LIGHT ALLOYS – NEWER TECHNIQUES AND TECHNOLOGIES

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ABSTRACT

Increases in development in aerospace and automotive majorly, have addressed environmental concerns, the fuel consumption and weight reduction has come to the fore. As Weight reduction simultaneously reduces fuel consumption and environmental concerns. These have put up an increase in usage of light alloys. The most used light alloys being Al, Mg and also Ti, Zn are increasingly used replacing alloys of steel and cast-iron. For engine components, Magnesium and Aluminium are prime candidates as a light weight alternative for steel and cast-iron. The replacement of light alloys over steel and cast-iron in the automotive industries has its two major issues, i) to provide safe and reliable components ii) the alloys themselves must also be designed for optimum strength. The future direction of the automotive industry requires more geometrically complex designs with a lower part count and efficient utilization of light alloys.

When it comes to the latest technologies and techniques, the major ideas are:

i) **Optimized design architectures - A scientific base is required to optimise routes for forming complex light alloy materials cost-efficiently. That can be done by understanding the deformation mechanics, microstructure and texture heterogeneity of the light metals.**

ii) **Joining advanced alloys and dissimilar materials – The preferred dissimilar light combinations like Al-Steel and Mg-Al cannot be done in traditional resistance and fusion welding. They can be done by methods - Solid-state Friction welding, Friction Stir Spot Welding (FSSW), power Ultrasonic Spot Welding (USW).**

iii) **Metal foam is another light weight alternative which can be produced by powder metallurgy or liquid metallurgy techniques. The morphology of the pores is different for the two techniques and is also dependent on various process parameters used in their production. Methods the foam metal can be produced are by Injection of gas into liquid metal, by production of foam using foaming agent, foam production using place holder/ filler. The joining of Aluminium foam-steel sandwiches and Al foam with Al sheets on either side is also possible. These techniques and technologies will be elaborated in this paper.**

ADVANTAGES OF USING LIGHT ALLOYS:

Light weight metals include aluminium, magnesium, titanium, and beryllium alloys. Aluminium and aluminium alloys are lightweight, non-ferrous metals with good corrosion resistance, ductility, and strength. Aluminium is relatively easy to fabricate by forming, machining, or welding. This metal is a good electrical and thermal conductor. Magnesium and magnesium alloys are non-ferrous metals with low density (relatively high strength to weight ratio), good ductility, moderate strength, and good corrosion resistance. Titanium and titanium alloys are non-ferrous metals with excellent corrosion resistance, good fatigue properties, and a high strength-to-weight ratio. Beryllium has the second lowest density compared to the common structural light metal alloys (Al, Mg, and Ti).

Magnesium has a density of 1.74 g/cc and aluminium has a density of 2.7 g/cc. Beryllium's unusually high Young's modulus (287 GPa) is a useful property in structural applications. The high modulus and low density make beryllium alloys useful for aerospace applications. Beryllium has superior specific heat dissipation (heat dissipation per unit mass) compared to other metals because of beryllium's high specific heat and thermal conductivity. Beryllium also has a low thermal expansion coefficient (CTE). Having these light metals and alloys of them with better physical properties, they can be used Magnesium and magnesium alloys are used in a variety of industries as well as in aircraft, marine and power tool applications. Aluminium is also useful as an alloying element in steel and titanium alloys. Titanium's properties result in the use of titanium and titanium alloys in aircraft or airframe parts, jet engine super-alloy components, corrosion resistant chemical process equipment (valves, piping, and pumps), prostheses or medical devices, and marine equipment. Many heat sinks and other thermal management products are fabricated from beryllium, beryllium alloys, and beryllium oxide ceramics due to beryllium's excellent thermal properties.

If we have learned nothing else after surviving 2009, we should all understand the importance of keeping an eye on the future in order to assure survival and, more important, prosperity. Research and development efforts must remain at the top of our "to do lists" especially now, as we address the current business climate.

NEED FOR LIGHT ALLOYS:

The challenges that will arise from the increased demand for better fuel efficiencies and environmental clean-up will be an increased need for better and lighter construction materials.

In order to understand the ramifications of today's economy, all of us, regardless of our job title, must think and talk about the future needs of our customers. We all have heard the buzz about the environment. We have heard about the search for more natural resources. And in a world that is becoming greener, we have heard about energy conservation. Meeting the demands of a greener planet is paramount to our economic revival (and survival).

As the search for natural resources continues, industry should be stepping up to the challenge of alternative energy, such as wind power and the cleanest (and safest) power generation at our fingertips, nuclear.

Transportation consumes a copious amount of resources. Unlike the United States, much of the rest of the world is addressing the issue with a growing emphasis on rail transportation. Today in China, for instance, 300 km/hr (+/- 200 mph) trains are being built on a daily basis, all with European-engineered technology.

When it comes to automobile manufacturing and creating product that will more efficiently utilize fuel, the European auto industry is leading the way here as well. In response to fuel costs which are four times more expensive than those found in the U.S., automobile manufacturers have begun utilizing lighter weight materials. The average European-manufactured vehicle is comprised of 85 percent aluminium, which contributes to a dramatic reduction in weight and thus increased gas mileage. American-made vehicles contain only 15 percent aluminium. More European automobiles are now using diesel and flex fuel systems to attain still greater gas mileage.

Background

For many years the biggest end-use market for aluminium has been the transportation sector. More than a quarter of all aluminium is used in the transport sector. Originally indispensable for its lightweight for the aerospace industry, aluminium is now widely used in cars, buses, coaches, lorries, trains, ships, ferries, aircraft and bicycles.

The aluminium industry supports the need to develop cleaner and more sustainable means of transportation. It stands ready to meet new challenges: customer demand for improved safety and comfort, stricter environmental legislation and public concern for environmentally friendly transportation and international competition.

Forecast Aluminium Usage in Transportation

The aluminium industry is active in developing a new range of light-weight products in collaboration with the transportation sector. The use of aluminium in automotive applications is expected to double in the next decade.

Reduced Fuel Consumption

Lower energy consumption and gas emissions through reduced weight: extensive use of aluminium can result in up to 300 kg weight reduction in a medium size vehicle (1400kg). For every 100 kg reduction in the automotive sector, there is a cut of 0.3 to 0.6 litres per 100 km in fuel consumption leading to 20% lower exhaust gas emissions and proportionally reduced operating costs. Moreover, in the transportation industry, the use of aluminium parts allows truck payload increases within the maximum vehicle weight and reduces the number of trips needed.

Recyclability

Aluminium offers unique recycling possibilities: aluminium can be repeatedly recycled without quality loss. Its high scrap value ensures reclamation and recycling: 95% of aluminium in cars is currently collected and recycled and accounts for over 50% of the material value of a vehicle at the end of its life.

Why the Transportation Industry Embraces the Use of Aluminium

The transport market is divided into four sectors: automotive, public, sea and air transport. Energy-saving design and unparalleled recyclability have lead to an increased use of aluminium in these sectors. The aluminium industry is responsible for stimulating important technological breakthroughs in order to promote the environmental benefits of aluminium.

The aluminium industry is responsible for researching and producing new body shells for high-speed trains, trams, buses, underground and regional trains in consultation with its customers in that sector. Energy saving, light weight and design flexibility are paramount criteria.

The Aluminium Industry Invests In the Development of New, Environmentally-Friendly Cars

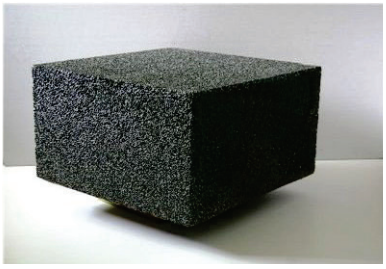
Aluminium car body structures and panels, safety systems, suspension parts and many other new applications have been created. As a result, up to 50% weight reduction can be achieved if aluminium parts are used. Many solutions are the result of new, innovative production methods, such as new casting technologies.

TECHNIQUES FOR LIGHT ALLOY CASTING:

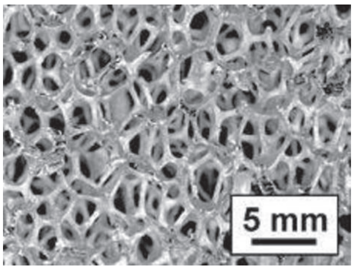
It's possible to produce a three-dimensional shape that has foam on the inside and an aluminum "skin" on the outer surface.

Metal casters view aluminum porosity as detrimental to castings. But, porosity can be used to advantage in a class of materials known as metal foams. These cellular materials contain a high proportion of regularly sized and spaced voids.

There are two types of metal foams: closed-cell and open-cell. Closed-celled foams, such as SAF, have solid faces so that each cell is sealed off from its neighbor, whereas open-cell foams contain the cell edges only. Using SAF, it is possible to produce a three-dimensional shape that has foam on the inside and an aluminum "skin" on the outer surface. This allows users of the technology to meet the requirement for components with complex geometries and coherent surfaces that can be painted or otherwise treated.



Stabilized Aluminium Foam



Open Celled SAF

Closed cell SAF

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The patented SAF process involves an aluminum alloy with ceramic particles added. The particles stabilize the bubbles formed in the foaming process, in so much as without the particles the bubbles would form but then immediately collapse.

In production, the molten alloy is poured into a "foaming box." Gas bubbles exiting from immersed, rotating impellers (a component of the air-injection system) form the foam. Foam collects on the surface, where it can be continuously drawn off and cast into shapes.

Cell size is controlled by the gas flow rate, impeller design, and impeller rotational speed. The rate and means by which the gas is introduced can be varied to produce foams with densities from 2.5% to 30% of the density of solid aluminum (i.e. 97.5-70% air). Because many of the mechanical and physical properties of SAF vary with density, having control over the density allows SAF to be tailored to suit the application. SAF's characteristics include a high strength-to-weight ratio, high-impact energy absorption, thermal and acoustic insulation, and recyclability.

A low-pressure casting technique is similar to aluminum low-pressure casting, now widely used to make vehicular wheels. SAF is injected into a mold, while the injection pressure is controlled so that it is sufficient to fill the mold precisely, but not so high as to collapse the cell structure.

Another potential application is using SAF for cores for castings. Metal casters typically use sand cores to make hollow cavities in castings, and to form rib structures where stiffening is required.

SAF could augment or replace these methods in castings made from zinc, magnesium, and aluminum — with these benefits:

- SAF would not have to be removed after casting (as a sand core typically is), so holes are not necessary in the casting.
- The SAF core would reduce the weight of the casting by replacing redundant material. Examples of components for this application are connecting rods, pistons, lower control arms, transmission gears, engine block, and brake pistons.
- The SAF core may cost less than the solid aluminum it replaces, depending on the application.
- SAF provides energy-absorbing properties, meaning the part can collapse on impact.
- Complex rib structures could be replaced by one simple part incorporating SAF, leading to simpler die or mold designs and processing methods.

REFERENCES:

1. The European Aluminium Association
2. Images – www.google.co.in
3. FoundryMag