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RHEOCASTING PROCESS APPLIED TO ATSi5Cu1 ALLOY

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Abstract. *Rheocasting process (RC), has been developed for manufacturing near-net shape components of high integrity directly from liquid alloys. The rheocasting process innovatively adapts the well-established high shear dispersive mixing action to the task of in situ creation of semisolid slurry followed by direct shaping of the semisolid slurry into a component using the existing cold chamber die-casting process.*
The rheocast component has close to zero porosity, fine and uniform microstructure throughout the entire component. Compared with those produced by conventional high-pressure die-casting, rheocasting samples have much improved tensile strength and ductility.
In the paper are presented the rheocasting process, the microstructure and mechanical properties of rheocast samples made from AtSi5Cu1 alloy.
Keywords: *semisolid slurry, rheocasting process, aluminum alloy.*

1. INTRODUCTION

Aluminum alloys, as lightweight structural materials, are playing an important role in achieving vehicle weight reduction and improving fuel economy in the automotive industry. Since 1990, the use of Al has been doubled in cars and tripled in the light truck market. Currently, 85% of all Al alloy castings are used by the automotive and mass transport industry, and a large proportion of such castings are produced by high-pressure die-casting (HPDC) process.
The new processes need to be capable of producing components of high integrity and improved performance while being comparable with the HPDC process in terms of production cost and efficiency.
Porosity due to turbulent mould filling could be reduced or even eliminated if the viscosity of the melt could be increased to reduce the Reynolds number sufficiently so that trapped air is minimized [1, 2]. This is the concept of semisolid metal (SSM) processing.
Since early 1970s, a number of SSM processing techniques have been proposed [2]. One of the most popular SSM processes is thixocasting, in which non-dendrite alloys are pre-processed by electromagnetic stirring and reheated to the semisolid region prior to the shaping process.
As a new processing technique, thixocasting does improve component integrity and performance, but proves to be cost intensive, low efficiency and less flexible. After 30 years of extensive R&D, thixocasting is currently experiencing a decline in acceptance as a viable production technology [3, 4]. Under such circumstances, the new processing concept - rheocasting process, has been developed.

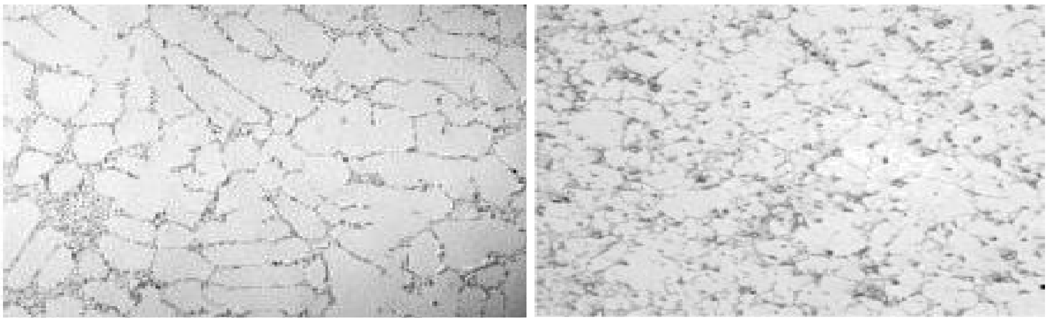
2. EXPERIMENTAL DATA

The process innovatively adapts the well-established high shear dispersive mixing action of the twin-screw extruder (originally developed for polymer processing) to the task of *in situ* creation of SSM slurry with fine and spherical solid particles followed by direct shaping of the slurry into a near-net shape component using the existing cold chamber die-casting process.
The rheocasting process starts from feeding predetermined dose of liquid metal from the melting furnace into the slurry maker where it is rapidly cooled to the SSM processing temperature while being mechanically sheared by a pair of closely intermeshing screws converting the liquid into a semisolid slurry with a pre-determined volume fraction of the solid phase dictated by the barrel temperature. The semisolid slurry is then transferred to the shot

chamber of the HPDC machine for component shaping. In order to prevent Al-alloy from oxidation, nitrogen gas is used as the protective environment during the slurry-making process.

2.1. Microstructures

A commercially aluminum alloy ATSi5Cu1 was used in this work. Alloy was melted at 700°C and fed into a slurry maker at the temperature of 40°C above their melting point. A laboratory cold chamber die-casting machine was used for casting the standard tensile test samples. Figure 1 shows the typical microstructures of rheocasted alloy versus the die-casting procedure.



a). b).

Fig. 1. Microstructures of experimental ATSi5Cu1 alloy, after die-casting (a) and rheocasting respectively (b).

Detailed micro structural characterization of various rheocast samples has revealed the following micro structural characteristics:

- Porosity is well below 0.4-0.5 vol.%. pores are rarely observed in the rheocast samples. Occasionally observed pores are small in size.
- Primary particles have a fine size, spherical morphology and uniform distribution throughout the entire casting.
- The remaining liquid in the SSM slurry solidifies under high cooling rate in the die resulting in the formation of extremely fine Al-phase (<10μm).
- Oxide particles are fine (few μm), spherical and well dispersed and uniformly distributed, reducing the harmfulness of oxide particle clusters and oxide film in cast components.
- Si-rich phases can be dispersed uniformly without any macro-segregation.

2.2. Mechanical properties

A special die was made to cast standard tensile test samples for mechanical testing. Processing parameters, such as screw rotation speed, shearing time, shot velocity, shot pressure, intensifying pressure and die temperature, were systematically varied. The effects of such processing parameters were assessed against sample quality in terms of microstructure and mechanical properties [5].

Table 1 summarizes the mechanical properties of the rheocast ATSi5Cu1 alloy in comparison with those of the same alloys produced by die-casting and sand cast processes. Rheocast ATSi5Cu1 alloy has much improved tensile strength and acceptable ductility.

Table 1. Experimental data with tensile strength, yield strength and elongation results for ATSi5Cu1 alloy.

ATSi5Cu1 – alloy			
Casting process	Tensile strength [MPa]	Yield strength [MPa]	Elongation [%]
Rheocast	252	125	7.8
Die-cast	212	115	6.3
Sand cast	172	92	5.0

3. CONCLUSIONS

The semisolid metal processing technology, rheocasting, has been developed for the production of aluminum alloy components with high integrity.
The rheocast samples have close to zero porosity, fine and uniform microstructure and are free from other casting defects.
Compared with high pressure die-casting or any available semisolid processing techniques, rheocasting offers components with improved strength and ductility, which can be attributed to micro structural refinement and uniformity, much reduced or eliminated porosity and refined and dispersed oxide particles.
Rheocasting process is particularly suitable for production of high safety, airtight and highly stressed components in the automotive industry.

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