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Analysis the Mechanical Characteristics of Al-Mg Alloy with Al2o3 Composite in Powder Metallurgy

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ABSTRACT

In this work an attempt has been made to analysis the mechanical behavior of Al-Mg and Al_2O_3 Composite were producing using powder metallurgy technique. Al-Mg alloy powders were homogenously mixed with following three weight percentages of alumina (Al_2O_3) and it should compact at a pressure ranging from 307 to 512 MPa. Green compacts should sinter at temperatures between 575 and 625°C. Experiments should perform under different conditions of temperature, Alumina content and compacting pressure. Experimental results indicate that various behavior of such as density and hardness can be improved effectively through Finite Element Method and Experimental setup and also may compare the results through Taguchi optimizing technique for ratio of weight percentage.

Introduction

A composite material (also called a composition material or shortened to composite) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials physical properties

The physical properties of composite materials are generally not isotropic (independent of direction of applied force) in nature, but rather are typically anisotropic (different depending on the direction of the applied force or load). For instance, the stiffness of a composite panel will often depend upon the orientation of the applied forces and/or moments. Panel stiffness is also dependent on the design of the panel. For instance, the fibre reinforcement and matrix used, the method of panel build, thermoset versus thermoplastic, type of weave, and orientation of fibre axis to the primary force.

In contrast, isotropic materials (for example, aluminium or steel), in standard wrought forms, typically have the same stiffness regardless of the directional orientation of the applied forces and/or moments.

The relationship between forces/moments and strains/curvatures for an isotropic material can be described with the following material properties: Young's Modulus, the shear Modulus and the Poisson's ratio, in relatively simple mathematical relationships. For the anisotropic material, it requires the mathematics of a second order tensor and up to 21 material property constants. For the special case of orthogonal isotropy, there are three different material property constants for each of Young's Modulus, Shear Modulus and Poisson's ratio—a total of 9 constants to describe the relationship between forces/moments and strains/curvatures.

In 2006, a fiber-reinforced composite pool panel was introduced for in-ground swimming pools, residential as well as commercial, as a non-corrosive alternative to galvanized steel.

In 2007, an all-composite military Humvee was introduced by TPI Composites Inc and Armor Holdings Inc, the first all-composite military vehicle. By using composites the vehicle is lighter, allowing higher payloads. In 2008, carbon fiber and DuPont Kevlar (five times stronger than steel) were combined with enhanced thermoset resins to make military transit cases by ECS Composites creating 30-percent lighter cases with high strength.

Pipes and fittings for various purpose like transportation of potable water, fire-fighting, irrigation, seawater, desalinated water, chemical and industrial waste, and sewage are now manufactured in glass reinforced plastics.

Production

Aluminium hydroxide minerals are the main component of bauxite, the principal ore of aluminum. A mixture of the minerals comprise bauxite ore, including gibbsite ($Al(OH)_3$), boehmite (γ-$AlO(OH)$), and diaspore (α-$AlO(OH)$), along with impurities of iron oxides and hydroxides, quartz and clay minerals. Bauxites are found in laterites. Bauxite is purified by the Bayer process:

$$AlO(OH) + H_2O + NaOH \rightarrow NaAl(OH)_4$$

$$Al(OH)_3 + NaOH \rightarrow NaAl(OH)_4$$

Except for SiO_2, the other components of bauxite do not dissolve in base. Upon filtering the basic mixture, Fe_2O_3 is removed. When the Bayer liquor is cooled, $Al(OH)_3$ precipitates, leaving the silicates in solution.

$$NaAl(OH)_4 \rightarrow NaOH + Al(OH)_3$$

The solid $Al(OH)_3$ Gibbsite is then calcined (heated strongly) to give aluminium oxide:

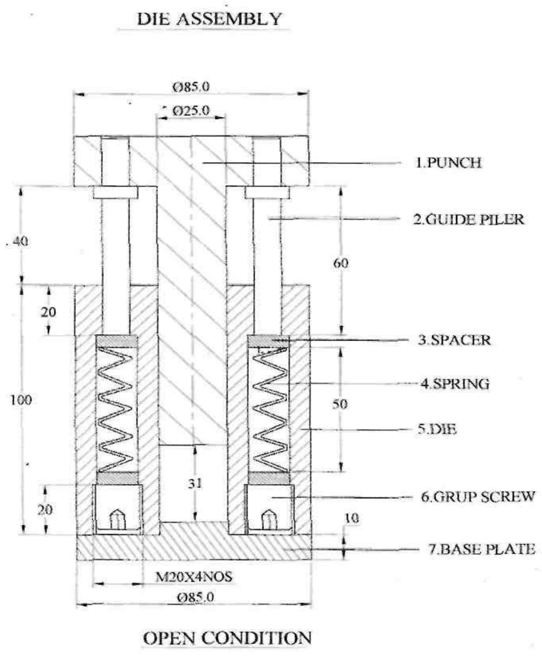
$$2\,Al(OH)_3 \rightarrow Al_2O_3 + 3\,H_2O$$

The product aluminium oxide tends to be multi-phase, i.e., consisting of several phases of aluminium oxide rather than solely corundum. The production process can therefore be optimized to produce a tailored product. The type of phases present affects, for example, the solubility and pore structure of the aluminium oxide product which, in turn, affects the cost of aluminium production and pollution control.

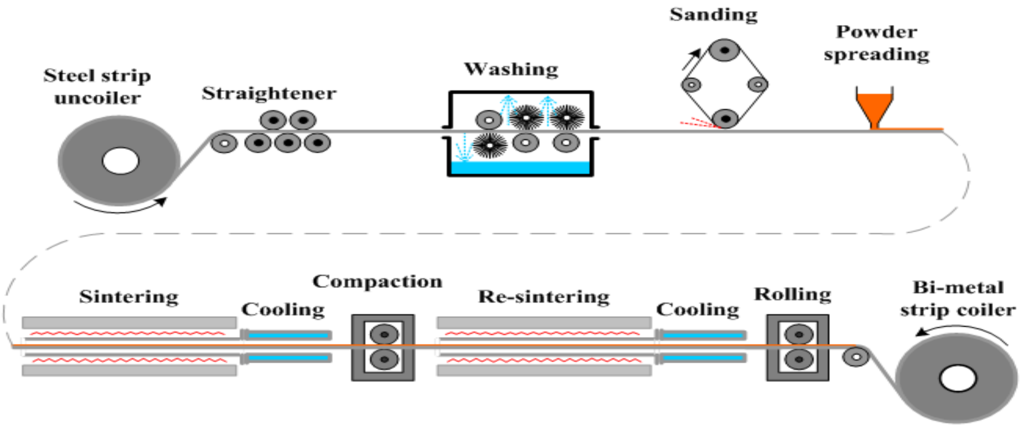
1 Powder production techniques

Any fusible material can be atomized. Several techniques have been developed which permit large production rates of powdered particles, often with considerable control over the size ranges of the final grain population. Powders may be prepared by crushing, grinding, chemical reactions, or electrolytic deposition.

Powders of the elements titanium, vanadium, thorium, niobium, tantalum, calcium, and uranium have been produced by high-temperature reduction of the corresponding nitrides and carbides. Iron, nickel, uranium, and beryllium sub micrometre powders are obtained by reducing metallic oxalates and formates. Exceedingly fine particles also have been prepared by directing a stream of molten metal through a high-temperature plasma jet or flame, atomizing the material. Various chemical and flame associated powdering processes are adopted in part to prevent serious degradation of particle surfaces by atmospheric oxygen.In tonnage terms, the production of iron powders for PM structural part production dwarfs the production of all of the non-ferrous metal powders combined. Virtually all iron powders are produced by one of two processes: the sponge iron process or water atomization.



Sintering process for copper based bi-metal strips



TAGUCHI METHOD OF ANALYSIS

Taguchi's approach to parameter design provides the designer with a systematic and efficient method to determine near optimum settings of design parameters of the experimental process. Taguchi method uses orthogonal arrays from design of experiments theory to study the parameter space with a small number of experiments.

Taguchi method is a quality analysis to evaluate the results obtained. This analysis can be achieved by employing the signal-to-noise (S/N) ratio, and this ratio depends on the quality characteristics of the process to be optimized .The three categories of S/N ratios are (a), higher the better(**HB**), (b) lower the better and (c) nominal the best. In any sintering process, the main objective is to maximize density and hardness. Hence, the HB type S/N ratio was applied for the sintering process.

$$\text{S/N Ratio} \quad = -10\log_{10}\left(\frac{1}{j}\right)\sum_{i=1}^{j}\frac{1}{y_i^2}$$

Where *j* number of repetitions of the experiment, *yi* observed response value

In Taguchi designs, a measure of robustness used to identify control factors that reduce variability in a product or process by minimizing the effects of uncontrollable factors (noise factors). Control factors are those design and process parameters that can be controlled. Noise factors cannot be controlled during production or product use, but can be controlled during experimentation. In a Taguchi designed experiment, you manipulate noise factors to force variability to occur and from the results, identify optimal control factor settings that make the process or product robust, or resistant to variation from the noise factors. Higher values of the signal-to-noise ratio (S/N) identify control factor settings that minimize the effects of the noise factors.

Taguchi experiments often use a 2-step optimization process. In step 1 use the signal-to-noise ratio to identify those control factors that reduce variability. In step 2, identify control factors that move the mean to target and have a small or no effect on the signal-to-noise ratio.

The signal-to-noise ratio measures how the response varies relative to the nominal or target value under different noise conditions. You can choose from different signal-to-noise ratios, depending on the goal of your experiment. Sintering of metallic powders. Most, if not all, metals can be sintered. This applies especially to pure metals produced in vacuum which suffer no surface contamination. Sintering under atmospheric pressure requires the use of a protective gas, quite often endothermic gas. Sintering, with subsequent reworking, can produce a great range of material properties. Changes in density, alloying, or heat treatments can alter the physical characteristics of various products. For instance, the Young's Modulus En of sintered iron powders remains insensitive to sintering time, alloying, or particle size in the original powder, but depends upon the density of the final product.

Sintering is static when a metal powder under certain external conditions may exhibit coalescence, and yet reverts to its normal behavior when such conditions are removed. In most cases, the density of a collection of grains increases as material flows into voids, causing a decrease in overall volume. Mass movements that occur during sintering consist of the reduction of total porosity by repacking, followed by material transport due to evaporation and condensation from diffusion.

In the final stages, metal atoms move along crystal boundaries to the walls of internal pores, redistributing mass from the internal bulk of the object and smoothing pore walls. Surface tension is the driving force for this movement.
A special form of sintering (which is still considered part of powder metallurgy) is liquid-state sintering in which at least one but not all elements are in a liquid state. Liquid-state sintering is required for making cemented carbide or tungsten carbide.
Sintered bronze in particular is frequently used as a material for bearings, since its porosity allows lubricants to flow through it or remain captured within it. Sintered copper may be used as a wicking structure in certain types of heat pipe construction, where the porosity allows a liquid agent to move through the porous material via capillary action. For materials that have high melting points such as molybdenum, tungsten, rhenium, tantalum, osmium and carbon, sintering is one of the few viable manufacturing processes. In these cases, very low porosity is desirable and can often be achieved. Sintered metal powder is used to make frangible shotgun shells called breaching rounds, as used by military and SWAT teams to quickly force entry into a locked room. These shotgun shells are designed to destroy door deadbolts, locks and hinges without risking lives by ricocheting or by flying on at lethal speed through the door. They work by destroying the object they hit and then dispersing into a relatively harmless powder. Sintered bronze and stainless steel are used as filter materials in applications requiring high temperature resistance while retaining the ability to regenerate the filter element. For example, sintered stainless steel elements are employed for filtering steam in food and pharmaceutical applications, and sintered bronze in aircraft hydraulic systems.

Signal-to-noise ratio	Goal of the experiment	Data characteristics	Signal-to-noise ratio formulas
Larger is better	Maximize the response	Positive	S/N = -10 *log(Σ(1/Y2)/n)
Nominal is best	Target the response and you want to base the signal-to-noise ratio on standard deviations only	Positive, zero, or negative	S/N = -10 *log(σ2)
Nominal is best (default)	Target the response and you want to base the signal-to-noise ratio on means and standard deviations	Non-negative with an "absolute zero" in which the standard deviation is zero when the mean is zero	$S/N = 10 \times \log((\overline{Y}^2) \div \sigma^2)$ The adjusted formula is: $S/N = 10 \times \log((\overline{Y}^2 - s^2 \div n$
Smaller is better	Minimize the response	Non-negative with a target value of zero	S/N = -10 *log(Σ(Y2)/n))

Results and discussion

Verification of the experimental results:

- The system which has related information is completely known as a white system, while a system for which the related information is completely unknown is a 'black' system. Any system between these limits is a 'grey' system having poor and limited information.
- Gray relational analysis is a measurement technique in gray system theory that analysis the degree of relation in a discrete sequence.
- The multiple performance characteristics were evaluated using grey relational analysis. In this analysis, the optimization of multiple performance characteristics can be converted into optimization of single grey relational grade. The following steps are considered for grey relational analysis.

1.Very high levels of purity and uniformity in starting materials
2. Preservation of purity, due to the simpler subsequent fabrication process (fewer steps) that it makes possible
3. Stabilization of the details of repetitive operations, by control of grain size during the input stages
4. Absence of binding contact between segregated powder particles – or "inclusions" (called stringering) – as often occurs in melting processes
5. No deformation needed to produce directional elongation of grains
6. Capability to produce materials of controlled, uniform porosity.
7. Capability to produce nearly net-shaped objects.
8. Capability to produce materials which cannot be produced by any other technology.
9. Capability to fabricate high-strength material like turbine blades.
10. After sintering the mechanical strength to handling becomes higher.

Conclusion

Mechanical behaviours such as strength, toughness, are analysed. The analysed result will satisfy the industrial needs with safe economy and environment.

References

[1] M. K¨ok , K.Ozdin (October 2006) "Wear resistance of aluminium alloy and its composites reinforced by Al2O3 particles" investigate and analys the sliding wear test.

[2] A.R.I. Kheder,G.S. Marahleh, D.M.K. Al-Jamea (December 2011) "Strengthening of Aluminum by SiC, Al2O3 and MgO" The objective of this experimental investigation is to produce a metal matrix composite (MMC)

[3] K.Hemalatha1, V. S. K.Venkatachalapathy2, N.Alagumurthy (December2013) "Processing and Synthesis of Metal Matrix Al 6063/Al2o3 Metal Matrix Composite by Stir Casting Process"

[4] Dinesh Kumar Koli, Geeta Agnihotri, Rajesh Purohit (October 2013) "Properties and Characterization of Al-Al2O3Composites Processed by Casting and Powder Metallurgy Routes (Review)" [5] Chinawad DHADSANADHEP1*, Tachai LUANGVARANUNT,1**Junko UMEDA2 and Katsuyoshi KONDOH2(November 2008) "Fabrication of Al/Al2O3 Composite by Powder Metallurgy Method from Aluminum and Rice Husk Ash"

[6] Azizah Wahi, Norhamidi Muhamad, and Abu Bakar Sulong (February 2015) “Sintering Parameter Optimization of µ PIM Co-30Cr-6Mo using Taguchi -Grey Relational Analysis based on Multiple Responses”.

[7] K. K. Alaneme, E. O. Adewuyi (March 2013) “Mechanical behaviour of Al-Mg-Si Matrix composite reinforced with alumina and bamboo leaf ash”
[8] P. Naphon, Effect of coil-wire insert on heat transfer enhancement and pressure drop of the horizontal concentric tubes, International Communications in Heat and Mass Transfer 33 (2006) 753–763.

[9] P. Naphon, P. Sriromruln, Single-phase heat transfer and pressure drop in the micro-fin tubes with fin insert, International Communications in Heat and Mass Transfer 33 (2006) 176–183.

[10] P. Sivashanmugam, S. Suresh,Experimental studies on heat transfer and frictionfactor characteristics of turbulent flow through a circular tube fitted with regularly spaced helical screw-tape inserts, Applied Thermal Engineering 27 (2007) 1311–1319.

[11] P. Sivashanmugam, S. Suresh, Experimental studies on heat transfer and friction factor characteristics of turbulent flow through a circular tube fitted with helical screw-tape inserts, Chemical Engineering and Processing 46 (2007) 1292–1298.

[12] S. Eiamsa-ard, P. Promvonge, Heat transfer characteristics in a tube fitted with helical screw-tape with/without core-rod inserts, International Communications in Heat and Mass Transfer 34 (2007) 176–185.

[13] P. Promvonge, Thermal augmentation in circular tube with twisted tape and wire coil turbulators, Energy Conversion and Management 49 (2008) 2949–2955.

[14] S.W. Chang, T.L. Yang, J.S. Liou, Heat transfer and pressure drop in tube with broken twisted tape insert, Experimental Thermal and Fluid Science 32 (2007) 489–501.

[15] A. Garc, J.P. Solano, P.G. Vicente, A. Viedma, Flow pattern assessment in tubes with wire coil inserts in laminar and transition regimes, International Journal of Heat and Fluid Flow 28 (2007) 516–525.