Review of Aluminium Alloy through Powder Route

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Abstract: Aluminum base powder metallurgy alloy article having an improved combination of high-transverse yield strength and high-stress corrosion cracking resistance. The alloy contains the basic precipitation hardening elements zinc. The bonding materials are mixed up with aluminum and zinc alloy to form a mixture. After the mixing process compacting and forming a solid mass of material by heating below the melting point of metal. Zinc varies from 8% to 12 % and mixed up with aluminum and heated below 400°c. In this an attempt has been be made to study the structural and mechanical properties of Aluminium alloy with zinc as macro addition using Powder metal forming with conventional sintering techniques. Powder metal forming process gives an advantage in terms Cost, quality of finished products, precision and considerable saving in raw materials as compare to other metal forming process.

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1. Introduction

1.1 Powder metallurgy (PM) is a term covering a wide range of ways in which materials or components are made from metal powders. PM processes can avoid, or greatly reduce, the need to use metal removable process, thereby drastically reducing yield losses in manufacture and often resulting in lower costs. Powder metallurgy is also used to make unique materials impossible to get from melting or forming in other ways. A very important product of this type is tungsten carbide (WC). WC is used to cut and form other metals and is made from WC particles bonded with cobalt. It is very widely used in industry for tools of many types and globally ~50,000 tons / year (t/y) is made by PM. Other products include sintered filters, porous oil-impregnated bearings, electrical contacts and diamond tools. The powder metallurgy press and sinter process generally consists of three basic steps: powder blending (pulverization), die compaction, and sintering. Compaction is generally performed at room temperature, and the elevated-temperature process of sintering is usually conducted at atmospheric pressure and under carefully controlled atmosphere composition. Optional secondary processing such as coining or heat treatment often follows to obtain special properties or enhanced precision. One of the older such methods, and still one used to make around 1 Mt/y of structural components of iron-based alloys, is the process of blending fine metal (normally iron) powders with additives such as a lubricant wax, carbon copper and nickel pressing them into a die of the desired shape, and then heating the compressed material ("green part") in a controlled atmosphere to bond the material by sintering. This produces precise parts, normally very close to the die dimensions, but with 5–15% porosity, and thus sub-wrought steel properties. There are several other PM processes which have been developed over the last fifty years. A much wider range of products can be obtained from powder processes than from direct alloying of fused materials.

1.2 Aluminium

Aluminium is a chemical element with the symbol Al and atomic number 13. It is a silvery white, soft, non-magnetic and ductile metal in the boron group. By mass, aluminium makes up about 8% of the Earth's crust, where it is the third most abundant element (after oxygen and silicon) and also the most abundant metal. Occurrence of aluminium decreases in the Earth's mantle below, however. The chief ore of aluminium is bauxite. Aluminium metal is highly reactive, such that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals. Aluminium is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in transportation and building industries, such as building facades and window frames. The oxides and sulphates are the most useful compounds of aluminium. Aluminium is a very light metal with a specific weight of 2.7 g/cm3, about a third of that of steel. This cuts the costs of manufacturing with aluminium. Again, its use in vehicles reduces dead-weight and energy consumption while increasing load capacity. This also reduces noise and improves comfort levels. It is extensively used in industries due to following desirable's properties

- Light Weight
- Corrosion Resistance
- Electrical and Thermal Conductivity
- Reflectivity
- Ductility
- Sound and Shock Absorption

.Sih.et al Aluminium Powder Metallurgy, The University of Queensland Australia, Wood head Publishing Limited 2011 (Pg. No 655 - 701).

The chapter is about the sintering of aluminum powder to know the physical and mechanical property changes under different sintering temperature. The specimen were compacted under a pressure of 165 MPa and sintered at 400^0 C During sintering following four overlapping stages were observed

- Particle reassessment
- Localized plastic deformation
- Homogeneous plastic deformation
- Bulk composition

The authors observed that the plastic deformation stages results in the hastening of the particle counter and the filling of void to the contact points and concluded that the process is very economical for max production - loss of material is less – it eliminates machining. Very good material utilization and can obtain any kind of property changes based on the application.

2.2 Powder Metallurgy Aluminium Matrix Composition.

J.M Torralba et al Powder Metallurgy Aluminium Matrix Composition, Centro de Ciencia's Technologies, Journal of materials processing Tech 2013 (Pg.No 203 - 207).

Aluminum alloy consisting of Al-Lithium (Li) alloy Composite materials were developed in line to obtain high stiffness using pirouette. Al-Li alloy decrease the density of the metal and increase the Young's Modulus which is most commonly used in Aerospace. Conventional Pirouette, Mixing – mining – uniaxial pressing – cold isotactic press – hot isotactic press
The materials were formed by unidirectional pressure under a load of 200 MPa and stirred art 300^0 C for a short period of time. The density ratio of the aluminum alloy was found to be decreased. At high temp the tensile strength was found to be increased more than 200 MPa.
The torque period of Sintering can produce dimensional lustabilities with in the specimen produced. The materials produced can be easily modified to satisfy different application.

2.3 Aluminium Powder Metallurgy Technology for High Strength Applications.

J.R, PICKENS, Aluminium Powder Metallurgy Technology for High Strength Applications, Matrix Marietta Lab, South rolling Road ,Baltimore, Maryland-USA, Tourna of material science1981 (Pg.No:1437-1457).
The powder metallurgy route was used the order to produce a metal with superior properties resulting from a superior properties and uniform microstructure. Atomization process was used to produce powder. The specimens were prepared by two different methods .Powder metallurgy, Ingot metallurgy under a sintering temp of 340^0C

Alloy	Method of formation	condition	Ultimate tensile strength (Mpa)	Yield stress (Mpa)	Elongation %
AL3003	Powder metallurgy	As-extruded	207	145	24
AL3003	Ingot metallurgy	As-extruded	131	83	32

Finally the author concluded that high strength alloy can be manufactured and can replace AL7000 for some applications. Solidification approach does not elimination the need of costly heat treatments.

2.4 Super plasticity in Powder Metallurgy Aluminium Alloys and Composites.

Powder metallurgy Fabrication was used in order the five Grained microstructure and intermetallic phase changes of formed specimens. Following composition was taken for the studies

- Aluminium alloy -40%
- Zirconium (Zr):atomic number 40-3%
- Chromium (Cr):atomic number 24-23%
- Manganese (Mn):atomic number 25-29%

All the above specimens were compacted at 150 MPa and sintering temperature was 4000 C. Different type of stress strain curves were absorbed during super plastic deformation was clearly discussed through graphs, changes in microstructure were revised and discussed.
Finally the author with this experiments concluded that a microstructure threshold stress needs to be taken into account for high strain rate super plasticity in aluminium alloy with fine dispersions or second phase composite constituents.

2.5 Powder Processed Aluminium Alloys

G.B.SCHAFFER, Powder Processed Aluminium Alloys, The university of Queensland , Australia , Institute of Material Engineering Ltd , Australia, Materials Forum1995(Pg.No:65-75).
The concept of this particular project was to form a material which is light Wight for cost effective processing using PM & Micro allying. Composition taken for studies Alloy (aluminium AA6061) with

- copper-0.25
- Magnesium -1.0
- Silicon -0.6

PM, Sintering (590^0C-620^0C , Micro allying, Metal matrix composites. The major application of lightweight aluminium is cam shaft bearing caps. As per the practical result the author absorbed that the practical grain size was increased and the fatigue life was increased up to 25% to 100Mpa. Further development will provide many more opportunities in the automotive industries. Low sintering temperature, easy machinability and good corrosive

resistant are the main advantages of PM.

2.6 Aluminium Powder Metallurgy

B.VERUNDEN, Aluminium Powder Metallurgy, University of Leuven –Belgium, TATAT 1401,EAA-European aluminium association (Pg.No126).

The main object is to understand the difference between conventionally produced and powder metallurgy aluminium with respect to potential uses. To understand the potential of aluminium produced by the route of PM and also have advantages and disadvantages of aluminium produced by PM. Material used: aluminium 7000 series.

Finally author concluded that PM alloy of 7000 series produced were having high strength but the ductility of specimens was very low (less than 1% elongation) Strength (654Mpa)-elongation (5%) fatigue limit (207 Mpa).

2.7 Microstructure Examination and Properties of premixed AL –CU-MG Powder metallurgy Alloy

Azim ciokee et al, Microstructure Examination and Properties of premixed AL –CU-MG Powder metallurgy Alloy, Elsevier B.V.

The experiment was about to obtain high strength material and also determine the microstructure of aluminium composite material produced using PM route.

The experiment was about to obtain high strength material and also determine the microstructure of aluminium composite material produced using PM route. Following composition was taken for the studies

- Aluminium powder
- Copper-5%
- Magnesium-5%

Aluminium powder was mixed with Cu & Mg in macro & micro level in order to produce light & strong specimen. High strength aluminium were developed with

- TRS value of 466 Mpa was obtained with the elemental mixture
- Hardness value of AL 5 CU 0.5 Mg alloy was two times higher than AL base material

Finally it was concluded that PM route is more effective for industries were high strength aluminium alloy are required. Mixture with micro and level result in greater hardness.

3 Expected outcome

In observation of all the above review papers .the authors have under gone many practical experiments on aluminium alloy alone and also with composition of two three materials by having AL as a primary material. Aluminium alloy alone the expect outcome result can be defined as:

- High strength aluminium can be obtained.
- The hardness value of aluminium high increase 1.5 times more in the specimen made by Powder metallurgy compared with conventional material.
- The ultimate tensile strength and yield stress can be increased up to 207 MPa &145 MPa respectively according to J.R PICKMENS.

Composition of aluminium and zinc

- Shapes and flexibility in machining.
- The mixed composition powder with micro and macro levels may result in light weight &low density.
- Uniform micro structure can be obtained under a sintering temp of 400^0C

4. Conclusion

Based on the literature survey of powder metallurgy plays a vital role in Industries which is need of high strength martial at low cost .Further development may provide more opportunities the automotive industries (cam shaft –piston etc.).Powder metallurgy alloys the materials obtaining better mechanical properties. Low cost and high developments within the materials are the main advantages of powder metallurgy route

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