit time, so the sprayed deposition is gentler and the sedimentary layer is thinner. In contrast, when the sedimentator reciprocates when the velocity is slow, the injected metal will concentrate on the smaller surface of the depositor, so the resulting spray deposited morphology is steep and the sedimentary layer is thickened [28].

7. Conclusions

Through the short carbon fiber reinforced magnesium matrix composite material, can effectively curb magnesium and its alloys poor corrosion resistance, oxidation resistance. At the same time, it can effectively reduce the air bubbles in the preparation of composite materials, improve the specific strength of the material itself, than the rigidity, high temperature and other properties, and has a small coefficient of thermal expansion, chemical stability, wear resistance, fatigue and excellent damping Performance and many other properties.

In the extrusion casting method, can effectively reduce the defects of the material itself, improve mechanical properties.

By pre-treating the surface of the short carbon fiber, the problem of low wettability can be satisfactorily solved, and a higher quality magnesium-based composite material can be obtained by spraying with magnesium.

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