International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 01 | Jan 2019 www.irjet.net p-ISSN: 2395-0072

# SECTIONAL ANALYSIS ON THE IMPACT OF STRONTIUM ON RECYCLED ALUMINIUM ALLOY

**G. Sathiyaseelan[1], C. Bhagyanathan[2]**

*[1]P.G Student, M.E Manufacturing Engineering, Sri Ramakrishna Engineering College, Vattamalaipalayam, Coimbatore-641022*
*[2]Associate Professor, Department of Mechanical Engineering, Sri Ramakrishna Engineering College, Vattamalaipalayam, Coimbatore-641022*

---***---

**Abstract -** Strontium is known to influence the properties of aluminium when added to it in molten state. In this article experimental works have been carried out to determine the effects of adding strontium to secondary aluminium in addition to the effects of the die on the cast metal. Die characterization was done to determine the flowability and the behaviour of the cast aluminium scrap. The process involved heating of machined and turned aluminium alloy scraps in an induction furnace. The cast metal was briefly analysed by sectioning it and determining the hardness along the sides and the diagonals. Chemical composition was determined and the hardness along the sides and diagonals were determined. Analysis of the die was done in Procast and comparisons were made between the actual and the estimated procast results.

***Key Words***: Secondary Aluminium, Strontium Addition, Die Characterization, Procast

## 1. INTRODUCTION

Aluminium is widely known for its properties like low density and high range of corrosion resistance, these properties ensure that aluminium is widely used in a variety of industries and its applications ranges from daily household Equipment's to intricate automotive components. The transportation industry is one of the largest energy consuming sectors, using about 19% of the world's energy demands [6]. Automotive industry uses aluminium castings in their various components such as intake manifolds, transmission housings, valve bodies, channel plates, rear axle and differential housings, drive shafts, brackets, brake master cylinders, suspension components and steering components. Automotive industry is the second largest contributor to greenhouse gas emissions, if the recycled aluminium components are introduced in it, the industry could reduce the $CO_2$ emissions and earn carbon credits.

## 2. LITERATURE SURVEY

The modification effect of Sr addition on the microstructure of Al-Si casting alloys (AlSi9Cu1 and AlSi9Cu3Fe) was investigated. The modification of eutectic in Al-Si casting alloys is a generally accepted process used primarily to improve mechanical properties by promoting the refinement of the inherently coarse and plate-like eutectic silicon phase. Furthermore, the combined effect of Sr addition and cooling rate was also studied in this paper because the microstructure of the eutectic is significantly affected by the cooling rate. The following measurements were used in this research: optical microscopy, measurement of secondary dendrite arm spacing, computer image analysis, scanning electron microscopy and electron microprobe analysis

Improvements in the casting process contribute greatly to the use of aluminium alloys. High-pressure die-casting enables increased production and the ability to produce complex-shaped castings with thin wall thickness. This is possible because the molten metal is injected at high velocity inside the die cavity and then it rapidly solidifies. However, these features reduce the quality of the component due to a substantial amount of air/gas entrapped during the filling phase. This prevents the opportunity for further property enhancement by heat treatment at high temperature. Due to difficulties in producing high integrity die castings, generally inexpensive secondary alloys are used. In order to eliminate or at least reduce the amount of entrapped porosity, semi-solid metal forming processes have been developed.

Die temperature in high-pressure die casting of A380 alloy is optimized by experimental observation and numerical simulation. Ladder frame (one part of the new motor EF7) with a very complicated geometry was chosen as an experimental sample. Die temperature and melt temperature were examined to produce a sound part. Die temperatures at the initial step and the final filling positions were measured and the difference between these values was calculated. Procast software was used to simulate the fluid flow and solidification step of the part, and the results were verified by experimental measurements. It is shown that the proper die temperature for this alloy is above 200◦C.

Thomas G. Digges et al. in their paper showed the basic principles involved in the heat treatment of iron and steel are presented in simplified form. General heat treatment procedures were given for annealing, normalizing, hardening, tempering, case hardening, surface hardening, and special treatments such as austempenng, ausforming, Mar tempering and cold treatment. Chemical compositions, heat treatments, and some properties and uses were presented for structural steels, tool steels, stainless and heat resisting steels, precipitation-harden able stainless steels and nickel-maraging steels.

By ERIK NES and BJARNE N.S studied about the dislocation density of slowly cooled, zone-refined aluminium single crystals, made by the strain-anneal method, using Lang's x-ray diffraction topography technique. Three supplies of aluminium were used in their experiment. The dislocation density in crystals from two of the supplies were found to be approximately linear to the cooling rate, and it was 2 x lo2 lines per cm2 for the slowest cooling rate, 2"c per hour. Three crystals were re-annealed, heated and cooled at a rate of 4"c per hour with maximum temperature 510"c, and topography of these crystals revealed both increase and decreases in dislocation density.

M N Islam1 and B Boswell conducted experiments on the influence of cooling method and drilling parameters on hole production has been investigated experimentally and analytically by measuring the hole quality. A three-level, three-parameter experiment was conducted using design-of-experiment methodology. The selected work and tool materials were aluminium 6061-6T and high speed steel (HSS), respectively. The measured output parameters were the three most widely used quality

## 3. EXPERIMENTATION

### 3.1 Collecting scrap

Scrap is the raw material of Al recycling. It can be modelled depending on the product, the time, and the rate at which material becomes available for recycling. It is generally accepted that rolled aluminum components in buildings, automobiles, and beverage cans have useful lives that are respectively ~50, ~15, and ~0.2 years. Therefore, the amount of scrap released into the market is known and can be forecast. The useful lifetime can be estimated and used to determine when the material becomes available as postconsumer scrap.

### 3.2 SORTING

Aluminum alloys are used in several sectors and applications in combination with a lot of different materials, such as metals (steel, copper, zinc) or, in other cases, rubber, plastic, and glass. The Al scrap inevitably contains residuals of such materials that oblige refiners to properly screen the scrap before melting to enhance recycling efficiency and reduce the presence of impure elements. Undesired particles and elements may be reduced during the melting by refining processes [36], but this is challenging due to thermodynamic barriers. The physical separation (sorting) of solid scrap streams is a reliable solution to prevent the commingling of metals and elements, even if the technical benefits are not completely evident.

### 3.3 PREHEATING OF THE SCRAP

Pre-heat oven is used to pre-heat scrap before it is added to the furnace. The heat comes from the recuperator and does not require the use of additional gas. Pre-heating is done to remove water from the scrap. The presence of water when the metal is placed in the furnace will cause an explosion as the water rapidly vaporizes.

### 3.4 MELTING IN THE INDUCTION FURNACE

An induction melting furnace for aluminum is designed specifically for the purpose of melting lower density metal, employing exactly the right temperatures and evenly distributing the heat. This is vital in melting such metals as aluminum if you want to preserve the expected lifetime of aluminum and its quality. The ideal melting furnace for aluminum will offer precise temperature controls in order to achieve this goal

The charge is introduced into the furnace and the melting of the aluminium scrap is done by the induction process, melting of aluminium takes nearly 7500C and it is held at that temperature for some more time for uniform melting. Once this is completed the melt can be poured.

### 3.5 POURING

The molten metal is poured into the ingots specifically preheated and coated with graphite. Preheating is done to avoid the huge temperature difference between the cast and the ingot as it might lead to certain casting defects. Graphite coating is done for easy removal of the cast from the ingot

### 3.6 STRONTIUM ADDITION PROCESS

- After the control sample is taken from the 30 kg melt, degassing tablet is added to remove the entrapped gasses
- Strontium was preheated for 1hr and 10 grams were added to the aluminium melt from which the control sample had already been taken
- Then the strontium is stirred up for both castings each and every time, thus the mixer is for the sediment formation and the holding time is required for the molten metal inside the furnace.
- Coverall flux is added to the mixture to avoid the formation of oxides. The sedimentation process is allowed for half an hour.

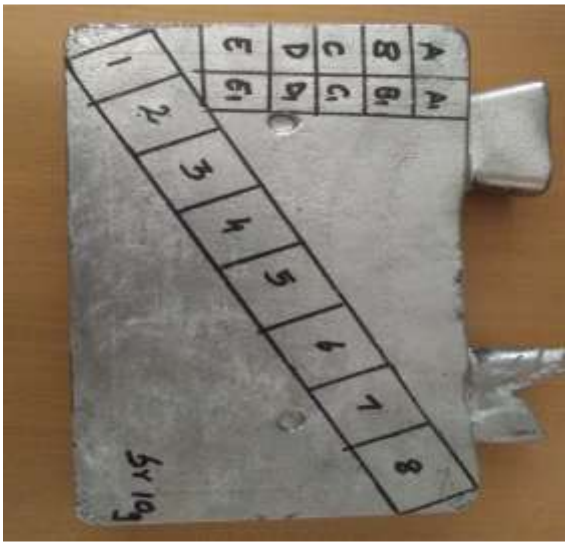
The cast metal is marked as shown in the figure above and the marked sections are cut and checked for hardness.

### 3.7 ANALYSIS

The rectangular die in which the material is being cast was analysed using the procast software to determine the flowability and behavior of the molten metal in the die

### 3.8 PRO CASTING

- Pro-casting is sophisticated sand and die casting simulation software that focus on the basic of any casting process, filling, casting solidification and porosity prediction.
- procast based on finite element technology in addition to the basic to able to predict deformation and residual stresses and can also addresses more specific processes like investment casting, semi-solid modeling, core blowing, centrifugal casting, last foam, and the continuous casting process.
- useful for all cast able alloys the metal casting, simulation software helps to addresses defect detection residual stresses, part distortion, microstructure and mechanical properties prediction.



## 4. RESULT AND DISCUSSION

Hardness test the first was to determine the Chemical composition of the samples and the other test pieces. To do this the samples were cut and machined properly to be easily detected in the spectroscopy machine. The machine used for this purpose was Optical Emission spectroscopy (OES) machine. The machine works on the principle of emission of light which produces a spark on the metal surface and based on the wavelength emitted by the metal surface the composition is determined.

The results are then collected in the form of printouts when a printer is attached to the machine.

- Precautions such as a clean surface is mandatory for the process.
- It is important to mention the type of material being analysed

| Casting | | Si | Fe | Cu | Mn | Mg | Zn | Ti | Sr | Al |
|---|---|---|---|---|---|---|---|---|---|---|
| Scrap | Control sample | 7.5 | 0.889 | 0.13 | 0.06 | 0.13 | 0.14 | 0.12 | 0.001 | 90.9 |
| | 10g Sr | 7.5 | 0.889 | 0.13 | 0.06 | 0.13 | 0.14 | 0.12 | 0.001 | 90.9 |

## HARDNESS TEST

The Brinell hardness test method as used to determine Brinell hardness, is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. Brinell testing often use a very high test load (3000 kgf) and a 10mm diameter indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies.

The Brinell method applies a predetermined test load (F) to a carbide ball of fixed diameter (D) which is held for a predetermined time period and then removed. The resulting impression is measured with a specially designed Brinell microscope or optical

system across at least two diameters – usually at right angles to each other and these results are averaged (d). Although the calculation below can be used to generate the Brinell number, most often a chart is then used to convert the averaged diameter measurement to a Brinell hardness number.

Common test forces range from 500kgf often used for non-ferrous materials to 3000kgf usually used for steels and cast iron. There are other Brinell scales with load as low as 1kgf and 1mm diameter indenters but these are infrequently used.

Hardness tests were conducted since strontium addition to the metal might induce porosity in the cast metal. Hardness tests were conducted on multiple samples at various sections to identify the influence of strontium in the cast aluminium alloy.

**MID PIECE 4&5**

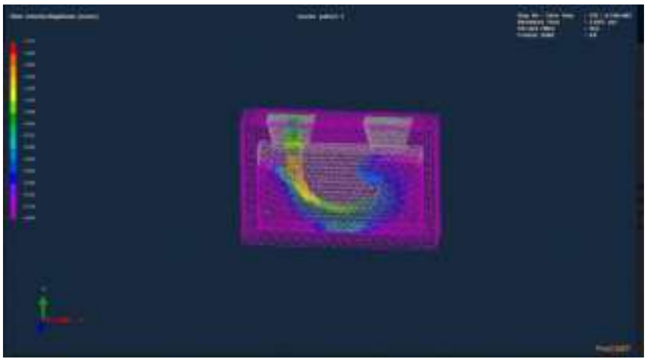
| S.NO | PIECE-4 | PIECE-5 |
|---|---|---|
| T | 82.45 | 76.78 |
| TR | 76.78 | 66.81 |
| TL | 79.55 | 64.56 |
| B | 76.78 | 71.58 |
| BU | 82.45 | 79.55 |
| BD | 62.40 | 69.15 |

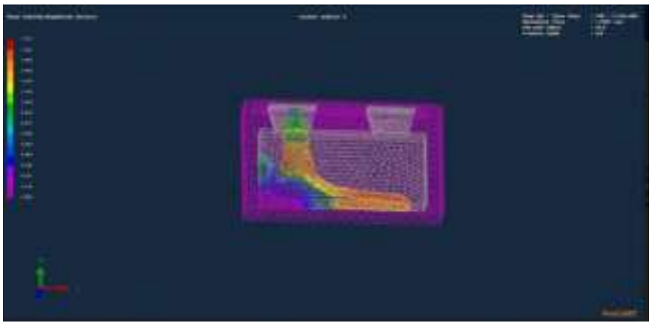
**DIAGONAL**

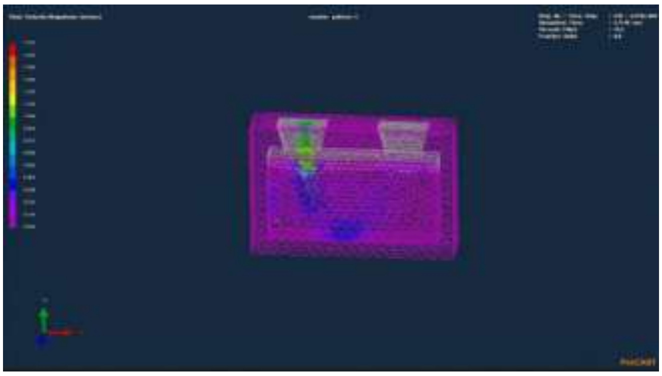
| S.NO | TOP | BOTTOM |
|---|---|---|
| 1 | 76.78 | 82.45 |
| 2 | 76.78 | 79.55 |
| 3 | 76.78 | 79.55 |
| 6 | 79.55 | 79.55 |
| 7 | 79.55 | 71.58 |
| 8 | 82.45 | 71.58 |

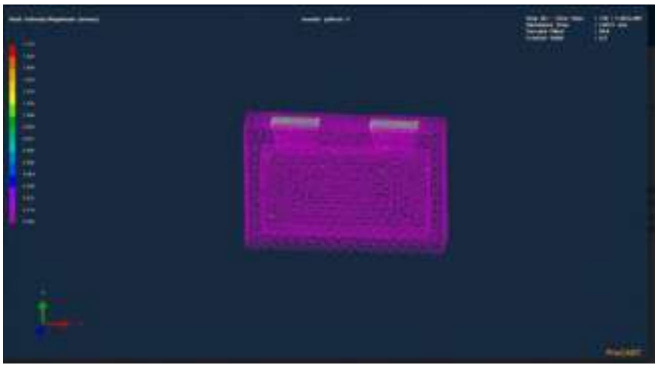
**ANALYSIS OF FLOWABILITY IN THE DIE**

Analysis In Procast Show The Flowablity Of Cast Metals In The Dieno Parmanent Fluidity Problm Occurs In The Die .This Shows Thattheoratical Analysis Of The Die As Been Perfect And Does Not Show Much Casting Defects To Occurs More Over When The Pouring Rate Is Constant The Die Cast Metal Will Not Shows Much Defects









## 5. CONCLUSION

The results clearly show that the strontium has deposited at the bottom to avoid the porosity in the material. This is clearly evident by the drop in hardness of the material.

Strontium is added to modify the morphology and microstructure of the eutectic silicon phase; eutectic silicon solidifies in a relatively coarse continuous network of thin platelets. That morphology provides abundant stress risers and thus limits to achieve maximum strength and ductility.

The rise in tensile strength and ductility can be seen in the tensile test results. As the tensile strength increases the hardness of the component falls. Strontium has a density almost equal to aluminium so it has a good bonding and spreads out uniformly in the cast.

Improper stirring might have led to the deposit of strontium in the top (when being melted in the furnace) as the strontium was added in powdered form.

## ACKNOWLEDGEMET

We would like to thank our Head of the Department Dr.P. Karuppuswamy for his support and the College for helping us to carry out the research works in the premises

## REFERENCES

1)Capuzzi, S., Ferraro, S., Timelli, G., Capra, L., Capra, G.F. and Loizaga, I., 2014. Development of Heat Treatments for Automotive Components die-cast with Secondary Aluminium Alloy at Semi-Solid state. Metallurgia Italiana, 106(3), pp.3-11.

2) Hall, E.O., 1951. The deformation and ageing of mild steel: III discussion of results. Proceedings of the Physical Society. Section B, 64(9), p.747.

3) Mathew, R.R. and KA, A.V., 2018. EFFECT OF STRONTIUM ON Al9Si ALLOY WITH COPPER AND NICKEL FOR AUTOMOTIVE PARTS.

4) Pezda, J. and Jarco, A., 2016. Effect of T6 Heat Treatment Parameters on Technological Quality of the AlSi7Mg Alloy. Archives of Foundry Engineering, 16(4), pp.95-100.

5) Kosa, A., Gacsi, Z. and Dul, J., 2012. Effects of strontium on the microstructure of Al–Si casting alloys. Journal Material Science and Engineering, 37(2), pp.43-50.

6) Sadeghi, M. and Mahmoudi, J., 2012. Experimental and theoretical studies on the effect of die temperature on the quality of the products in high-pressure die-casting process. Advances in Materials Science and Engineering, 2012.

7) Timelli, G. and Bonollo, F., 2007. Fluidity of aluminium die castings alloy. International Journal of Cast Metals Research, 20(6), pp.304-311.

8) Gunasegaram, D.R., Finnin, B.R. and Polivka, F.B., 2007. Melt flow velocity in high pressure die casting: its effect on microstructure and mechanical properties in an Al–Si alloy. Materials science and technology, 23(7), pp.847-856.

9) Miresmaeili, S.M., 2005. Oxidation of liquid Al-7Si alloys containing strontium and magnesium. Metal 2005, pp.223-231.

10) Puga, H., Barbosa, J., Soares, D., Silva, F. and Ribeiro, S., 2009. Recycling of aluminium swarf by direct incorporation in aluminium melts. Journal of Materials Processing Technology, 209(11), pp.5195-5203.

11) Nabawy, A.M., Samuel, A.M., Alkahtani, S.A., Abuhasel, K.A. and Samuel, F.H., 2016. Role of cerium, lanthanum, and strontium additions in an Al–Si–Mg (A356) alloy. International Journal of Materials Research, 107(5), pp.446-458.

12) Yu, J.M., Wanderka, N., Rack, A., Daudin, R., Boller, E., Markötter, H., Manzoni, A., Vogel, F., Arlt, T., Manke, I. and Banhart, J., 2018. Influence of impurities, strontium addition and cooling rate on microstructure evolution in Al-10Si-0.3 Fe casting alloys. Journal of Alloys and Compounds, 766, pp.818-827.

13) Dinnis, C.M., Dahle, A.K., Taylor, J.A. and Otte, M.O., 2004. The influence of strontium on porosity formation in Al-Si alloys. Metallurgical and materials transactions A, 35(11), pp.3531-3541.

14) Timpel, M., Wanderka, N., Schlesiger, R., Yamamoto, T., Lazarev, N., Isheim, D., Schmitz, G., Matsumura, S. and Banhart, J., 2012. The role of strontium in modifying aluminium–silicon alloys. Acta Materialia, 60(9), pp.3920-3928.

15) Mohandass, M., Venkatesan, A., Karthikeyan, S., Prasanth, P. S., & Vinuvarshith, S. K. (2014). Effect of cooling rate on mechanical behavior of bulk cast of A380 aluminium alloy. Int. J. Eng. Technol, 6, 374-380

16) Kolahdooz, A., et al. "Investigation of the controlled atmosphere of semisolid metal processing of A356 aluminium alloy." Journal of Mechanical Science and Technology 28.10 (2014): 4267-4274.

17) Digges, T. G., Rosenberg, S. J., & Geil, G. W. (1966). Heat treatment and properties of iron and steel (No. NBS-MONO-88). NATIONAL BUREAU OF STANDARDS GAITHERSBURG MD.

18) Nes, E., & N∅ st, B. (1966). Dislocation densities in slowly cooled aluminium single crystals. Philosophical Magazine, 13(124), 855-865.

19) Islam, M. N., & Boswell, B. (2016, February). Effect of cooling methods on hole quality in drilling of aluminium 6061-6T. In IOP Conference Series: Materials Science and Engineering (Vol. 114, No. 1, p. 012022). IOP Publishing.

20)Kolahdooz, A., Nourouzi, S., Bakhshi, M., & Hosseinipour, S. J. (2014). Investigation of the controlled atmosphere of semisolid metal processing of A356 aluminium alloy. Journal of Mechanical Science and Technology, 28(10), 4267-4274.

21)Abubakre, O. K., Mamaki, U. P., & Muriana, R. A. (2009). Investigation of the quenching properties of selected media on 6061 aluminum alloy. Journal of Minerals and Materials Characterization and Engineering, 8(04), 303.