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PRODUCTION OF CLOSED CELL ALUMINIUM 6351 FOAM

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ABSTRACT

The unique combination of physical and mechanical properties offered by porous metals, combinations that cannot be obtained with dense metals, or either dense or porous polymers and ceramics, makes them attractive materials for exploitation. The nonflammable, recyclable and lightweight open-cell and closed-cell metal foams have been used as functional and structural engineering applications. The closed-cell metal foams, in particular the aluminum alloy (Al-alloy) foams, have been used in structural engineering applications (e.g., automotive, aerospace, industrial equipment and building construction) that require lightweight structures with high strength-to-weight and stiffness-to-weight ratios, high impact energy, absorbing capacity with a good damping of noise and vibration. Aluminium 6351 is considered for the production of foam. Aluminium 6351 foam is produced by casting method using CaCO3 as foaming agent, which is relatively lower cost than other foaming agents

Keywords: Aluminium Foam, Closed cell foam, foam, Metal foam, Production of foam, Production of metal foam

INTRODUCTION

It has now become possible to obtain metallic foams of various metals and alloys in a fairly simple way. The development of foams was driven by the requirement for increased passenger safety and the need for weight reduction in order to reduce fuel consumption. Metal foams enlarge the application range of cellular materials because of their excellent mechanical, thermal, electrical and other physical properties as well as due to the fact that they are easier to recycle in comparison to polymeric foams. Aluminum metal foam production is divided into two types: open cell and closed cell. The present paper will be restricted to closed-cell aluminium alloy foams. For closed cell foam production there are a number of gas source types for metal foam production. The same gas sources are used to obtain cell structures in different casting systems as in other foam production systems such as gas agents, precursors, gas

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pressure chambers, or blowing gas into the melt with a nozzle. Generally, $CaAl_2O_4$, ZrH_2, $CaMg(CO_3)_2$, TiH_2, and MnO_2 are used as gas agents for Al alloys. There are different gas agents for other alloys. Production systems affect the aluminum metal foam's grain size, pore or cell size and shape, amount of pores, and shell thickness. Thus, production has a major influence on the properties of the final product. The amount of pores varies from 5%–97%, depending on the production method. Parts of an almost arbitrary shape can be made by this foaming technique. The foamability of aluminum alloys depends on viscosity and cooling conditions.

ALUMINIUM 6351:

Al 6351 has high corrosion resistance and 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. Thermal and electrical conductivity is four times greater

CALCIUM CARBONATE ($CaCO_3$)

Calcium carbonate is the active ingredient in agricultural lime and is created when calcium ions in hard water react with carbonate ions to create lime scale. $CaCO_3$ is used in the purification of iron from iron ore in a blast furnace. PVC cables can use $CaCO_3$ at loadings to improve mechanical and electrical properties

EXPERIMENTAL PROCEDURE:

than steels. 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

Aluminium alloy 6351 is melted in an melting furnace to a temperature of 725°C. $CaCO_3$ (typically 6% by wt) is directly added to the aluminium melt and stirred till semisolid state is reached. The aluminium

and $CaCO_3$ mixture is poured into predesigned mould and allowed to solidify.

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Fig. 1: Molten Aluminium 6351 in crucible

Fig.2: Aluminium 6351 Precursor obtained after solidification

The cast obtained is further heated in muffle furnace at 400°C for 30 minutes and allowed to cool in furnace. Foaming agent decomposes under the influence of heat and releases gas which then propels the foaming process. Foaming of aluminium alloy with CaCO3 blowing agent is caused by the thermal decomposition of calcium carbonate in
contact with molten aluminium. The overall chemical reaction is complex, consisting of several successive reactions which lead to the formation of various solid (CaO, Al2O3, Al4C3) and gaseous phases (CO2, CO). The decomposition of CaCO3is usually described by CaCO3=CaO(s)+CO2(g) (1) Theoretically, under normal atmospheric
pressure the thermal decomposition of pure CaCO3 is thermodynamically favorable only at temperatures above 840°C. However, note that in the real system, chemical decomposition occurs at the interface of CaCO3 and liquid or semi-solid aluminium. Hence, in order to investigate the real process of foaming additional chemical reactions should be also considered. Here only three possible ones are listed, although several others also reported.

2Al(I)+3CO2(g)=Al2O3(s)+3CO(g) (2)

8Al(I)+3CO2(g)=2Al2O3(g)+Al4C3(s) (3)

6Al(I)+3CO2(g)=2Al2O3(g)+Al4C3(s) (4)

Above three reactions are thermodynamically favorable, even at temperatures significantly below the melting point of aluminium.

Fig.3: Aluminium 6351 foam obtained after annealing

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RESULTS OBTAINED:

Result 1: Microstructure

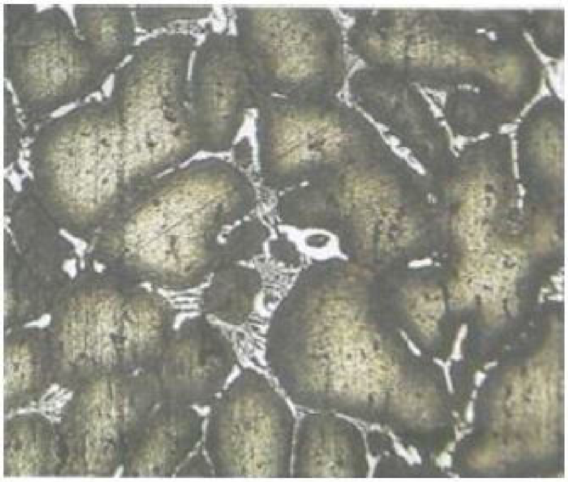

Fig.4 (b): Optical microscope image of closed cell Al 6351 foam

Fig.4 (a): Optical microscope image of parent metal

Figure 4(b) Show the microstructure of developed aluminium foam using $CaCO_3$ as foaming agent. The microstructures clearly reveal that there is visible porosity in the developed cast aluminium foam.

Result 2: density

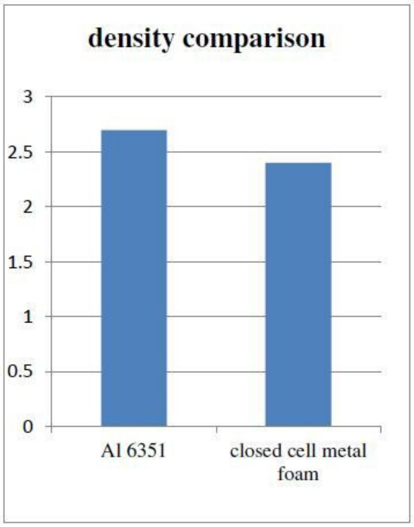

Fig 5: Variation of density in Al 6351 and developed foam

Figure.5 reveals that there is a reduction in the density of the developed foam when compared with base alloy. There is reduction in density of 11.11% is observed in closed cell Al 6351 foam.

Result 3: Porosity

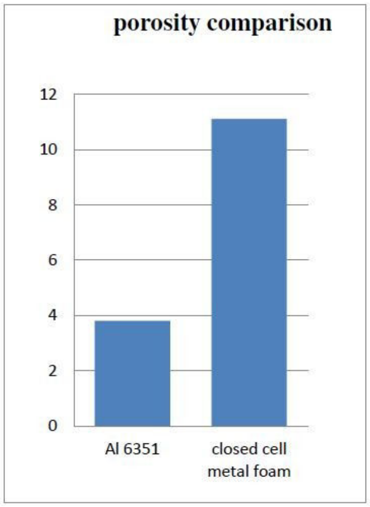

Fig.6: variation of porosity in Al 6351 parent metal and developed foam

From the Figure.6 it is observed that the percentage porosity in closed cell aluminium 6351 foam is 11.11% and 3.86% in parent metal.

Result 4: Brinell Hardness

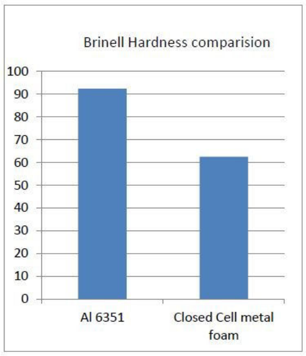

Fig.7: variation of Brinell hardness in Al 6351 parent metal and developed foam

From the Figure.7 it is observed that there is reduction in hardness of developed Al foam when compared with parent metal. Brinell hardness number for parent metal and closed cell Aluminium 6351 foam is 93.28 and 63.526 respectively.

CONCLUSION

Closed cell Aluminium 6351 foam is produced by casting process efficiently at low cost. Percentage porosity of 11.11% and density of 2.4 g/cc is obtained for closed cell Aluminium 6351 foam. The experimental findings prove that the microstructure and hardness of the Aluminium foam conforms to required standards. Commercial foaming agents are successfully replaced by CaCO3. Foams produced by CacO3 as foaming agent can be used for structural applications in automotive, aerospace industries and ship building.

FUTURE SCOPE:

As the metal foam production 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 foams with higher quality. Foams with homogeneous porosity can be manufactured by proper controlling of cooling rate and percentage of foaming agent in the precursor. Use of CaCO3 can be extended for production of steel and other metal foams. Closed cell foam can also be produced by using CaCO3 through powder metallurgy process followed by uniaxial compaction or extrusion.

REFERENCES

1. https://en.wikipedia.org/wiki/Meta_foam
2. John Banhart,manufacture characterization and application of cellular metals and metal foams, progress in materials science 46, Pp 559-632, 200
3. V. Gergely, h. P. Degischer, t.w. Clyne, recycling of MMC's and production of metallic foams, Vol.3, (ISBN: 0-080437214); pp 797-820.
4. J. Banhart, Adv. Eng. Mater. 8 (2006) 9, 781
5. Bernd Friedrich, KatherinaJessen, Georg Rombach, ERZMETALL 56 (2003) Nr. 11, pp 656-660.
6. U. Ramamurty, M.C. Kumaran, Acta Mater. 52 (2004) 181–189.
7. VaruzanKevorkijan, Low Cost Aluminium Foams Made By CaCO3 Particulates, Association of Metallurgical Engineers of Serbia, MJoM Vol. 16 (3), Pp. 205-219, 2010.

8. Banhart J, Ashby MF, Fleck N. Cellular metal and metal foaming technology. Germany: Verlag MIT; 2001.
9. P. Neumann, proceedings of MetFoam'99, p. 169.
10. Ashby MF, Evans A, Fleck NA, Gibson LJ, Hutchinson JW, Wadley HNG. 2000, Metal Foams:A Design Guide. Butterworth – Heinemann, UK.
11. Banhart J., Baumeister J., Weber M., Proc. Euro. Conf. Advanced PM Materials (PM'95), Birmingham, UK, 23.-25.10.1995, p. 201.
12. Jin, I.; Kenny, L.D.; Sang, H. Lightweight Foamed Metal and Its Production. International Patent Application WO91/03578, 21 March 1991.
13. Banhart, J. Light-metal foams history of innovation and technological challenges. Adv. Eng. Mater. 2013, 15, pg 82–111.
14. Zheng Y., Sridhar S., Russell K.C., in „Advances in Porous Materials", eds: S. Komareni etal., MRS Society Bull. Vol. 371, p. 365, (1995).
15. Weigand P., Banhart J., in „Metallschäume", Proc. Symp. Metal Foams, ed.: J. Banhart, MIT-Verlag, Bremen, (1997), p. 91, (in German).
16. Banhart J, Ashby MF, Fleck NA, Eds., Metal Foams and Porous Metal Structures, MIT-Verlag, Bremen, 1999.
17. Leitlmeier D, Degischer HP, Flankl HJ, Development of a foaming process for particulate reinforced aluminum melts, Adv. Eng. Mat., 2002, Vol. 4, 735–740.
18. www.metalfoam.net
19. Degischer HP, Kriszt B, Eds., Handbook of Cellular Metals, Wiley-VCH, Weinheim, 2002.

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