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PRDUCTION OF ALUMINIUM 6351 OPEN CELL FOAM

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ABSTRACT

Metals are widely used in everyday life. These metals are heavier and sometimes may fail in sustaining impact loads. To avoid some of such problems possessed by metals metal foams came into picture. The formation of porosity in a solid metal is called metal foam. The metal foams are of two types closed cell and open cell. Closed cell metal foams are those which does not have interlink between the pores where as open cell metal foams are those which have an interlink between the pores. Metals foams can be made with different materials such as steel, aluminium, zinc, tin etc. Among these metals aluminium metal foams are widely used because of their feasibility, availability, low cost. Among all aluminium alloys aluminium 6351 alloy is widely used for formation of metal foam. Aluminium 6351 metal foam can be produced by different methods among which five methods are more important. Decomposition of plastic in molten metal technique is used for formation of open cell. The various advantages by using metal foams are sustaining high impact load, low conductivity, sound absorbing ability, low density.

INTRODUCTION

A metal is a material (an element, compound, or alloy) that is typically hard, opaque, shiny, and has good electrical and thermal conductivity. Metal foam is a cellular structure made up of a solid metal containing a large volume fraction of gas-filled pores. These pores can either be sealed (closed-cell foam), or they can be an interconnected network (open-cell foam). The closed-cell foam is referred to as metal foams, while the open-cell foam is referred to simply as porous metal.

The metal that is commonly used to make metal foams is aluminium. However, other

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varieties of metals can be used to make the foam, such as titanium and tantalum, steel.

ALUMINIUM 6351: Al 6351 has high corrosion resistance and can be seen in forms of extruded rod bar and wire and extruded shapes. It is easily machinable and can have a wide variety of surface finishes. It also has good electrical and thermal conductivities and is highly reflective to heat and light. Due to the superior corrosion resistance, Al 6351 offers extremely low maintenance. Al 6351 is only one-third the weight of cast iron, with about 75% of comparable tensile strength. Al 6351 is known for its light weight (ρ = 2.7g/cm3) and good corrosion resistance to air, water, oils and many chemicals. Thermal and electrical conductivity is four times greater than steels. It has higher strength amongst the 6000 series alloys

The chemical composition of aluminium 6351 is:

S.no	Material	Composition
1	Aluminum	97.342
2	Silicon	0.93
3	Ferrous	0.36
4	Copper	0.1
5	Manganese	0.57
6	Magnesium	0.55
7	Zinc	0.134
8	Titanium	0.014

PROPERTIES OF METAL FOAM:

The key properties of metal foam are as follows:

- Ultra light material (75–95% of the volume consists of void spaces)
- Very high porosity
- High compression strengths combined with good energy absorption characteristics
- Thermal conductivity is low
- High strength

OPEN CELL METAL FOAM:

Open cell metal foams are those which contain inter links between the pores formed in the foam. Open cell foams are permeable materials with metallic properties. They feature a very homogeneous structure which guarantees constant characteristics over a wide range. Open-cell metal foams can be produced in a large spectrum of pore sizes and densities.

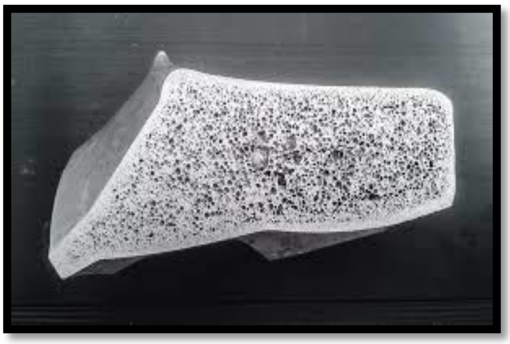

Fig.1: Metal foam

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The adjustable pore sizes range from 0.3 to 5 mm, the relative density can vary between 5 and 30 %. Because of the structure‘s high variability, the functional properties like mechanical strength, sound absorption, fluid and heat transfer can be precisely adjusted. With this, functional materials with an enormous application range arise.

MAKING METAL FOAMS:

1. Bubbling gas through molten aluminium alloys.
2. By stirring a foaming agent in to molten alloy and controlling the pressure while cooling.
3. Consolidation of a metal powder with a particulate foaming agent followed by heating in to the mushy state and the foaming agent releases hydrogen, expanding the material.
4. Manufacture of ceramic mold from a wax or polymer foam precursor, followed by burning out of the precursor and pressure in filtration with a molten metal or metal powder slurry which is then sintered
5. Vapour phase deposition or electro deposition of metal onto a polymer foam precursor which is subsequently burned out, leaving cell edges with hollow cores

PLASTIC DECOMPOSITION IN THE MOLTEN METAL:

The metal foam can be obtained by adding plastic granules into the molten metal. Polystyrene granules are widely used for this process. The addition of plastic granules is accounted for the 90% of total volume. After solidification the metal is again heated to temperature which is greater than the melting point of granules and less than the melting point of metal. Due to this the plastic decomposes leaving pores in the metal. Thus the metal foam is obtained. This results in the formation of open cell metal foam.

Fig.2: Polystyrene granules

PROCESS FOLLOWED TO PRODUCE OPEN CELL METAL FOAM:

To obtain the metal foam with open cell pattern, “plastic decomposition in molten metal” technique is used.

Metal: aluminium 6351

Foaming agent: polystyrene granules

Furnace: open heat furnace

Aluminium 6351 is also used to produce open cell metal foams. It is widely employed due to its high flexibility in preparation of metal foams

To make an open cell metal foam of aluminium 6351, plastic de composition in the melt is widely used.

The plastic employed for this process is polystyrene. Since polystyrene melting point is 200^{o}c, it is widely used compared to other plastics.

Aluminium 6351 which is available in solid blocks is to be melted in to molten state initially to carry out the process. This is done in the melting furnace.

The melting furnace uses coal as the fuel to raise the temperature. A crucible is used to feed the metal and melt it. The crucible is made up with silicon carbide.

The process is carried out by initially preparing the mould. A mould is prepared with silica sand thoroughly mixed with required quantity of water which acts as

A square prism pattern is prepared with wood. The dimensions are $12x12x7cm^3$. The dimensions of the pattern include shrinkage allowance, machining allowance. The pattern is made very soft by giving finishing with emery paper of grade3/0.

The pattern is placed on the mould board in upside down position at the centre of mould board the drag is then placed on the mould board, in upside down position. The drag box is then filled with silica sand. The silica sand is heat filled in the drag box by hitting it with the rammer. Then the drag box is turned and vent holes are made in the sand by pumping air in the sand with the cylinder. The pattern is then removed carefully from the mould

After that the graphite is applied on the mould so that the molten metal doesn't get attached to the silica sand. The graphite paste is carefully applied over the mould and then the mould is subjected to the with fire torch. The fire torch is used to dry the graphite paste. Then the mould is kept aside for a while to make it cool.

The melting furnace is fed with coal and coke as fuel by which the required temperature is obtained i.e., 680^0 which is the melting temperature of aluminium 6351. A radiation thermometer is used to measure the temperature.

A crucible of grade 20 is used for melting the aluminium 6351. The crucible is fed with aluminium blocks which weighs 2.5 kg by weight and is then placed in the melting furnace. As the temperature of the furnace increased, the metal slowly started to melt and at the temperature above it's melting point i.e., 700^0c, the metal is converted in to molten state.

Before melting the crucible is coated with graphite paste, which acts as a debonding agent and resists the adhesion of melt to the walls of crucible.

After the metal is completely melted, the impurity present in the material is removed by using scum powder. The required quantity of scum powder is added into the molten metal, which will bring up all the impurities present in the molten metal to the surface and thus the impurities are easily removed.

The polystyrene plastic granules are taken into other crucible in the required quantity. The granules are taken by considering the volume ratio. They are taken 90% to the overall volume.

After the metal becomes molten state the aluminium melt is poured into the crucible containing plastic and is stirred thoroughly. The plastic becomes melted into liquid due to the high temperature of molten metal.

Now the mixture containing melt and plastic is poured into the mould. The mixture slowly loses temperature and becomes solidified. The plastic reinforces with metal and forms a solid block as shown in the figure.

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Fig.3: Aluminium and polystyrene block

The block is now needed to be heat to a temperature of 400^0c due to which the plastic decomposes leaving the metal. Therefore the solid block is now placed into the crucible of grade 20. A stand made up of iron is placed inside the crucible to separate metal from the plastic.

The crucible is now placed in open heat furnace and the temperature of furnace is raised. The temperature of crucible is brought up to 400^0c. The temperature of crucible is measured using radiation thermometer.

After heating the block for about 30 minutes the plastic settles down in the crucible leaving the metal on the stand. The metal thus obtained contains pores formed due to the plastic decomposition.

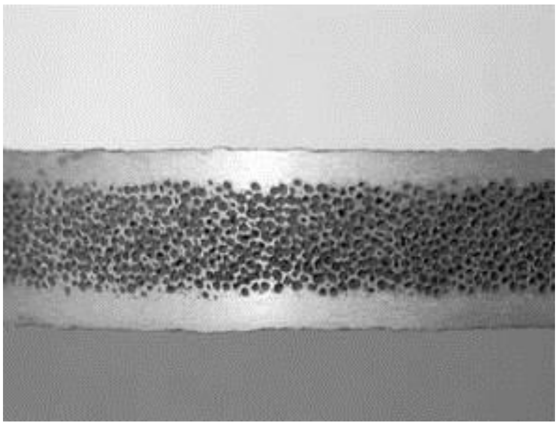


Fig.4: Open cell aluminium6351 foam

The metal foam thus obtained is subjected to machining. It is split into two halves by using wheel grinding machine. The metal foam is now subjected to the following tests:

Micro structure

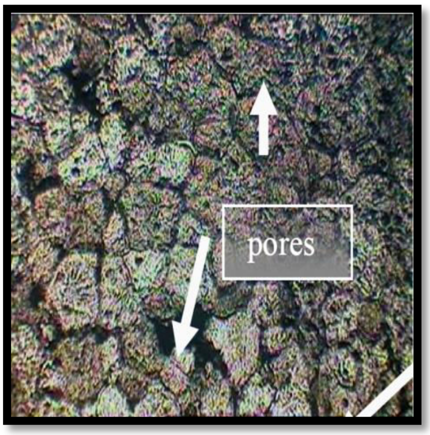
Density

Porosity

RESULTS OBTAINED:

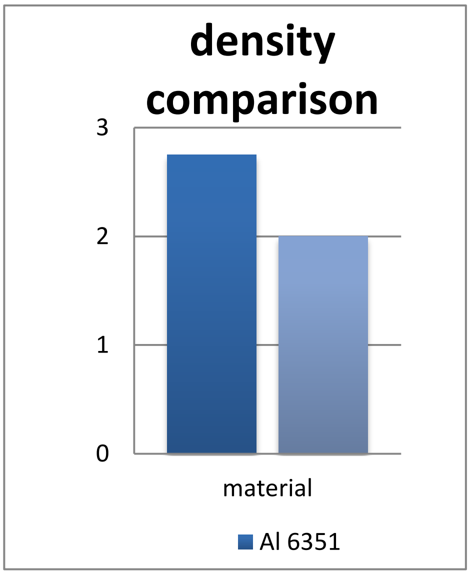
Result 1: Microstructure

(a)Optical microscope image of parent metal

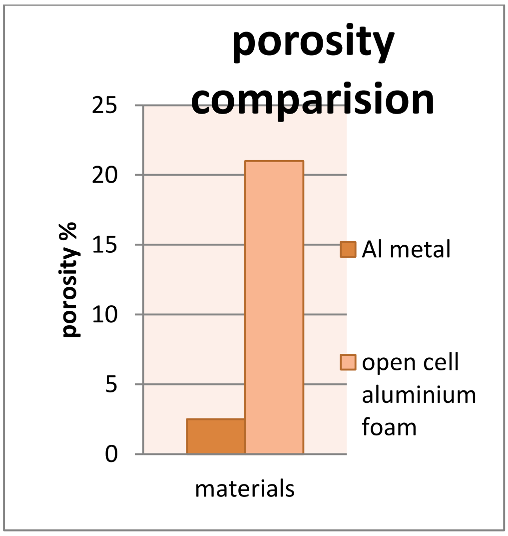


(b)Optical microscope image of open cell metal foam

Result 2: density



Result 3: porosity



Conclusion

1) The Aluminium sponge is successfully produced economically by closed cell as well as open cell method in research laboratory with good quality.

2) Percentage porosity of 21.771% and is obtained for open cell Aluminum foam.

3) Polystyrene granules as space holders are better utilized for open cell Aluminium sponge production.

4) From the experimental findings it is obvious that the properties of Aluminium sponge significantly depend on its porosity, which means that a desired property can be tailored by the sponge density.

5) The experimental findings prove that the microstructure and hardness of the Aluminium sponge conforms to required standards.

6) Production cost is reduced drastically.

7) Quality of the aluminium sponge is up to required standards.

8) Co-efficient of friction of the foam is considerably low which makes it fit for automotive applications.

9) The Corrosion and wear rate of produced Aluminium sponge is low.

SCOPE OF FUTURE WORK :

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By utilizing the materials like polystyrene we have made an attempt to obtain the Aluminium sponge with good foam structure. As the metal foam producing is challenging process, there is lot of scope in this area and in future using the experience from past experiments, utilizing the available resources effectively we can develop the Aluminium metal sponges with higher quality. Further the polystyrene granules as space holders in open cell sponges and $CaCO_3$ as foaming agent in closed cell aluminium sponges can be used in the powder metallurgy route and sponge can be produced.

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