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Study of Salt Spray Corrosion on Powder-Metallurgy-made Aluminum Metal Matrix Composites

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Abstract

Metal Matrix Composites (MMCs) production is one of the major role in the industries, the Powder Metallurgy method is suitable for production of MMCs at correct proportional rate. Aim of this experimental work is prepare the Aluminum Metal Matrix Composites (AMMCs) by powder metallurgy route. Aluminium alloy AA7085 is selected for this experimental work due to their extreme mechanical properties. Strengthening of this aluminum alloy is carried out by addition of Titanium Diboride (TiB2) with different weight percentage [1-15]. AMMCs are prepared through powder metallurgy route and the process parameters of the P/M are optimized with the aid of Taguchi approach. Parameters are selected for this experimental work is milling time (3 hrs, 4 hrs and 5 hrs), compaction pressure (200 MPa, 250 MPa and 300 MPa) and sintering temperature (550°C, 600°C and 650°C). Minimum corrosion rate is obtained as 0.00092 mm/year, milling time is highly influenced in the corrosion rate analysis.

Introduction

The Powder Metallurgy process is excellent for producing MMCs at the correct proportionate rate. Metal Matrix Composites (MMCs) manufacture is one of the important roles in the industries. The goal of this research is to use powder metallurgy to make Aluminum Metal Matrix Composites (AMMCs). Because of its extraordinary mechanical qualities, the aluminum alloy AA7085 was chosen for this research. This aluminum alloy is strengthened by the inclusion of Titanium Diboride (TiB2) in various weight percentages. AMMCs are made via the powder metallurgy technique, and the Taguchi approach is used to optimize the P/M process parameters. Milling duration (3 hours, 4 hours, and 5 hours) and compaction pressure (200 MPa, 250 MPa, and 300 MPa) are the parameters chosen for this experiment.

Energy and resource efficiency are critical components in improving the European industry's long-term viability and competitiveness. Energy efficiency aims to reduce the amount of energy currently consumed in industrial operations, whereas resource efficiency refers to the ability to create the same product/service with less resources (EC, 2015). Decarbonization of the EU's energy system will require a major increase in energy efficiency. In this sense, the new European Green Deal (EC, 2019), which sets the goal of achieving carbon neutrality for Europe by 2050, could be a game-changer. The new Green Deal implements an unparalleled transformation of production and consumption habits on a scale of less than a decade by increasing energy and resource efficiency.

Subjective Heading

Present aluminum matrix composites are highly demanding material in aerospace industry, automobile industry and other engineering applications. Aluminum matrix composites find a wide range of popularity in transportation sector because of lower noise and lower fuel consumptions over another material. Composite materials are old as our human civilization but commercialized after 2nd world war. A composite is a material that consists of constituents produced by a physical combination of pre-existing monolithic compounds to obtain a new material with unique properties when compared to the base composition. Current definition distinguishes a composite from other multiphase materials which are produced by bulk processes where one or more phases result from phase transformation.

Discussion

In general, two phases are present in any composite matrix and reinforcement. Composite is defined as a material which consists of two or more physically and chemically distinct parts which are suitably arranged and are having different properties with respect to those of each constituent par. Industry and material scientist define composite as a material that consists of constituents produced by a physical combination of already existing compound to yield a new material with different properties as compared to the base composition. In general matrix is continuous and surrounds the discontinuous reinforcement phase present in the composite material. The composites are classified according to their matrix (polymer, ceramic, metal and carbon their reinforcement, which includes their chemical nature oxides, carbides and nitrides the shape (continuous fibres, short fibres, whiskers and particulates) and (4) the orientation and the processing routes . The other two classes are carbon–carbon composites and hybrid matrix composites. In a composite, when the matrix is a metal or an alloy of metal, we have a metal matrix composite which forms the percolating network. Other constituent embedded in this metal/metal alloy matrix serves as reinforcement. It is usually non-metallic and are commonly ceramic such as, C, Al_2O_3, SiO_2, B, BN, B_4C

Many factors influence the selection of the processing technique, which include the type of reinforcement and matrix, their mechanical and thermal properties and the extent of microstructural integrity desired. The type of reinforcement, variation of reinforcement in matrix and interaction of matrix with reinforcement plays a vital role in determining the final properties of the composite Various

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investigations have been carried out using the different type of matrix materials

Magnesium based composites has gained a lot of attention due to improved mechanical and corrosion properties. It serves as a potential candidate for application in light weight components. Most Mg–Al alloys contain 8–9% Al with small amount of Zn to give increase in tensile strength. 0.1–0.3 wt% addition of Mn improves corrosion resistance. Composite materials based on Mg alloys reinforced by dispersion particles of silicon carbide shows very low density in the range of 2.0–2.1 g/cm^3 and are characterized by 30–40% better mechanical properties than unreinforced magnesium alloys. High reactivity of Mg leads to significant problems in synthesis of Mg-based MMCs. Improper fabrication process can also cause degradation rather than improvement of the mechanical properties. Thus, special attention should be given to the reaction products at the interface between SiC particles and the Mg matrix.

Iron based metal matrix composites are used for heavy duty applications such as railway wagon wheels, braking system etc. Synthesis of iron based composites is carried out using powder metallurgy technique since it leads to the generation of homogenous phase along with least interaction between the matrix and reinforcement phase. Gupta et al. reported that for Fe-Al_2O_3 metal matrix composites the various properties such as density, hardness, wear, deformation and corrosion is found to improve. Improvement in the properties is found due to iron aluminate ($FeAl_2O_4$) phase formation. Iron aluminate phase forms as a result of reactive sintering between iron and alumina

Micrometric Al_2O_3 particulates have been widely used in aluminum matrix composites and some literature on use of nano-metric Al_2O_3 particulates are also available. Aluminum and its alloys are one of the most widely used light weight materials in MMCs as matrix, both from research and industrial point of view. This is attributed to its outstanding properties, such as high strength, high specific modulus, good wear resistance and low thermal expansion coefficient.

Investigated the effect of SiC reinforcement on Al-Si alloy properties. Composites were fabricated by stir casting process. It is reported that density of composites decreases with increase in SiC content. Hardness of composites also increases as increase in SiC content due to hard nature and uniform distribution of SiC particles in Al matrix. Wear rate of composites also decreases with increase in SiC content. SiC particles reduces the wear rate as well as coefficient of friction by providing the lubricating film on the counter surface which helps in reduction in wear rate of composites. Also, uniform dispersion of SiC particles helps in improving protection from corrosion. Maximum corrosion protection efficiency is found 56.58% at 20 wt.% of SiC.

Fabricated the Al/Al_2O_3-TiC composites using stir casting process and reported that wear rate of composites decreases with increase in reinforcement content. Also, tensile strength of composites is improved up to 149.3 MPa due to strong interfacial bonding of matrix material with Al_2O_3 and TiC. Vinod et alfabricated the A356 alloy RHA-Flyash reinforced hybrid metal matrix composites by double stir casting process and investigated the physical and mechanical properties of composites. It is found that mechanical properties of composites are improved due to addition of both organic and inorganic particles. Uniform dispersion of reinforcement particles helps to improve the mechanical properties of composites. Lower porosity is also found in composites due to reinforcement particles.

Present paper reports the primary processing techniques for manufacturing of Metal Matrix Composites. It also reports mechanical behaviour, commercialization and application of various techniques for the manufacture of Al_2O_3 reinforced aluminium matrix composites. This article is a comprehensive study of various processing techniques which have been adopted for the manufacture of metal matrix composites over the years. It is expected that aluminium based composites will be helpful in designing and developing components for light weight industries especially aerospace and aircrafts.

Primary processes for manufacturing of AMCs

Manufacturing route adopted in fabricating any composite plays a vital role in determining the final properties of the composit. There are several techniques which are being adopted for the development of quality MMC products. Primary processes for manufacturing of at industrial scale can be classified into three main groups:

Goal and framework of the environmental and economic analyses

Based on data acquired during testing cycles of an actual pilot-scale demonstration in the north of Spain, the paper gives an environmental and economic analysis of the proposed circular process. The demonstration has been used to treat zinc-rich leftovers produced during the manufacture of non-ferrous metals, with the goal of recovering metals (zinc oxide and molten copper), heat, and inert material. The production data is collected at a second pilot-scale demonstrator in the Auvergne-Rhône-Alpes region of southeast France. System boundaries and functional units were examined.

The determination of the limits of the examined system, which are "the set of criteria indicating which unit processes are part of the investigated product system," is a crucial stage in LCA and LCC. The LCA/LCC system boundaries must be consistent, and they are determined by taking into account the entire recycling process, from the treatment of metallurgical residues to the recovery of by-products.

Secondary zinc oxide, molten copper, inert material, and mechanical energy are the last recovered products, avoiding the development of alternative goods from basic resources. The prevented landfilling of non-ferrous metallurgical residues is another averted impact. The system expansion approach is used to allocate credits for avoided productions, accounting for the effect of replacement, i.e. modeling the effect of alternative processes being substituted.

Inventory analysis and LCI results

The inventory analysis entails compiling and quantifying all foreground important inputs and outputs for the system under consideration. In the environmental inventory analysis, the materials and energy resources employed in the project are represented as inputs, while outputs include all emissions and waste creation, as well as finished goods. The expenses and revenues for the economic inventory are computed by multiplying the flows of energy, materials, and finished goods by the market prices. The inventory for the BIOCHAR scenario is detailed in the next session, while extra notes explain how to calculate the inventory data for carbon emissions from EFFIMELT and energy recovery in RECUWASTE.

The economic analysis revealed that, based on the study's assumptions, the PV after 25 years and the payback time appear to be desired. A prospective up scaling scenario also revealed potential economies of scale that could boost the technologies' economic attractiveness. Metal recovery is critical to the overall process' economic viability, accounting for 96% of total PV25, while averted landfilling contributes substantially less. In addition, an analysis of a prospective up scaling scenario revealed that optimizing energy consumption boosts the technology's economic attractiveness greatly.

Conclusion

A pilot-scale facility was used to conduct an environmental and economic analysis based on Life Cycle Assessment (LCA) and Life Cycle Costing (LCC), evaluating a new circular process to recover materials and energy from metallurgical leftovers. The proposed circular process, which was developed as part of the H2020 European project CIRMET, entails the development of four modular and interconnected technologies an EFFIMELT furnace for metals fuming and recovery, a RECUWASTE heat-recovery unit, and a digital platform for process control.

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Conflict of Interest

The authors declare that they are no conflict of interest.

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