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Ablation Casting Process – An Emerging Process for Non Ferrous Alloys

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ABSTRACT
Ablation casting process is a new casting method in which liquid alloy is poured into a casting mould and when it is still in the liquid state, from a certain distance, moulds are washed allowing direct contact between water and the surface of the casting, at the same time eliminating the air gap- it limits the flow of heat outside the casting. A big gradient of temperature in the cross-section of a casting facilitates the elimination of shrinkage porosity .[5] Solidification occurs under conditions of unprecedentedly high temperature and speed gradients, as a result of which a microstructure is created with extremely fragmented phases which solidify last .[7] Abalation process produce castings of the characteristics obtained by high pressure die casting with great ease casting can be removed provide sharp edge & clean curves of finished size as by grinding or finishing. Internal or shielded gates may need to be machined off.

key words —New Casting method, Nonferrous casting, Solidification grain growth, expendable moulds.

1. INTRODUCTION

The process of ablation casting whose name was probably coined from a latin word ablutio- which means washing, abalation, bath, cleaning- regards castings, mainly made of Aluminium and Magnesium alloys in expendable moulds.[1-2]

The technology of abalation casting is mainly predestined for making castings, with differentiated wall thickness and complicated shapes, in sand moulds, in which castings solidify relatively slowly, which results in an unfavourable growth of grains.

Patented by Alotech in 2006. A sand mould is prepared to be poured with liquid metal is placed on a belt conveyer outside the set of spraying nozzles. After pouring the mould with liquid metal the mould is moved horizontally under the set of spraying nozzles where under high pressure of water the mould is destroyed and the casting is quickly cooled.[3-5]

Fig. 1. The execution of the process of ablation casting [2]

Fig 1 present the execution of the process of ablation casting with the use of the described equipment.

Since the region of the shang dynasty china have been fore runner in abalation casting it recreate different types of handles for vessels made mostly of bronze, clay moulds with ropes are used. After burning ropes, ashes were removed and the ready-made mould was poured with metal.

The idea from shang dynesty is considerably modified. In metal matrix composit the increased viscosity of composit melt often prevents entrapped gas bubbles from leaving the liquid melt, thus particles can stabilize the bubble within suspension.

Also conventional casting with low rate of solidification reduce the overall strength of the composit material.

Intermetallics in the ablated specimen were finer in size than those found in the conventionally cast specimen. Also shrinkage porosity is observed in fracture surface of conventionally cast specimen

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which normally if present on ablated specimen were found on the surface.

Today high pressure pump manufactured by Bosch which enables to achieve the flow of liquid 6.5l/min at maximum pressure 12Mpa. During research a pump which could efficiently wash the mould of medium size should have following specification;
Pouring temperature – 700
Rate - 20rpm
Vertical feed – 30cm/min
Water pressure – 12 Mpa

2. Experimental

Moulds were made from silica sand of AFS 60 fineness, bonded with a proprietary binder based on sodium silicate.

Table 1 the chemistry of the metal cast steering knuckle was as follows (A356) alloy.

Si	Fe	Cu	Mn	Mg	Zn	Ti	Na	v
7.18	0.089	0.006	0.002	0.36	0.007	0.13	0.0014	0.009

The metal was melted in a resistance heated crucible furnace in a SiC- Graphite crucible. Prior to start of a casting shift the temperature was raised to the pouring temperature 730^0 C and rotary degassing with nitrogen was applied for 20 minutes. The metal is being transferred into the mould cavity via a glass cloth screen. Mould was tilted at about 20^0 above the horizontal. As soon as the melt temperature reach 720^0 C the mould is poured, filled by starting the rotation of the mould, lowering its angle of tilt through the horizontal, to 20^0 below the horizontal in five seconds.

Ablation using overhead water sprays at 65^0 C was immediately applied to the far ends of the casting, progressing upwards along its length and completing the ablation of the mould and the frezzing of the casting, feeder is now planted off from casting along one of the relatively narrow arms.

Clean and cold casting was ready for subsequent dressing and heat treatment.

Solution heat treatment was recommended at 540^0 C for two hours followed by aging at 155^0 C for 4 hours and 12 hours then at 160^0 C for 3.5 hours.

Tensile test of bars were then exercised at room temperature.

3. Results

Table 2 shows a comparison of Mechanical properties.[2]

Property	Sand	Perm. Mold	Squeeze cast	Ablation
UTS MPa (ksi)	228 (33)	262 (38)	312 (45)	325 (47)
Y.S. MPa (ksi)	179 (26)	207 (30)	243 (35)	261 (38)
%El	3.5	4	11.0	12.5

Optical microscopy results show limited regins of the dendrite spacing that have been refined.

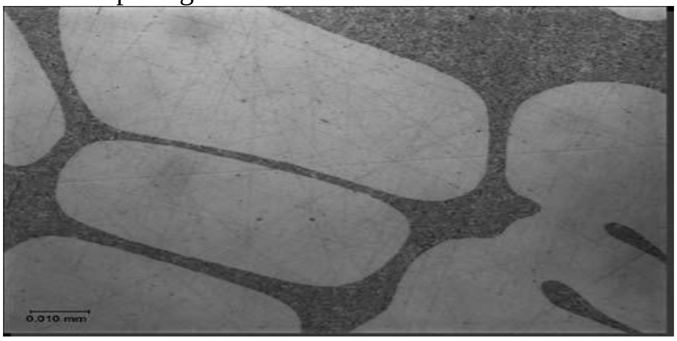

Fig. 2 Eutectic phase at 1000X.[2]

Fig 2 illustrated extremed fineness of the eutectic spacing that is difficult to resolve even at 1000 magnification.

At 4 hours of ageing the room temperature tensile properties averaged over three samples were 0.2% proof stress 215 Mpa, UST 310 Mpa and 12 % elongation.

At 12 hours the corresponding figures were 260, 340 and 9% respectively.

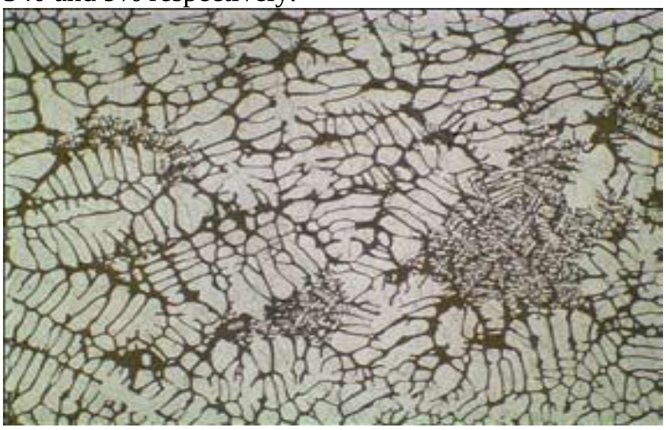

Fig. 3 Mixed DAS by late ablation.[2]

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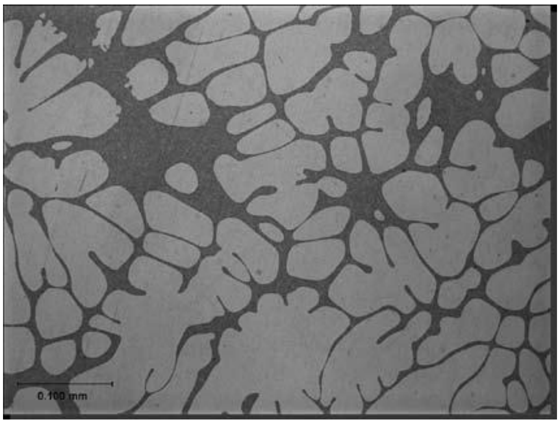

Fig. 4 DAS with traces of late ablation.[2]

Fig 3 & 4 shows extent of freezing the ablation cooling to reach these regions. Thus 3 & 4 show (DAS) secondary dendrite arm spacing which is coarse and typical of a sand casting of section thickness which is fine at centre, which is the result of ablation arriving in time to limit dendrite arm coarsening in these regions, which would often contain porosity, thus weakning the structure.

Fig 5 shows the fine DAS achievable in timely ablation.

This process gives eutectic structure with interparticle spacing under 1□µm. This spacing are consitent with finest chill modified structures. Secondary beta –iron particles can be discerned in the eutectic, but are extremely fine, and in general less than approximately 5□µm long.

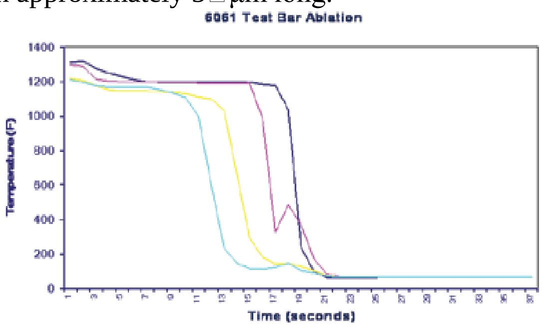

Fig. 5 Higher cooling rate achieved through ablation arrives in time is plotted here.[2]

Figure shows that higher cooling rate is achieved through ablation arrives in time which remove latent heat & solidification hence improves the quality of casting.

4. Discussion

Alloys that are traditionally difficult to cast production of low gas and low oxide containing melts, can be easily cast with this method. The ablation solvent results in rapid unidirectional solidification which leads to much more refined structure (fig 2 to 5) like interdendritic eutectic and a uniform distribution of reinforcement particles in composit casting. It is extremely environmental friendly process. Economically viable still there is the scope of improving surface quality of castings. The distortion during solidification is a major area of concern.[3,4]

The tensile strength of the ablated specimen was on average 249 Mpa in comparison of 217 Mpa of the same chemistry whereas the average percentage of the conventional and ablated specimens was 0.38 and 0.33 % respectively.

5. Conclusion

1. Ablation of composites has shown to increase the yield strength of hybrid Al-SiC-graphite composite by 20% over conventional heavily chilled sand casting. Further improvements are possible, through higher cooling rates and a reduction in porosity. The percent elongations of ablated components were similar to conventional castings despite the higher strength of ablated castings.
2. The microstructure of ablated samples exhibit four distinct phases: SiC particles, graphite platelets, α- aluminum dendrites, and Si eutectic second phase. In addition, some porosity was also present.
3. The average sige of the SiC was 15 microns. The graphite platelet size was 84 microns. The SiC and graphite particles were present in the interdendritic regions along with eutectic silicon.
4. The dispersion of reinforcements is more uniforme in the ablated sample than in conventionally cast sample.
5. The DAS/cell size of ablated specimen was 50.3 µm (0.00198 in), compared to the DAS of the conventionally cast specimen of 62.5 µm (0.00246 in). In addition to the refinement of the α-Aluminum phase, the eutectic silicon and nickel intermetallics also were refined by the ablation process.
6. The fracture surface of each sample exhibits predominantly brittle characteristics, with evidence of graphite flakes, shrinkage pores and gas pores at the surface, which may have contributed to the initiation of failure.

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