# PATTERN OF COOLING CONTOURS IN THE FLYASH CERAMIC SHELL CASTING OF AL-MG ALLOYS

**A. Chennakesava Reddy[1] & S. Sundararajan[2]**
[1]Professor, JNTU College of Engineering, Anantapur – 515 002
Email: dr_acreddy@yahoo.com

[2]Scientist – G, Defence Research and Developmental Laboratories
Hyderabad – 500 058
Email: s_sundarrajan@hotmailo.com

**Abstract**
The major ceramic shell parameters that influence the solidification characteristics are: i) thermal conductivity of the shell mould, ii) the shell mould geometry and its thickness, and iii) heat transfer from the shell mould to the atmosphere. Coal flyash shells produce coarsed grain structure in Al-alloy castings on account of slow rate of solidification.

**Key words:**
Cooling contours, flyash, ceramic shells

## 1. INTRODUCTION

Solidification of liquid metal occurs by the nucleation of minute grains or crystals, which then grow under the influence of the crystallographic and thermal conditions that prevail. The size and character of these grains are controlled by the composition of heat of the alloy and by the cooling rate. Growth ceases when all the available liquid metal has solidified.

Heat is being extracted from the molten metal as soon as the metal enters the ceramic shell. This heat is often referred to as superheat, since it represents that which must be removed before solidification can begin. The latent heat of fusion is also evolved. This must be transferred to the surrounding shell mould before complete solidification can be achieved. Finally, the solid metal transfers heat to the shell mould, and then to the atmosphere as it cools to room temperature.

The major ceramic shell parameters that influence the solidification characteristics are: i) thermal conductivity of the shell mould, ii) the shell mould geometry and its thickness, and iii) heat transfer from the shell mould to the atmosphere. Since these parameters operate through their effect on the solidification process, major attention was given to the refractory filler material used for ceramic shell moulds.

In this work, the fly ash has been used to prepare the ceramic shells. The cooling pattern governed by the flyash ceramic shells was compared that of alumina ceramic shells. The cooling curves were constructed during the solidification of Al-Mg alloy in the ceramic shells.

## 2. EXPERIMENTAL PROCEDURE

The bee's wax was used as pattern material to make the ceramic shells. The design of the pattern was carried out to get the cylindrical shell cavity of 25mm internal dia. Bee's wax was melted into the liquid form and was poured into the cast iron die. The die was cooled for a half-hour and the wax pattern was ejected out.

The ceramic shells were made by applying a series of ceramic coatings to the patterns. The ceramic shells were dewaxed by dipping them into the boiling water for 15min. The wax recovery was good. The dewaxed shells were fired at different temperatures to remove moisture (free and chemically combined), to burn of residual wax and to sinter the ceramic. The sintered ceramic shells are shown in Figure 1.

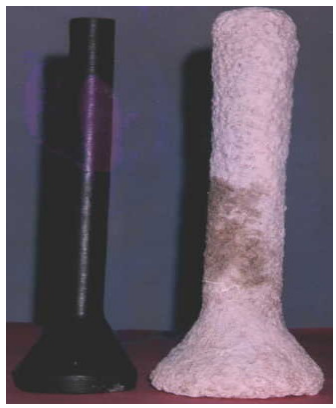

Figure 1. Wax pattern and ceramic shell

An Al-Si-Mg (A356) alloy was melted in oil fired furnace. During melting, the alloy was coated with flux (covral-11S) to prevent the oxidation of the metal. The liquid metal was degasified with tetrachloroethane tablets and also modified with sodium. The liquid alloy was gravity poured into the pre-heated ceramic shells. Thermo couples were inserted in the walls of ceramic shell and the casting. The temperatures were recorded with respect to time. The shells were knocked off by hand hammer after solidification of the molten. The castings were cleaned with soft brush and visually inspected for pins and projections (Figure 2).

## 3. RESULTS AND DISCUSSION

### 3.1 Pattern of Cooling Contours in Ceramic Shells and Al-Alloy Castings

The pattern of cooing contours in ceramic shells and castings is primarily dependent on the thermal conductivity of alloy and filler material. The pattern of cooling contours in flyash shell and casting is illustrated in Figure 3 (a). The slope of cooling contours in flyash shell is greater than that of cooling contours in the Al-alloy casting. This shows that the rate of cooling in flyash shell is slow due to its poor thermal conductivity and consequently the temperature gradients in the casting are nearly flat.

The pattern of cooling contours in alumina shell and casting is shown in Figure 3(b). The slope of cooling contours in the Al-casting is higher than that of cooling contours in the alumina shell. This proves that the rate of cooling in alumina shells is fast owing to its good thermal conductivity and therefore the temperature gradients in the casting are nearly steep. Hence, flyash shells favor less progressive solidification whereas alumina shells exert a noticeable influence on progressive solidification.


Figure 2. Castings after knocking out from the ceramic shells

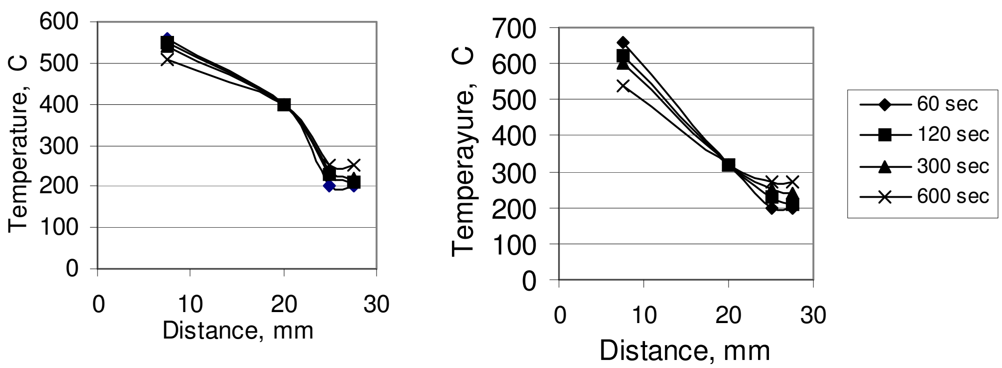


Figure 3. Cooling contours while casting in (a) the flyash shell and (b) the alumina shells.

### 3.2 PATTERN OF MICROSTRUCTURE IN AL-ALLOY CASTINGS.

Figure 4 reveals the microstructures of Al-alloy castings produced from flyash and alumina shells. The only difference between the microstructure of flyash shell casting and alumina shell casting was that the latter structure exhibits a slightly finer phase distribution than the former. In both the castings, the section phase appears at the interdendritic regions. The size of $\alpha$-phase (Aluminium rich phase) was larger in flyash shell casting than alumina casting. The appearance of section phase is possible because the primary phase to form during the earlier stages of solidification is $\alpha$. Thus the liquid gets depleted with Aluminium and will be enriched with section. During the progress of solidification the liquid melt present in the interdendritic zone attains eutectic. Thereafter while solidifying two phase mixture of $\alpha$ + Si is formed.The sizes of phases in flyash shell casting was larger than alumina shell casting due to longer solidification time. Prolonged solidification retards nucleation and promotes growth.

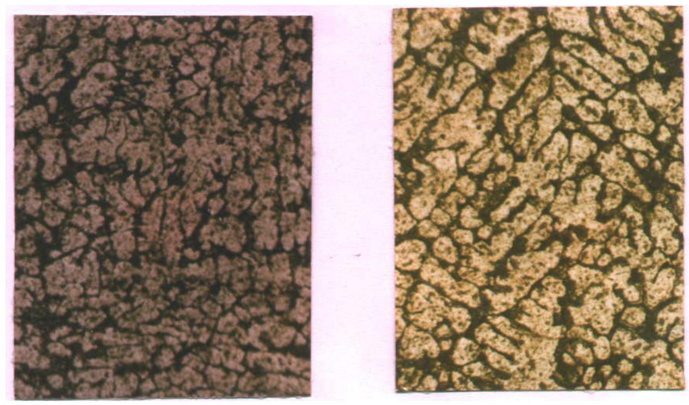

Figure 4. Micrographs of Al-Si-Mg alloy castings, 100X. (a) Casting from the fly ash shell (b) Casting from the alumina shel

## 4. CONCLUSIONS

Coal flyash shells produce coarsed grain structure in Al-alloy castings on account of slow rate of solidification. The alumina shells induce fined grain structure owing to fast rate of solidification.

**REFERENCES:**

1. R.A. Horton, Investment Casting, Metals Hand Book, 8th edition, Vol.5, 1975, P-253.
2. A. Chennakesava Reddy and V.S.R. Murti, Studies on the lost-wax process using silox binder, proceedings of Xth ISME conference on Mechanical Engineering, December 1996.
3. A. Chennakesava Reddy, K.M. Babu, P.M. Jebaraj and M.P. Chowdaiah, Accelerator for faster shell making and its effects on the properties of investment shell moulds, Indian Foundry Journal, Vol.41, No.10, 1995, P-3.
4. A. Chennakesava Reddy, V.S.R. Murti and S. Sundara Rajan, Some aspects of reducing sedimentation rate of filler in the Investment Casting Process, Engineering Advances, Vol.10, No.8, 1998, P-61.
5. J. Doskar and J. Gabriel, How dip-coat materials affect ceramic investment shells, Foundry, Vol.95, May 1967, P-146.
6. A. Chennakesava Reddy, H.B. Niranjan and A.R.V. Murti, optimization of investment shell mould using colloidal silica binder, Indian Journal of Engineering and Material Sciences, Vol.3, No.4, 1996, P-180.
7. 7. D.J. Kenny and Rutt, Thickness of precoat for invstment casting, Foundry, Vol.87, Feb, 1959, pp.82.
8. J.P. Nielson, and W. Morse, Homogeneous solidification by super cooling well below solidus, Proceedings of 9th International Precious Metals Institute Conference, Allen Town, PA, USA, 1986, pp.409.