ORIGINAL RESEARCH ARTICLE

Preparation and Forming Technology of Particle Reinforced Aluminum Matrix Composites

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ABSTRACT

This paper introduces the performance and preparation technology and forming technology of particle reinforced aluminum matrix composites. The application status of particle reinforced aluminum matrix composites is illustrated, and its development prospect is pointed out.

KEYWORDS: particle reinforced aluminum matrix composites; preparation process; forming technology; application; prospect

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1. Introduction of Particulate Reinforced Aluminum Matrix Composites

1.1. Brief introduction of particle reinforced aluminum matrix composites

Particle reinforced aluminum composite materials with low density, specific strength, high specific stiffness, high shear strength, low thermal expansion coefficient, thermal stability and thermal conductivity, good electrical conductivity, and wear resistance and resistance to organic liquids and solvent erosion And a series of advantages. Moreover, the abundant aluminum resources in the world, coupled with conventional equipment and process processing and processing, and thus the preparation and production of aluminum-based composite materials than other metal-based composite materials more economical, easy to promote and apply. Therefore, the particle reinforced aluminum matrix composites in the economic field has a wide range of applications, and has been generally attached [1-8].

Particulate reinforced aluminum composite materials in the aerospace, automotive engines, precision instruments, electronic packaging, sports equipment, etc. have an important application prospects. In the late 1970s, the US government began to include composite materials in the list of weapons research and published its research results. Japan's Ministry of International Trade in the early 1980s began to implement the 'next century industrial basic technology' plan, the development of aluminum-based composite materials in the main position, and financial and material resources to the institutions, universities and companies tilt The Since the mid-1980s, more than ten years of efforts have been made in the field of particle-reinforced aluminum-based composites, and the interface of composite materials has been close to the international advanced level. Al-based composites have been listed as national '8 6 3 'new material research topics.

The extent and value of the current application of the particle-reinforced aluminum matrix composites are extremely disproportionate to the huge investment and manpower spent on their research for decades. The fundamental reason lies in the limitations of its application and the lack of commercial production Process. Attention to the development of its casting molding low-cost products, and according to the needs of different applications to produce a series of different performance products for large-scale industrial production pave the way for composite materials research and application of urgent problems to be solved.

1.2. Particle Reinforced Aluminum Matrix Composites Performance Advantages

The modulus (E / ρ) of the material is the key to the lightweight design of the aerospace structure. High modulus material can achieve the structure of the system of light and stiffness stability, effectively meet the structural lightweight requirements. The modulus of the material is an important factor in determining the vibration frequency of a part or component and is directly related to the fatigue life of the material. The specific modulus of the aluminum matrix composites [(3. 5 - 4. 0) × 1010m2 / s2] is much higher than that of the traditional structural materials including aluminum alloy, titanium alloy, magnesium alloy, nickel base super alloy and steel [5 - 3. 2) × 1010m2 / s2], between the longitudinal and transverse properties of the fiber-based composites (Fig. 1 [8]).

High performance aluminum matrix composites are ideal materials for achieving advanced aircraft light weighting. US DWA Company developed SiCp / Al composite structure scale used in aircraft, helicopters and other key structural components to confirm this point [9].

Aerospace's many applications include satellite and payload light instrumentation and structural parts, missile and satellite navigation systems require materials at the same time with resistance to mechanical load and thermal load deformation. Mechanical deformation resistance depends on the specific modulus of the material, the shape of the parts and loading methods, the greater the modulus of the material, the greater the deformation resistance. The thermal deformation resistance depends on the coefficient of linear expansion of the material α and the thermal conductivity μ, α is small, the deformation of the component is small; λ is higher, the temperature gradient of the component is small, the thermal stress is small; therefore, the larger λ / α value, More conducive to reducing the deformation of components under the action of thermal load. The comparison of E1 / 2 / ρ and λ / α of various metals, ceramics and composites that may be used on the structure and function of the optical instrument in the space-space field (Fig. 2 [8]), aluminum-based composite materials , The instrument system components and functional components have significant advantages.

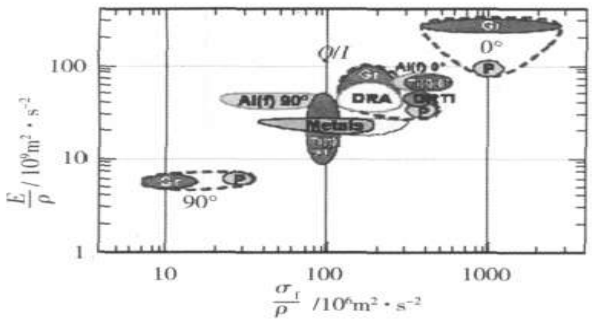

Figure 1. Comparison of specific strength and specific modulus of particle reinforced aluminum matrix composites (DRA) with traditional metal alloys, fiber reinforced aluminum, titanium matrix composites and fiber reinforced resin matrix composites

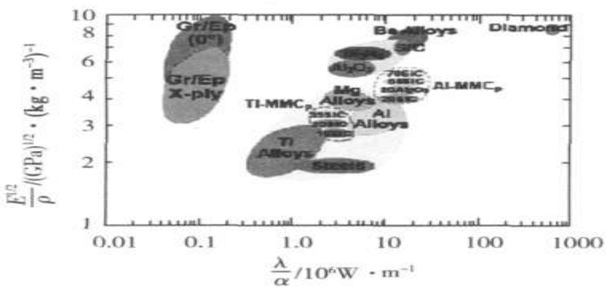

Figure 2. (Al - MMCp) and aluminum, titanium, magnesium, beryllium, steel and other alloys, alumina, silicon nitride, silicon carbide, diamond and other ceramic and particle reinforced titanium matrix composite materials and fiber resin matrix composites Comparison of E1 / 2 / ρ and λ / α

2. Preparation of Particle Reinforced Aluminum Matrix Composites

Particulate reinforced aluminum matrix composites (PRAMCs) have broad application prospects in aerospace, aerospace and automobile industry because of their high specific strength, high specific rigidity, good wear resistance and low coefficient of thermal expansion. In this paper, the research status of PRAMCs preparation and forming technology in recent years is reviewed.

2.1. Preparation and forming process

2.1.1 Agitation preparation method

The agitation method, also known as the whirlpool method, is the basic principle of adding the particle reinforcement directly into the molten aluminum alloy melt, through a certain way of mixing, so that the particles dispersed in the aluminum alloy melt, and finally into the PRAMCs melt. According to the enhanced particles and aluminum liquid mixing method, this can be divided into mechanical agitation, high-energy ultrasonic composite method and electromagnetic stirring method. The mechanical agitation method requires low equipment, simple process, wide adaptability to particle type and size, and can be formed by almost all casting methods. Wu Zhaoling et al [10] use the method of SiCP / A356 composite materials through the diff erential pressure casting technology, the preparation of the railway vehicle brake disc. However, due to the mechanical mixing process easy to get involved in the gas, resulting in casting defects; Zhu Ruijie et al [11] in the vacuum conditions, the use of electromagnetic stirring technology and mechanical mixing technology compound method, prepared a 10% α-Al_2O_3 aluminum composite material. The results show that the composite agitation method solves the problem that the composite material is prone to uneven distribution and the phenomenon of rolling gas by single mechanical stirring method. Han Fei et al. [12] prepared 5% SiCP / ZL102 composites by mechanical agitation using a subsequent liquid forging process, with SiCP uniform distribution, dense organization and no casting defects.

2.1.2 In situ reaction preparation method

The inversion reaction of the composites prepared by in situ reaction method has the advantages of small size, clean and clean interface, good thermal stability, good compatibility with substrate and low preparation cost. It has become an aluminum matrix composite material in an important direction of development. In situ autogenous aluminum matrix composites are prepared by self-propagating high-temperature synthesis method, diff usion method (XD method), direct reaction method, mixed salt reaction method, contact reaction method and reduction reaction method. Mixed salt as one of the in situ synthesis methods, with a simple process, short cycle, without vacuum and inert gas protection, can be directly cast forming, easy to mass production and promotion, is an economic way to obtain high-performance composite materials Method, is currently the most studied, the fastest growing in situ technical methods. TAN Yan-jun et al. [13] prepared in situ TiB_2 particle reinforced Al-7Si composites by mixed salt method. The results show that the prepared TiB_2 particles are uniformly distributed at about 900 nm and the average size is about 400 nm. TiB_2 particles have signifi cant eff ect on α-Al and eutectic Si.

However, these methods are prevalent in the presence of in situ reaction to generate reinforcement, resulting in unnecessary harmful impurities and thus deterioration of material properties and other issues. $(SO_4)_2$ powder was added to the aluminum solution, and the decomposition reaction was carried out to produce ultrafi ne Al_2O_3 particles, which were dispersed in the molten aluminum liquid, and the aluminum alloy was prepared by adding a new self- In the formation of reinforced particles, the method in the introduction of reinforcement at the same time, will not produce harmful second phase. The size of the ceramic particles produced by the in situ decomposition reaction is small (usually submicron size), the dispersion is distributed, and the compatibility with the matrix interface is better, and thus has a higher thickness than the conventional direct Al_2O_3-based composite material Strength and wear resistance, more importantly, the decomposition of SO_3 can continue to react with the aluminum liquid to produce Al_2O_3 and SO_2, the formation of Al_2O_3 particles size is small, the resulting SO_2 can melt the refi ning, degassing, eliminating the composite Uneven distribution of particles and high porosity and other shortcomings.

GROHE et al. [15] prepared Al_2O_3 / Al-Cu composites by in situ reaction near liquidus casting. The results show that the Al_2O_3 particles formed by the reaction are polygonal and have a diameter of less than 1μm. The Al_2O_3 particles formed in situ have the eff ect of refi nement and homogenization of the composites. When the content of the particles reaches 5.3wt%, the granules are uniformly distributed. Zhang Bangwen et al. [16] proposed a new method for the fabrication of surface-reinforced composites using frequency-frequency current, which is characterized by the application of an alternating current to the alloy melt, the use of alternating current and its induced magnetic fi eld to produce electromagnetic forces, The lower second opposing edge migrates and solidifi es to obtain a surface-reinforced composite. The surface silicon hardness is 10 - 20 times higher than that of pure aluminum. The method has the advantages of simple process and is not limited by the shape and size of the casting, and can be used for the large scale preparation of the surface reinforced metal material. In addition, the reaction complex method is also the focus of the current research, Liu Jingyan et al [17] through the in situ reaction to generate Al_3Ti enhanced phase, the use of high shear graphite mixer to add a small amount of nano-SiC enhanced particles, using in situ reaction and liquid stirring synthesis Preparation of Mixed Phase (Al_3Ti + SiCP) to Enhance Hypereutectic Aluminum Matrix Composites. The results show that the Al_3Ti produced by the in situ reaction method has a good grain refi nement eff ect, and the Al_3Ti enhanced phase particles and the primary crystal silicon can be refi ned by liquid stirring. Because of the existence of SiC, the Al matrix is distorted, resulting in dense dislocations and the comprehensive properties of the materials are optimized. The method of in situ reaction and liquid agitation can be used to prepare the composite particles to enhance the hypereutectic aluminum matrix composites.

2.1.3 Extrusion casting method

Squeeze Casting Due to the solidifi cation of the composite under high pressure, it not only improves the wettability of the molten metal and the reinforcing particles, but also eliminates the defects such as loose and porosity, which greatly improves the strength and plasticity of the composites. Therefore, the quality of the prepared aluminum matrix composites is better. Li Guirong et al [18] Al3Zr and Al2O3 reinforced aluminum matrix composites were synthesized in situ by melt direct reaction with Al2ZrOCl2, and conventional casting and extrusion experiments were carried out at 720 ℃. The results show that the extruded specimen has small grain size and no obvious shrinkage and so on, which is benefi cial to improve the comprehensive mechanical properties and abrasion resistance of the composites. Linchengfeng et al. [10] selected SiC particles and fl aky graphite as the reinforcement, and the SiCP + Gr / 2024Al composite was prepared by extrusion casting method, and the processing performance of the material was improved under the premise of ensuring the mechanical properties of the material. The results show that the composites are denser and the graphite and SiC particles are evenly distributed in the matrix. No interfacial reactants are found in SiC and graphite particles and matrix Al alloys.

2.1.4 Centrifugal casting method

The centrifugal casting method is a method of forming a composite material by infi ltrating the molten metal into the reinforcing material gap under the action of centrifugal force. Through the preparation process, need to continuous control of micro-structural elements, so that the composition and organization of continuous change, there is no obvious interface, which greatly ease the thermal stress. Pan et al. [11] prepared SiCP / Al composites melt by stirring method. The discs with continuous gradient change were prepared by centrifugal casting. The wettability of the granules was increased by reasonable process, and the distribution of particles was uniform Composite melt. By changing the centrifugal speed, the desired particle gradient distribution is obtained, and the particle and matrix interface are well bonded. As the particle volume fraction increases, the hardness of the sample increases accordingly. Gao Kun et al [12] also used this technology to prepare thin-walled steel sets.

2.1.5 Pressure casting method

PRAMCs are poorly processed, so the molding problem (especially near net forming) is the key to its wide application. Pressure casting is a relatively advanced and widely used near-final forming process, the shape of die casting can be very complex, such as the use of die-casting process to produce PRAMCs parts, can eff ectively expand the scope of application of aluminum-based composite materials, Promote the development of aluminum-based composite molding technology [19]. However, since the PRAMCs are remelted, the sedimentation of the particles is generally generated,

So it is diffi cult to die-cast PRAMCs in the whole liquid. Fang Yan-Yan et al. [20] fi rst with the mechanical mixing method of SiC and aluminum alloy melt mixed with the melt through the tundish into the mold, the rotating magnets generated by a strong electromagnetic fi eld on the material applied a strong stirring, cooling after solidifi cation, and the composite material is obtained from non-dendritic billet. The composite material non-dendritic billet with diff erent percentage of SiC was prepared by the above method. Then, the semi-solid die-casting was carried out by secondary heating of the blank with medium frequency induction heating equipment to obtain the die casting of composite material.

2.1.6 Powder metallurgy method

The powder metallurgy process is divided into three steps: mixing, compaction and sintering. The products have the advantages of little interfacial reaction, the content of the enhanced phase can be adjusted according to the need and the phase distribution is uniform, the performance is stable, and the traditional machining can be carried out. (1.5%, 5%) submicron (130 nm) and micrometer (14 μm) composites were prepared by cold pressing and hot extrusion. Fan Jianzhong et al [22] using high-energy ball mill mixture through the SiC particles into the Al powder and gradually evenly distributed in the Al powder, in order to achieve the uniform distribution of fine SiC particles to solve the mechanical mixing difficult to achieve Al powder and fine SiC powder Uniform mixing problem. The experimental results show that the high-energy ball mill mixed powder metallurgy method is a very eff ective method for preparing ultra-fi ne SiC particles reinforced aluminum matrix composites with higher strength and easy cutting. However, the method is complicated and costly, and the shape and size of the products are limited, which is not conducive to large-scale popularization and application.

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 °C, 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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