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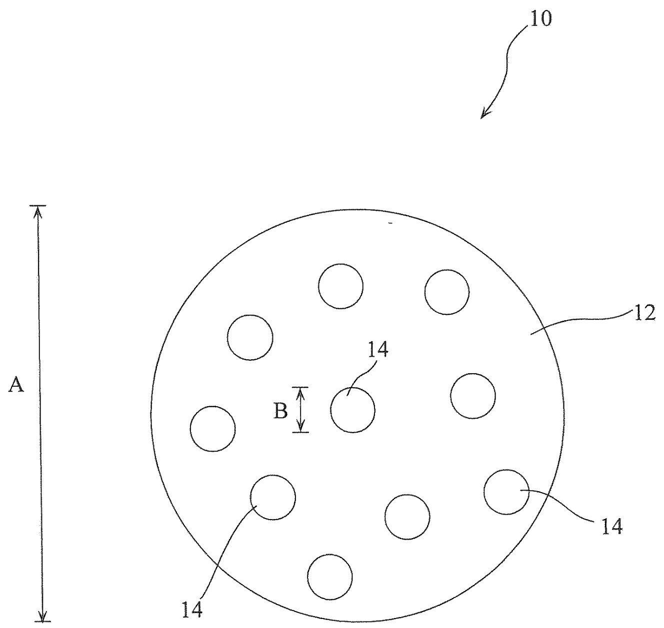
Remarks:
This application was filed on 17-03-2009 as a divisional application to the application mentioned under INID code 62.

(54) **Metal particles, process for manufacturing the same, and process for manufacturing vehicle components therefrom**

(57) Magnesium-based metal particles in the form of spheres having a mean diameter of 40 μm to 100 μm, composed of magnesium metal and magnesium silicide particles having a mean diameter of 1 μm to 10 μm uniformly dispersed in the magnesium metal, the magnesium-based metal particles being obtained by mixing 80 wt.% to 94 wt.% of magnesium, 5 wt.% to 10 wt.% of silicon and 1 wt.% to 10 wt.% of aluminum, and the magnesium silicide particles being formed in the metal particles by the reaction of the magnesium and the silicon.

FIG 1



EP 2 065 108 A1

Description

CROSS REFERENCE TO RELATED APPLICATIONS AND INCORPORATION BY REFERENCE

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2005-244247, filed on August 25, 2005; the entire content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to magnesium-based metal particles comprising magnesium silicide dispersed therein, a process for manufacturing the magnesium-based metal particles, process for manufacturing components for use in a vehicle, and components manufactured thereby.

2. Discussion of the Related Art

[0003] Magnesium is widely used for preparing so-called light alloy because of the low specific gravity thereof. It is also known that the mechanical properties such as a rigidity of a product made from magnesium alloy are improved when the material magnesium alloy contains therein magnesium silicide (Mg_2Si) particles in a dispersed state. In this case, the smaller the mean diameter of the magnesium silicide particles, the more increases the mechanical properties of the magnesium alloy. For instance, magnesium alloy containing magnesium silicide particles with a mean diameter of 10 μm or less has extremely good mechanical properties.

[0004] The magnesium silicide particles are formed in a magnesium metal, e.g., by solidifying magnesium wherein silicone is dissolved.

[0005] It is known that particles made of pure magnesium or Mg-Al-Zn alloy can be obtained by gas atomization method. In the atomization method, a metal melt is scattered into small particles by applying a gas jet stream to the molten metal.

[0006] When the melt is subjected to atomization, it is necessary that the metal is maintained in a liquid form, for forming particles without blowholes, and to appropriately receive the gas jet stream. Moreover, it is also necessary that the melt is heated to a temperature which is higher than the melting point by about 300 °C for satisfactory atomization.

[0007] As to the pure magnesium metal, it is know that the melting point is about 651 °C, and the boiling point is about 1090 °C. In other word, the atomization was applicable to the pure magnesium.

[0008] On the other hand, when 10 wt.% of silicon is added to magnesium, the melting point of the mixture is increased to 880 °C, and the boiling point has almost no change from 1090 °C. Therefore, the atomization process was not applicable to the mixture of silicon and magnesium, since the processing temperature, which is 300 °C higher than the melting point (880 °C) exceeds the boiling point.

[0009] In addition to the above, it is difficult to use a casting method to the mixture of Mg and Si, because the viscosity of the mixture in the liquid state is high, comparing with that of the magnesium metal. As a result, it is difficult to cast the magnesium melt containing 5 to 10 wt.% of silicon therein by a usual manner. Further, since the solidifying rate of the magnesium melt containing silicon is slow, magnesium silicide particles formed in the melt grow by the end of the solidification. In some cases, it is possible magnesium silicide particles with diameters of 100 μm or more are formed. The magnesium alloy obtained in this way does not have excellent mechanical properties. When the magnesium alloy in a semi-fused state is subjected to injection molding, the mechanical properties of the alloy are not good.

[0010] In order to disperse finely-divided magnesium silicide particles in a magnesium alloy, Japanese Kokai Publication 2000-17352 discloses a casting method wherein finely-divided magnesium silicide particles with diameters of 10 μm or less are dispersedly formed in a magnesium alloy. Herein, a preform is obtained by adding silicon particles to magnesium matrix, and the preform is impregnated with a melt of magnesium alloy. Accordingly, in-situ reaction between the silicon particles and magnesium alloy occurs, and finely-divided magnesium silicide particles are formed in the magnesium alloy.

[0011] Further, Japanese Kokai Publication 2004-225080 discloses technology for dispersing magnesium silicide particles in a magnesium alloy by powder metallurgy. For using metal powders as raw materials, pre-treatments such as particle diameter treatment, compression molding, sintering and the like are necessary.

[0012] More specifically, Japanese Kokai Publication 2004-225080 discloses that magnesium powder and silicon powder, and optionally aluminum powder, are mixed by using a ball mill, whereby a powder mixture is obtained. Then, the thus obtained powder mixture is solidified by applying pressure thereto, and the solidified powder mixture is heated in the atmosphere of an inert gas. The heating operation causes a solid phase reaction between magnesium and silicon, whereby magnesium silicide is formed. Furthermore, the solidified workpiece is densified by warm processing. Thus, magnesium silicide particles with diameters of 1 to 30 μm are formed in the magnesium alloy.

[0013] In the casting method disclosed in Japanese Kokai Publication 2000-17352 , magnesium silicide to be formed has to be subdivided by the use of additional equipment. Further, the magnesium melt containing silicon has a high viscosity, and the casting is sometimes difficult depending on size and shape of a preform/product to obtain. In addition to the above, a primary crystal formed in the course of the solidification of the melt could lead to the formation of a metal alloy with a course structure, which may not have a satisfactory rigidity/strength.

[0014] Based on Japanese Kokai Publication 2004-225080 , it is necessary to homogenously mix two kinds of raw material powders, i.e., magnesium and silicon, for carrying out solid phase reaction between magnesium particles and silicon particles. Moreover, it is difficult to completely convert the silicon to magnesium silicide. It sometimes happens that a few % to several tens % of silicon remains un-reacted.

[0015] According to Japanese Kokai Publication 2004-225080, it is necessary to use a ball mill to mix raw material powders, so that the raw material powders cannot always be maintained to be spherical. On the other hand, it is important in powder metallurgy to use uniformly shaped particles with well adjusted particle distribution, for obtaining a product with a good compaction by a compression molding. It is possible that particles with irregular forms are formed based on the disclosure of Japanese Kokai Publication 2004-225080, which is not always satisfactory for good compaction. The irregularly shaped particles have to be subjected to classification and particle diameters adjustment, prior to the use. Moreover, in this technology, different kinds of powders have to be mixed at the stage of producing the product.

WO 03/105983 A2 discloses metal matrix composites with intermetallic reinforcements. A reinforced metal composite consists of a metal matrix element. As least one of the elements of the intermetallic particles is the same as the matrix material. The metallic powder particles are produced by gas atomization and are further processed to form billets which are then further hot extruded.

EP 1 433 862 A1 discloses a magnesium base composite material. The manufacturing method for such material includes the steps of blending matrix powder containing Mg and Si powders to obtain a blended matter, applying a plasticization treatment to the resulting blended matter to form a solid body, heating the solid body and applying a warm plasticization treatment to the heat solid body.

OBJECT AND SUMMARY OF THE INVENTION

[0016] It is an object of the present invention to provide metal particles in the form of spheres having a mean diameter of 10 μm to 100 μm, which already have a predetermined formulation of metals with a uniform distribution of the metals in the particles, which can be directly used for forming a product without mixing different kind of metals, especially for compression molding, for producing a product with excellent mechanical properties.

[0017] The solution to this object is given in claim 1.

[0018] When aluminum is used, in addition to magnesium and silicon, mechanical properties of the product therefrom can be changed in a wide range. For instance, it is possible to control processability of the material, and wear resistance and hardness of the obtained product, by blending aluminum.

[0019] It is preferable, in the above-mentioned metal particles, that silicon is almost completely converted to magnesium silicide, because the complete conversion of the magnesium silicide and the uniform dispersion thereof will increase fatigue strength at high temperatures.

[0020] Another object of the present invention is to provide a process for manufacturing metal particles approximately in the form of spheres containing therein uniformly dispersed magnesium silicide particles having a mean diameter of about 1 μm to about 10 μm, which is easy to perform and cost effective.

The solution to this object is given in claim 2.

[0021] When aluminum is used, in addition to magnesium and silicon, it is possible to lower the viscosity of the metal melt, so that the handling property of the melt can be increased.

[0022] In the production process of the invention it is preferable that the temperature of the mixture heated in the container is in the range of 940 °C to 960 °C, and the outlet port of the container is set to have a diameter in the range of 1.0 mm to 2.0 mm.

[0023] In the production process of the invention, it also is preferable that the pressure in the container is higher than in the chamber by 0.4 bar or more.

[0024] By selecting the temperature and the outlet port diameter in the above range, and/or setting the pressure as mentioned above, it is possible smoothly extrude the melt and hence to produce the particles of the present invention with a sharp particle size distribution, in a stable manner. In addition, the magnesium silicide particles are uniformly dispersed in the metal particles when the metal melt was flowed out of the container under the above-mentioned conditions.

[0025] In particular, it was made possible to discharge the melt of the present invention by selecting the pressure difference between the inside of the container and the outside thereof, although the melt does not have sufficient flowability when the pressure difference between the inside of the container and the outside thereof.

[0026] Furthermore, it is preferable in the process of the present invention that a high-frequency induction furnace is used as the container. By using the high-frequency induction furnace, it is possible to easily maintain a large quantity of metal melt at a predetermined temperature, and hence to produce a large amount of metal particles continuously in a stable condition.

[0027] A still another object of the present invention is to provide a process for manufacturing a vehicle component, which is easy to perform and economical.

The solution to this object is given in claim 3.

[0028] When necessary, it is possible that the metal particles are pre-treated. For instance, it is possible to classify the particles depending on the diameters.

[0029] The vehicle component obtained by use of the production process of the invention are light weight because of the formulation and has good mechanical properties, such as excellent fatigue strength at about 300 °C. A piston for engine having excellent strength, in particular excellent fatigue strength at high temperatures, can be obtained by the method of the present invention.

[0030] In accordance with the process for producing the vehicle component of the invention, it is possible to easily and economically produce the vehicle component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] A more complete appreciation of the invention and many of the attendant advantages thereof will be readily perceived as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a diagram for showing a magnesium-based metal particles according to the present invention wherein magnesium silicide particles are dispersed;

Fig. 2 is a diagram for explaining an apparatus for manufacturing magnesium-based metal particles according to the present invention;

Fig. 3A is a diagram for explaining a charging and fusing step for manufacturing magnesium-based particles by using the apparatus shown in Fig. 2;

Fig. 3B is a diagram for explaining pressure increasing step for manufacturing magnesium-based particles by using the apparatus shown in Fig. 2;

Fig. 3C is a diagram for explaining scattering and solidifying step for manufacturing magnesium-based particles by using the apparatus shown in Fig. 2; and

Fig. 4 is a table for showing experimental conditions and results as to Examples of the present invention and Comparative Examples.

DETAILED DESCRIPTION OF THE INVENTION

[0032] Other features of this invention will become apparent in the course of the following description of exemplary embodiments, which are given for illustration of the invention and are not intended to be limiting thereof.

[0033] Fig. 1 is a diagram for explaining an internal structure of a magnesium-based metal particle 10 according to the present invention. The magnesium-based metal particles 10 of the invention have spherical shapes having a mean diameter A of 40 to 100 μm. The magnesium-based metal particle 10 is prepared from 90 to 95 wt.% of magnesium and 5 to 10 wt.% of silicon, as starting materials.

[0034] More precisely, the magnesium-based particle 10 is formed substantially from magnesium metal 12 and finely-divided magnesium silicide particles 14 uniformly dispersed in the magnesium metal 12, and the magnesium silicide (Mg_2Si) particles 14 are formed as solid particles having a mean diameter B of 1 μm to 10 μm, by a reaction between the previously mixed magnesium and silicon. It is preferable that substantially all the amount of 5 to 10 wt.% of silicon is converted to the magnesium silicide particles 14. In this way, the magnesium silicide particles 14 are finely dispersed in the magnesium metal matrix 12.

[0035] The magnesium-based metal particles 10 are applicable to powder metallurgy, and many products or preforms are prepared therefrom. Such product made from the magnesium alloy material has good mechanical properties including excellent fatigue strength at high temperatures. This is because the nnely-divided magnesium silicide particles 14 are uniformly dispersed in the metal particles 10, and a stress applied to the particles 10 are uniformly dispersed.

[0036] The magnesium-based metal particles 10 of the present invention are ready to use for powder metallurgy, because the metal particles 10 is already in a premix state containing magnesium and magnesium silicide uniformly dispersed therein.

[0037] Moreover, the metal particles 10 can be tightly compacted when pressure is applied thereto because of the spherical or approximately spherical shapes. In other words, compressibility of the metal particles 10 of the invention is greater than that with irregularly shaped particles.

[0038] After the metal particles 10 are subjected to compression molding, sintering and then forging, the uniform dispersion of finely-divided magnesium silicide particles in the metal particles 10 is maintained, whereby a product with good mechanical properties can be obtained.

[0039] It is also possible that the magnesium-based metal particles 10 is obtained from the starting materials including 80 to 94 wt.% of magnesium, 5 to 10 wt.% of silicon, and 1 to 10 wt.% of aluminum. Based on the above formulation, magnesium-based metal particles 10 are obtained as particles containing magnesium-aluminum alloy as a matrix 12 and magnesium silicide particles 14 dispersed in the alloy matrix 12. It is also possible to adjust the mechanical properties of the depending on the usage of the product obtained therefrom, by adjusting the aluminum content. A satisfactory compaction property can be carried out also in this case. Further, when adding aluminum, it is possible to increase the handling property of the molding material, and the mechanical properties such as wear resistance and strength of the product, in comparison with the materials made from magnesium and silicon.

[0040] Fig. 2 is a schematic cross-sectional view of an apparatus 20 for producing metal particles 10 according to the present invention. The apparatus 20 itself is commonly used in atomization method, for example, for pure magnesium metal or magnesium alloy based on magnesium, aluminum and zinc.

[0041] In the atomization method, metal particles 10 are obtained by applying a gas jet stream 36 from gas injection nozzles 30 against the metal melt 32 discharged from a container 20 to scatter/disperse the melt 32 in the air, and solidifying the melt. The solidification occurs by a rapid temperature decrease of the melt after the discharge from the container 20.

[0042] In the present invention, a metal melt containing 5 to 10 wt.% of silicon is stably atomized, and finally metal particles 10 as shown in Fig. 1 is obtained.

[0043] The atomization apparatus 20 includes a fusing container 22 and an atomization chamber 40 provided below the fusing container 22. The container 22 is formed as a crucible for fusing the metal particles 10.

[0044] The open end of the fusing container 22 is sealed by a cover 23 for appropriately controlling the pressure inside the container 22. Furthermore, a high frequency coil 26 is provided around the container 22 for heating the container 22 and maintaining the temperature for a predetermined period. It is possible to provide a thermometer (not shown) for measuring the temperature in the container 22. At the bottom of the container 22, an outlet port 28 is formed, which allows the melt 32 to flow therethrough. The atomization chamber 40 is provided below the container 22. Around the outlet port 28, a heater is provided (not shown) for appropriately heat the outlet port 28 so as to prevent the melt 32 to solidify at the outlet port 28.

[0045] A movable stopper 24 in the form of a bar is provided by penetrating the center of the cover 23, for opening and closing the outlet port 28 of the container 22. By moving the stopper 24 up and down, the outlet port 28 is closed and is made open. The injection nozzles 30 are provided nearby the outlet port 28 for injecting a gas against the metal melt 32. For instance, argon gas with a high speed is blown for the collision with the metal melt 32, and hence the metal melt 32 is scattered, whereby particles of metal melt 32 are obtained. Then, the particles are solidified, and metal particles 34 having uniformly dispersed finely-divided magnesium silicide particles therein are obtained.

[0046] It is also possible to provide a stirring mechanism in the container 22, for stirring the metal melt contained therein so as to obtain a homogeneous melt. Examples of the stirring mechanism are commonly used mechanical stirring apparatuses and a stirring unit wherein blowing gas is utilized. Moreover, it is possible to use a high-frequency induction furnace, instead of using the container 22 and the higla-frequency coil 26 individually. The high-frequency induction furnace has a capacity to contain a relatively large amount of melt and to maintain the melt at a predetermined temperature. Therefore, it is possible to produce a large amount of metal particles 34, continuously.

[0047] It is also possible that the container 22 has a weighing unit which is, for instance, for measuring the entire weight of the container 22 containing the melt 32 therein. By using such weighing unit, the flow rate of the melt 32, and the residual amount of the melt 32 can be accurately measured.

[0048] Figs. 3A to 3C are schematic cross-sectional views of the apparatus 20 for use in the present invention, for explaining the procedure for producing metal particles 34.

[0049] Fig. 3A shows that the container 22 is charged with a raw material 31 which is a mixture of solid magnesium (90 to 95 wt.%) and solid silicon (5 to 10 wt.%). Before charging the container with the raw materials 31, the outlet port 28 of the container 22 is closed by the stopper 24. The air in the container 22 and the atomization chamber 40 are replaced by an inert gas such as argon.

[0050] Then, the mixture in the container is heated by the high-frequency coil 26 provided around the container 22 optionally with starring the mixture, to obtain a homogenous metal melt 32 the container 22.

[0051] By monitoring the temperature, the metal melt 32 is maintained at a temperature which is greater than the solidification point and is lower than the boiling point, e.g., 950 °C (charging and fusing step, Fig. 3A). It is also possible to prepare the metal melt 32 in advance, and to introduce the fused material into the container 22.

[0052] Thereafter, as shown in Fig. 3B, the container 22 is sealed up for changing the pressure inside the container 22. In the conventional use of the atomization chamber, the container is set to have an internal pressure higher than the atomization chamber by about 0.3 bar. In the present invention, however, it is necessary to set the inner part 38 of the container 22 to have a pressure higher than in the atomization chamber 40 by 0.4 bar or more, preferably in the range of 0.4 bar to 1.5 bar. It is preferable that the atomization chamber 40 is substantially in vacuum.

[0053] Following the pressure increase in the container 22, the outlet port 28 is heated by the heater 31. At this stage, the argon gas jet stream is preliminarily started to run. (pressure increasing and fusing step, Fig.3B).

[0054] Thereafter, as shown in Fig. 3C, the stopper 24 is pushed down for discharging the metal melt 32 from the outlet port 28. Since the internal pressure of the container 22 has been increased, the metal melt 32 can be flowed out of the outlet port 28 in spite of the high viscosity. Argon gas jet stream is injected from the gas injection nozzles 30 against the discharged metal melt 32. The melt 32 which received the gas jet stream is scattered in the form of particles with a mean diameter of 40 to 100 μm. Then, the metal melt is solidified (scattering and solidifying step, Fig. 3C). Accordingly, magnesium-based metal particles 34 are manufactured in such a state that minute magnesium silicide particles with diameters of 1 to 10 μm are uniformly dispersed in the magnesium-based metal particles.

[0055] The outlet port 28 of the container 22 is closed after producing the metal particles 34. The pressure of the inner part 38 is lowered, the gas injection from the injection unit 39 is stopped. The container can be made ready for further production.

[0056] In accordance with the process for producing magnesium-based metal particles of the present invention, the metal particles 10 are readily and economically prepared.

[0057] In the above embodiment, it is possible to maintain the metal melt 32 at a temperature in the range of 940 °C to 970 °C, more preferably in the range of 940 °C to 960 °C. When the temperature of the melt 32 is set in the range of 940 to 960 °C, and the outlet port 28 of the container 22 is set in the range of 1.0 to 2.0, the melt 32 can be smoothly discharged from the atomization chamber 40. Depending on the viscosity of the melt, the temperature of the metal melt 32 and the diameter of the outlet port 28 are appropriately chosen. By obtaining appropriate flow of the melt through the outlet port 28 with appropriate diameters, it is possible to obtain finely-divided metal particles with narrow particle distribution, wherein minute magnesium silicide particles are uniformly dispersed.

[0058] It is possible that the metal melt contains 80 to 94 wt.% of magnesium, 5 to 10 wt.% of silicon, and 1 to 10 wt.% of aluminum. By using either formulation, magnesium-based metal particles having a mean particle diameter of 40 to 100 μm containing magnesium silicide particles having 1 to 10 μm uniformly dispersed therein can be obtained.

[0059] In the course of manufacturing particles at the step shown in Fig. 3C, it is possible to measure the flowing rate of the metal melt 32, and hence to measure and/or indicate the manufacturing rate of the metal particles 34 constantly, for instance, in every 30 minutes. The measurement and indication of the flowing rate and the manufacturing rate is useful in case of possible sudden change of the flowing rate. If the flowing rate is monitored to be unexpectedly changed, it is possible to suspend the manufacture as emergency.

[0060] If metal particles 34 with diameters of more than 100 μm, for example, in the range of 200 to 600 μm is desired, such particles with large diameters can also be manufactured by changing the flow rate. In this case, it is possible to obtain particles containing uniformly dispersed magnesium silicide therein.

[0061] According to the present invention, the metal particles 34 are used for preparing vehicle components. By using the metal particles 34 of the invention, the vehicle components can be easily and quickly manufactured.

[0062] The metal particles of the present invention are useful for preparing vehicle components such as a piston for an engine. In the process for manufacturing a vehicle component of the invention, the metal particles 10 can be directly charged into a mold for a compression molding, and pressure is applied to the metal particles. Accordingly, the metal particles are plastically deformed, and hence a molding is produced.

[0063] As additional operations, if the metal particles to be used do not have a uniform particle diameters, it is possible to classify the particle size and to use particles with narrow particle size distribution. On the other hand, when it is desired to use particles with different particle diameters, i.e., broad particle distribution, it is possible to blend particles with different diameters.

[0064] The preform obtained from the metal particles of the present invention is heated to a temperature lower than the melting point of the mixture of magnesium and silicone, for sintering the preform. During the sintering process, particles are fused to each other. As a result, the density of the sintered preform is increased (densification), and hence the strength of the product is increased.

[0065] Thereafter, the sintered preform, which is usually porous, is forged so that the voids are eliminated, and the rigidity of the product is increased.

[0066] Consequently, it is possible to easily and economically produce a light-weight vehicle component, such as a piston for a vehicle engine, with excellent mechanical properties by using particles of the present invention.

[0067] The engine made from the metal particles of the invention wherein finely-divided silicide particles are uniformly dispersed shows excellent fatigue strength at high temperatures. Moreover, the light-weight of the piston reduces a load to be applied to the engine.

[Examples]

[Manufacture of metal particles]

[0068] Metal particles are prepared based on the procedure explained with referring to Figs. 3A to 3C by using the apparatus shown in the figures. The opening of the outlet port was set to have a diameter of 1.5 mm.

[Examples 1 and 2 and Comparative Example 1]

[0069] 95 wt.% of magnesium and 5 wt.% of silicon both in pulverulent form are introduced into a fusing container (container), with introducing an inert gas thereto. Then, the temperature of the raw material mixture was increased to 950 °C to obtain a melt.

[0070] Pressure was applied to the inside of the sealed fusing container so as to make the pressure inside the fusing container is 0.4 bar higher (Example 1), 1.5 bar higher (Example 2), and 0.3 bar higher (Comparative Example 1), with respect to the atomization chamber.

[0071] The melt obtained from Comparative Example 1 had a high viscosity and could not discharge from the outlet port of the fusing container. (Result = X in Fig. 4) On the other hand, the melt obtained from Examples 1 and 2 had a good flowability and was discharged from the outlet port (Result = O in Fig. 4) .

[0072] Against the discharged melt of Examples 1 and

2, argon gas jet stream was applied with the gas flowing rate being controlled depending on the viscosity of the melt.

[Examples 3 and 4, and Comparative Example 2]

[0073] The procedure as to Examples 1 and 2 and Comparative Example 1 was repeated except that 95 wt.% of magnesium and 5 wt.% of silicon used as raw materials were replaced by 90 wt.% of magnesium and 10 wt.% of silicon. Pressure was applied to the inside of the sealed fusing container so as to make the pressure inside the fusing container is 0.4 bar higher (Example 3), 1.5 bar higher (Example 4), and 0.3 bar higher (Comparative Example 2), with respect to the atomization chamber. The melt from Comparative Example 2 could not be discharged because of the high viscosity, while it was possible to discharge the melt obtained from Examples 3 and 4.

[0074] Against the discharged melt of Examples 3 and 4, argon gas jet stream was applied with the gas flowing rate being controlled depending on the viscosity of the melt.

[0075] According to Examples 1 to 4, magnesium-based metal particles with a mean diameter of about 50 μm were produced in a stable condition. In the metal particles, silicon initially mixed to magnesium in a finely-dispersed state was completely converted into magnesium silicide particles, and the magnesium silicide particles with diameters of 5 μm or less were uniformly dispersed in the magnesium-based metal particles.

[Manufacture of piston for engine]

[0076] From the magnesium-based metal particles obtained by Examples 1, 2, 3 and 4, pistons for vehicle engines were produced via treatment of the metal particles, the compression molding of the metal particles, sintering and forging the preform.

[0077] The pistons had a fatigue strength of in the range of 25±25 MPa to 35±35 MPa at a temperature of 300 °C.

[0078] The present invention being thus described, it will be clearly understood that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the present invention, and all such modification as would be easily understood to one skilled in the art are intended to be included within the scope of the appended claims.

Claims

1. Magnesium-based metal particles (10) in the form of spheres having a mean diameter of 40 μm to 100 μm, composed of:

magnesium metal (12) and magnesium silicide particles (14) having a mean diameter of 1 μm to 10 μm uniformly dispersed in the magnesium metal (12), the magnesium-based metal particles (10) being obtained by mixing 80 wt.% to 94 wt.% of magnesium, 5 wt.% to 10 wt.% of silicon and 1 wt.% to 10 wt.% of aluminum, and the magnesium silicide particles (14) being formed in the metal particles (10) by the reaction of the magnesium and the silicon.

2. A process for manufacturing magnesium-based metal particles (10) in the form of spheres containing magnesium metal (12) and therein uniformly dispersed magnesium silicide particles (14), having a mean diameter of 1 μm to 10 μm, comprising:

charging a container (22) with a mixture of 80 wt.% to 94 wt.% of magnesium, 5 wt.% to 10 wt.% of silicon and 1 wt.% to 10 wt.% of aluminum under an inert gas atmosphere,
heating the mixture to a temperature which exceeds the solidification temperature of the mixture and which is lower than the boiling temperature thereof,
maintaining the temperature of the mixture,
increasing the internal pressure of the container (22) with respect to the internal pressure of a chamber (40) which is provided below the container (22) by 0.4 bar or more,
discharging a melt of the mixture from an outlet port (28) of the container (22) to the chamber (40), applying a jet gas stream (36) to the melt discharged from the outlet port (28) so as to scatter the melt in the form of particles having a mean diameter of about 40 μm to about 100 μm, and solidifying the particles.

3. The process for manufacturing metal particles (10) in the form of spheres containing therein uniformly dispersed magnesium silicide particles as claimed in claim 2, wherein the temperature of the mixture heated in the container (22) is in the range of 940°C to 960°C, and the outlet port (28) of the container (22) is set to have a diameter in the range of 1.0 mm to 2.0 mm.

4. The process for manufacturing metal particles (10) in the form of spheres containing therein uniformly dispersed magnesium silicide particles as claimed in any of claims 2 or 3, wherein the pressure in the container (22) is higher than in the chamber (40) by 0.4 bar to 1.5 bar.

5. The process for manufacturing metal particles (10) in the form of spheres containing therein uniformly dispersed magnesium silicide particles as claimed in any of claims 2 to 4, wherein high-frequency induction furnace is used as the container (22).

6. A process for manufacturing a vehicle component, comprising:

subjecting magnesium-based metal particles (10) of claim 1 compression molding to give a molding;
sintering the molding by heating the molding to a temperature lower than the melting temperature of the mixture to give a sintered material, and
forging the sintered material with application of heat thereto.

7. The process for manufacturing a vehicle component as claimed in claim 6, wherein the vehicle component is a piston for an engine.

FIG 1

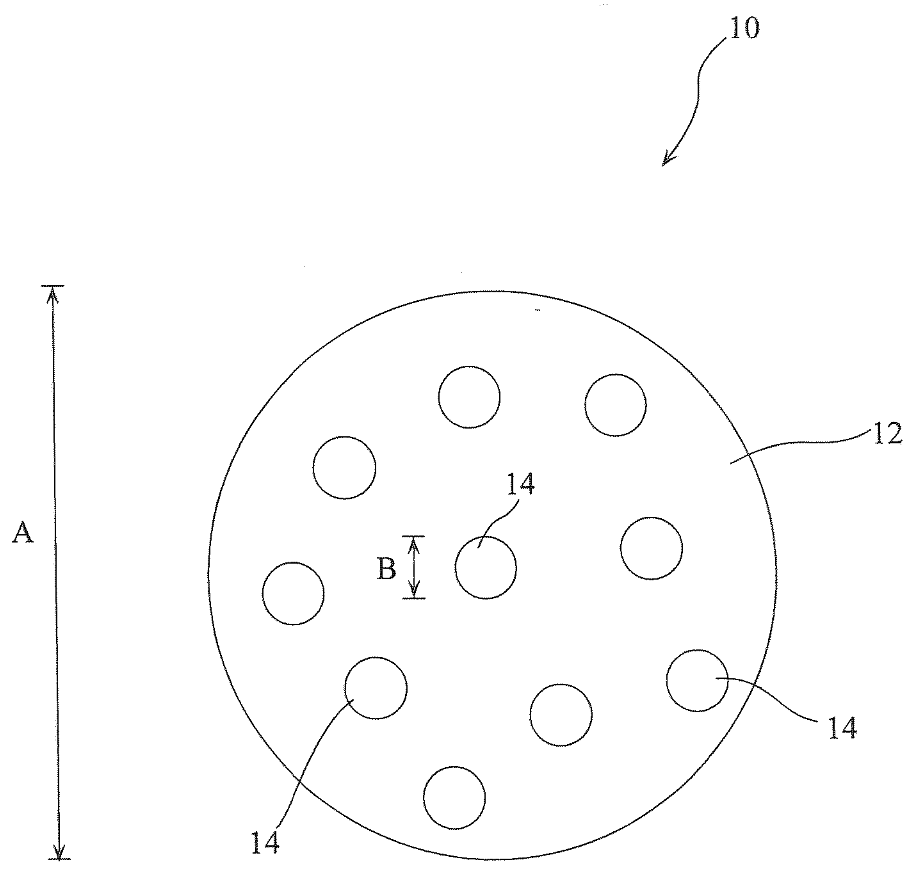


FIG. 2

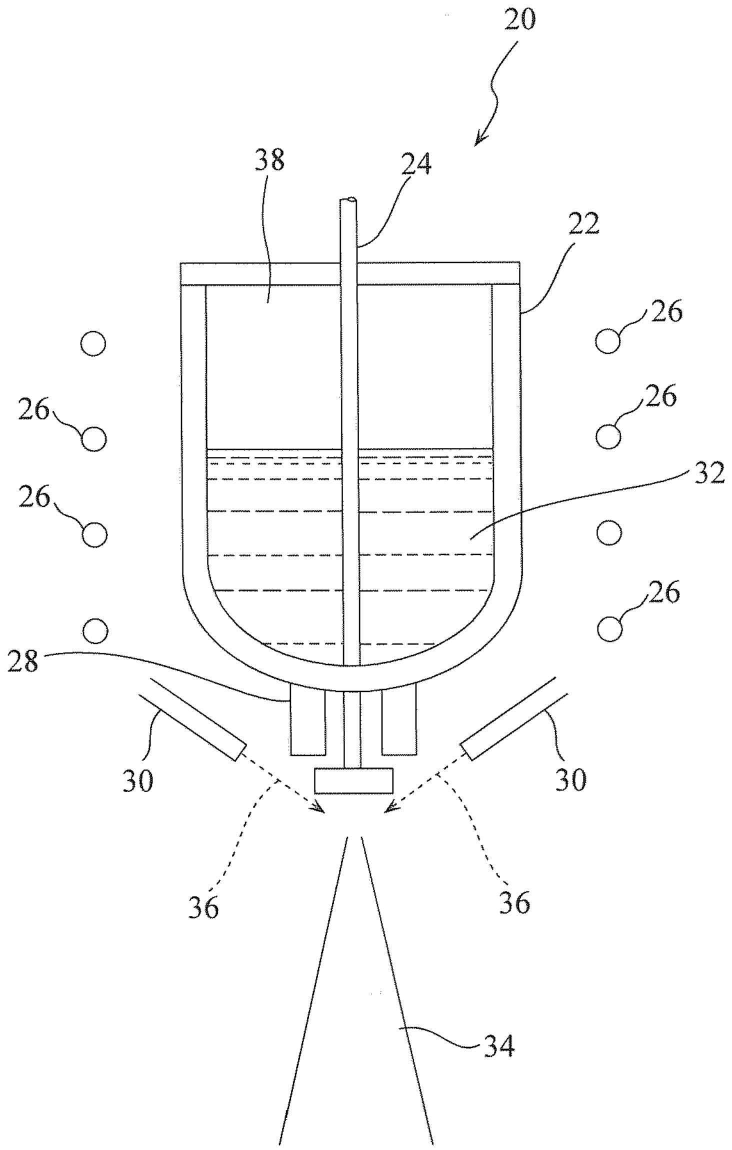


FIG. 3C

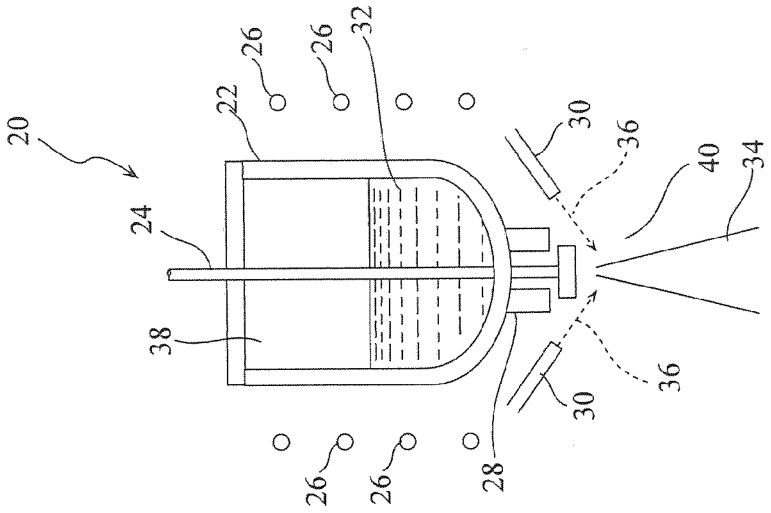


FIG. 3B

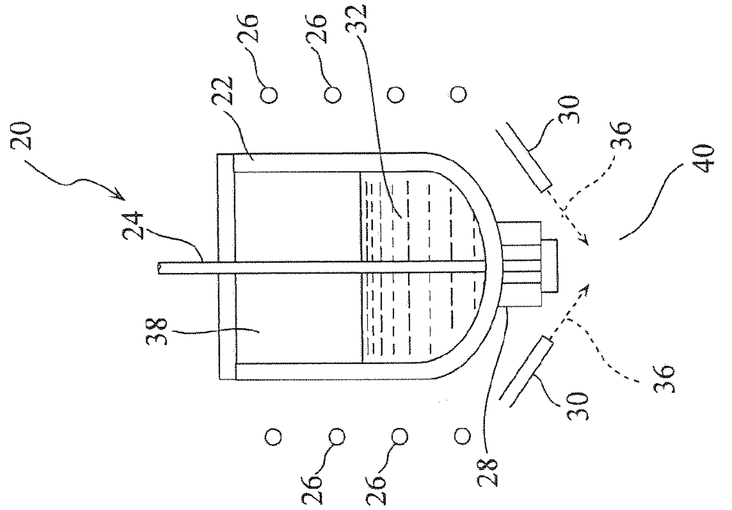


FIG. 3A

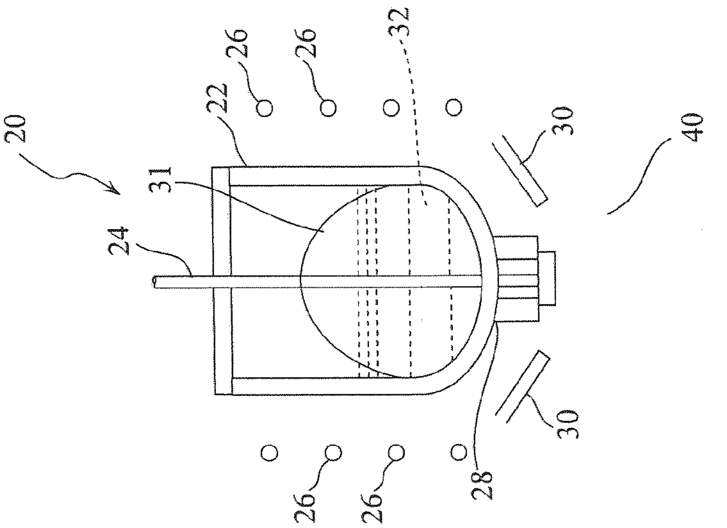


FIG. 4

Examples	Materials	Liquidus Temp.	Boiling Point of Mg	Temperature of the melt	Pressure Difference*	Result
Comparative Example 1	Mg 95 wt. % Si 5 wt. %	Ca. 780℃	1090℃	950℃	0.3 bar	×
Example 1					0.4 bar	○
Example 2					1.5 bar	○
Comparative Example 2	Mg 90 wt. % Si 10 wt. %	Ca. 880℃	1090℃	950℃	0.3 bar	×
Example 3					0.4 bar	○
Example 4					1.5 bar	○

* Pressure in the container was higher than the outside by the shown value.

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 5334

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	1 April 2009	Zimmermann, Frank

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