2.1.7 Spray deposition method

The current preparation technology of PRAMCs is characterized by low temperature, low interfacial reaction, low grain size and low segregation degree. Mostly in the spray deposition process will be a certain amount of enhanced phase particles sprayed into the atomization cone, and metal droplets forced mixed after deposition in the deposition device to obtain composite blank. The biggest drawback of this approach is to enhance the low utilization of particles, high cost of material preparation. SUN You-ping et al. [23] studied the eff ect of hot extrusion on the uniformity of SiC-reinforced particles by using SiCP / 7090Al composite powders prepared by multi-layer spray deposition and their billets. The experimental results show that the multi-layer spray deposition technique can achieve the combination of the enhanced particles and the atomized droplets of the alloy in the air to achieve good metallurgical bonding between the matrix and the reinforcing particles. The hot extrusion process is used to densify the composite material the strong plastic deformation of the matrix leads to redistribution of the particles, thereby improving the micro-uniformity of the particles in the material, and improving or eliminating the segregation of the reinforcing particles in the micro-region. This technology has eff ectively solved the problem of uneven distribution of particles in the matrix and low utilization rate. TiC / Al-20Si-5Fe composites have been successfully prepared by this technique.

2.1.8 Infiltration method

In this paper, based on the analysis of the preparation methods of various traditional aluminum matrix composites, the impregnation method of aluminum-based composite materials is proposed, which is based on the infi ltration method and the non-pressure infiltration method. And the Al2O3 + SiC / Al composites were successfully prepared by this process. The results show that the composites prepared by this new process have good interface, dense structure and excellent performance. Under pressure, the composites prepared by semi-solid doping method have more compact and better mechanical properties than those prepared by liquid infi ltration under pressure. The preparation method not only has the advantages of high production effi ciency, stable quality and low cost, but also can prepare the whole composite material, and can be used to prepare the local reinforced composite material in combination with the conventional liquid forging (extrusion casting) process and die casting process. The characteristics of this process for the defense equipment and automotive industry wear parts are of great signifi cance, has a broad application prospects.

Compared with mechanical infi ltration and vacuum pressure infi ltration, no pressure infi ltration process is simple, no high-pressure equipment, low cost, can be profi led shape, and can produce large complex components, enhance the volume of the volume adjustable, even Up to 75%, and is the current research hot spots. The pressureless permeation method is a preform which is preliminarily bonded with an appropriate binder and made into a desired shape, and then the preform is placed in a suitable position within the mold cavity, the molten metal is cast, the metal liquid Self-weight pressure and surface tension, so that it penetrates into the reinforced preform, after solidification into the required aluminum-based composite material. This method is mainly applied to the preparation of aluminum matrix composites with good interface wettability of particle reinforcements and aluminum alloy matrix materials. HAN Gui-chuen [25] successfully achieved high-volume fraction of SiCP / 2 with a low-cost no-pressure infi ltration process and combined with the hot-die casting precision forming technology of silicon carbide pellets and the surface penetrating barrier technology without blanks, Al composite materials, the size of the blank and the surface roughness of aluminum alloy precision casting parts of the level of precision. The law

It is an ideal method for making complex, large-sized components of high-volume SiCP / Al composites. Zhou Xianliang et al. [26] prepared the silicon carbide particle reinforced aluminum matrix composites by pressureless permeation method to improve the micro-yield resistance of the composites to meet the physical properties of the materials used in optical, precision devices, electronic packaging, inertial navigation and other fields Performance, dimensional stability requirements. Zou Jin et al [21] in the United States Lanxide pressure infiltration method developed on the basis of the air atmosphere of the pressureless infi ltration method, the process is characterized by the need for atmosphere protection can make the molten Al liquid infi ltration of SiC particles layer, The same shape of the high volume fraction of SiCP / Al composites.

3. Introduction to Advanced Manufacturing Methods

3.1. Advanced manufacturing methods

3.1.1 Integration of solidification and forming technology

In order to solve the problem that the plasticity of aluminum matrix composites is poor, the energy consumption of the preparation process is low and the performance of the products is low, the traditional solidifi cation and forming methods are discussed. The solidifi cation and forming technology of aluminum matrix composites are put forward. Li Yinglong et al. [27] combines the advantages of continuous casting (Castex) and rheological forming technology to

realize the integration and continuous of aluminum matrix composites in solidifi cation, semi-solid forming and solid plastic forming, as well as single-process forming of products , And through the expansion of forming, which can continue to produce infi nitely long

High-performance aluminum-based composite materials are large-size pipe, wire and profile products. As the integration of solidification and forming technology products produced by the basic and continuous extrusion equipment, can produce all kinds of composite materials and tubes, rods, lines, profiles. At the same time, in the aluminum-based composite material solidification and forming integrated forming mold set expansion molding die, which can achieve high-performance aluminum-based composite materials, large diameter pipe and other products.

3.1.2 Semi-solid forming technology

It has the characteristics of low deformation resistance and good formability in semi-solid state, and the semi-solid processing temperature is slightly higher than the solidus line, which is much lower than the casting temperature, which can eff ectively avoid excessive occurrence of the particle reinforced phase and the substrate Harmful interface response. Zhou Xuefeng et al [28] used high-frequency induction heating equipment to self-prepared particles reinforced composite materials for secondary remelting to the appropriate semi-solid temperature, and then by extrusion to further form a composite material, studied semi-solid extrusion SiC particles enhanced Eff ect of Aluminum Matrix Composites on Microstructure and Properties. The results show that the composites can be further formed at lower pressure, and the SiC particles are evenly distributed after extrusion, and the pores inside the blank can be eliminated, and the bonding between the particles and the matrix can be improved. Liu et al. [24] prepared TiCP / 7075 composites by in-situ reaction jet deposition, and semi-solid thixoforming experiments were carried out to study the semi-solid thixoformability of TiCP / 7075 composites and the microstructure and microstructure Mechanical properties. The results show that the material has a good semi-solid thixotropic forming, in the forming pressure of only 20 - 25MPa under the conditions, can be semi-solid thixoforming. After semi-solid thixoforming at 625 ℃, the microstructures can maintain the uniform equiaxed grains, and the average grain size is distributed in the range of 30 - 40μm. Li Chao et al. [25] used the semi-solid forming technique to prepare zirconia particles reinforced aluminum matrix composite non-dendritic billet and die-cast into test pieces. PRAMCs with a small amount of liquid semi-solid extrusion has good forming properties, can be further formed under the lower deformation of the shape of the more complex products, as PRAMCs secondary forming a practical and reliable method to make aluminum Composite materials of large-scale industrial applications become a reality.

3.1.3 Rapid prototyping technology

Rapid prototyping technology is a manufacturing technology developed on the basis of the idea of ' tiered manufacturing', especially for diffi cult-to-process metal and ceramic-based composites, and rapid prototyping of spare parts is not even required. Qi Haibo et al [29] using rapid prototyping technology to prepare aluminum-based composite materials, open up a new composite process. Electron beam rapid prototyping technology has the advantages of no refl ection and no oxidation of the forming material in the vacuum environment. Therefore, it can not only overcome the temperature rise caused by the low melting rate of the aluminum alloy in the laser cladding process, High unfavorable factors, and can effectively avoid the oxidation of aluminum alloy melt, is a promising method of manufacturing composite materials. Compared with the traditional composite material preparation method, the electron beam sintering rapid manufacturing technology provides a more effi cient and convenient way, the specifi c preparation process route is as follows: aluminum alloy powder and particles fi rst by a certain percentage in the vacuum ball mill for mechanical mixing And then fed into the dedicated storage box or powder feed tank, and then use the roller or scraper device will be fed to the work platform on the composite powder evenly paved on the substrate, the electron beam under the control of the computer in accordance with the scanning profi le scan sintering The After sintering, the table down a certain height, the next layer of sintering, layers of accumulation, and fi nally get the entire parts.

3.1.4 Casting - Decanting - Casting Technology (CDC)

Casting - decanting - casting technology [27] is a technology for the production of functional gradient composites, close to net forming parts, using single-stage three-step process based on traditional casting technology, with greater fl exibility than other methods. CDC technology is a three-step process-based technology, and instantly melt two alloys: the fi rst step, alloy A into the mold, due to the formation of a mold wall heat absorption, when the hard layer, that is, hard shell When the thickness is specifi ed, the remaining central metal liquid is decanted and returned to the crucible. In the second step, alloy B is poured into the remaining mold cavity. If alloy B has selected a suitable superheat level, a thin layer on the surface of alloy A is remelted and the local alloying of the two metals avoids one The formation of discrete interfaces, replaced by the formation of chemical composition between the two alloys and low magnifi cation of the gradient, the formation of a functional gradient composite materials. The CDC process is suitable for many conventional casting methods, including several gravity casting and low pressure casting techniques. The low voltage technology used in the CDC process technology is based on the extension of low pressure permanent die casting

technology, which allows the functionally graded material to be enclosed in a closed mold Casting, thus avoiding melt turbulence.

4. Application of Aluminum Matrix Composites

4.1. Application of Particulate Reinforced Aluminum Matrix Composites

Because the particle reinforced aluminum matrix composite material has good comprehensive performance, its specifi c strength is higher than the traditional aluminum alloy, and the modulus is even more than titanium alloy, used as high performance structural materials, can improve the structural safety, or optimize the structural design. At the same time, the particle reinforced aluminum matrix composite material excellent physical properties, in some special circumstances can be used as functional materials.

4.1.1 Aviation, aerospace and military industrial applications

At present, many of the aerospace vehicles require high stiff ness and low coeffi cient of thermal expansion of the parts, in the trial of aluminum composite materials. Cercast company uses the investment casting process to manufacture the aircraft camera universal frame, its diameter up to 780mm, weight 17.3kg, material A357 +20vo1% SiC. This part of the original titanium alloy, switch to aluminum-based composite materials can signifi cantly reduce the weight and cost, and to improve the thermal conductivity. The material is also used in the manufacture of satellite reaction wheels and gimbal support frames. In addition, casting A3 5 6 and A357 / SiC particle reinforced composite materials can produce aircraft hydraulic tube, helicopter bracket and valve body. Al2009 + 25vo1% SiCp material can be used to make rocket engine parts.

Domestic, Beijing Institute of Aeronautical Materials has been carried out for many years 863 project 'particle reinforced aluminum composite materials precision casting' research, has made a variety of aerospace parts sample, which aircraft engine hydraulic sub-oil cover has been through the use of the initial department test, satellite remote sensor lens has been identifi ed by internal quality. In the weapons, aluminum-based particle composite materials also have many applications. A357 + 20vo1% SiCp can be used to manufacture the substrate and missile wing of the tank fi re control mirror. The TiC reinforced A201 alloy can be used as armored vehicles and high speed missile structural materials.

The high elastic modulus and low coefficient of thermal expansion of aluminum-based particle-reinforced composites are well suited for the manufacture of optical and electronic package shell parts, which are also often used in aerospace and weapons. Especially the high volume ratio (50-70vo1% of the particulate aluminum matrix composite material, has a very low coefficient of thermal expansion and good thermal conductivity, is the ideal electronic packaging shell material, such parts in the advanced radar in the great demand The

4.1.2 Application of automobile industry and other civil industry

Granular aluminum composite materials used in the car, can reduce the weight of the car and improve its performance, and can save oil, reduce pollution and extend the service life. Compared with cast iron, with A359 +20vo1% SiCp brake discs, weight reduction of 50 to 60%, such as 5.4kg weight cast iron plate with a composite material instead of weighing only 2.5kg, after 5000km travel test shows that the composite brake disc Wear less, and can reduce the brake noise and improve the thermal conductivity (cast iron is 5 to 7 times.

4.1.3 In the field of nuclear energy

Advanced nuclear reactors use DWA Technologies, Inc. Production of BORTEC # B4Cp / Al Composites and Ceradyne, Inc. Production of BORAL # B4Cp / Al composite materials for the manufacture of nuclear waste treatment vessels. The composition of the BORTEC # B4Cp / Al composite is 10% to 35% B4 Cp / 1100 (6061 or 6090, and the sheet size is 4 450 mm $ (225 to 890 mm $ (1. 3 to 25 mm, the tensile strength of the annealing is 103 - 172 MPa, the elongation is 0.5% - 8% [30].

4.1.4 In the field of transportation

Knorr Bremse AG developed a high-speed train brake disc for the German ICE-2 high-speed rail with a weight loss of 500 kg per unit using 20% SiCp / AlSi7Mg composites manufactured by Duralcan. Kolbenschmidt developed 20% - 30% SiCp / Al - Si composite brakes for the Volkswagen Lupo - 3L TDI, similar brake discs for Toyota RAV - 4EV cars, Plymouth prowler, Ford prodigy, Lotus Elise, etc. The Japan Toyato Motor Corporation manufactures 2ZZ - GE engine piston, piston ring, brake disc. Toyota Altezza has developed and produced TiB2 / Ti composite exhaust valves [31] by

powder metallurgy instead of 21 - 4N steel. The high cost of particle-reinforced aluminum-based composites limits its large-scale production and application in the transportation sector.

In other respects, the application of particulate aluminum matrix composites includes bicycle sprockets, golf heads and medical prostheses.

5. Prospects for Particulate Reinforced Aluminum Matrix Composites

In the 'Eleventh Five-Year' period, around the application of particles to enhance the aluminum-based composite materials, from the material properties, billet preparation capacity, plastic deformation of parts, parts precision machining applications such as particle reinforced aluminum composite materials large size complex structure The development of the whole process has made a major breakthrough to solve the problem, but from the engineering application still exists high cost, low manufacturing efficiency, reliability and stability to be improved and other new materials in the process of practical problems, 'Twelve Five' period, the need for large-size, complex shape particles reinforced aluminum composite structure of low-cost, high-efficiency preparation technology, breakthrough components near the final shape; large-size particles reinforced aluminum composite materials and structural parts Reliability control technology; large-size, complex shape particle reinforced aluminum composite structure of high-precision precision manufacturing technology to achieve a number of typical applications, the particle reinforced aluminum composite materials developed into a field of aerospace materials with the main material [32].

At present, the particle reinforced aluminum matrix composites have excellent mechanical properties and continue to have high specific strength, high specific stiffness, excellent electrical conductivity, thermal conductivity, and high toughness, high impact properties, high wear resistance and low thermal expansion coefficient Performance direction. Although the preparation and forming process of particle reinforced aluminum matrix composites still remain in the laboratory stage, with the continuous maturing of preparation and forming process, the reduction of preparation cost and the new process of new technology have been continuously developed to enhance the aluminum matrix composites Will be its excellent characteristics in the automotive and aerospace, aerospace, military and other high-end areas play a greater role.

1. Development trend of particle reinforced aluminum matrix composites

Particulate reinforced aluminum matrix composites have been in rapid development, the trend of its research and development work as follows:

1) Optimize the design method and develop new materials;

2) Innovative preparation process, to achieve low cost and scale;

3) The use of the characteristics of the research and application of the expansion;

4) The defense industry will continue to lead the development of high performance particulate reinforced aluminum matrix composites.

Material is the material basis of human society, the rapid development of society to promote the development of new materials boom. Particulate Reinforced Aluminum Matrix Composites are one of the key research and development areas of metal matrix composites. The development prospect is very broad and will lead the revolution of advanced materials through large-scale production and application.

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