Facility for Rheo Pressure Die Casting

The focus of the foundry industry is being shifted towards the modern casting processes to meet the requirement of high performance components, especially with light weight alloys. Among the modern casting techniques, the rheocasting process, a variant of semi solid casting is considered as one of the new generation casting processes. Unlike the conventional processes, the casting is done in semi solid state i.e. in between liquidus and solidus temperature of the alloy instead of liquid state. Though rheo casting has been developed internationally, it is not practiced in India due to lack of knowledge in the Indian casting industries about this process. In view of the above, Department of Science and Technology (DST), New Delhi, along with Council of Scientific and Industrial Research (CSIR), New Delhi have granted this project entitled "Facility for Rheo-Pressure Die Casting" to CSIR-CMERI in association with Indian Institute of Science (IISc)- Bangalore and Jadavpur University-Kolkata, Mahindra & Mahindra Ltd. being the industrial partner.

In this project, a Rheo Pressure Die Casting (RPDC) system has been developed indigenously to produce semisolid casting of automobile components with aluminium alloys. The process has been developed in-house in an end-to-end-manner, carrying out research and development in every step so as to develop a thorough scientific understanding of all the processes involved. The basic objective of establishing a cost-effective indigenous process was established, and the process is ready for transfer to Indian industries will full know-how and know-why. The developed rheo pressure die casting system is simple and readily adaptable in the existing pressure die casting industry.
The developed rheo pressure die casting is shown in figure 1. It comprises of nine sub systems *viz.* a melting furnace [1] of 200 kg capacity to melt the aluminium alloy, a curved shaped cooling slope or inclined channel fitted beneath the melting furnace for the generation of semi solid slurry, a holding furnace [3] of 100 kg capacity for storing the semi solid slurry isothermally, a ladling unit [4] for transferring the semi solid slurry from holding furnace to the pressure die casting machine, a pressure die casting machine [5] of 350T clamping force to cast the semi solid slurry, a control unit [6] that controls the operation and movement of the furnaces, a hydraulic and pneumatic power pack [7] that control the hydraulic oil and compressed air flow and pressure in hydraulic and pneumatic cylinders respectively in the system, a sleeve temperature control unit [8] and a mould temperature controlling unit [9] to maintain required temperature of the sleeve and mould respectively during casting. The control unit [6] can be run in both manual mode and auto mode through Programmable Logic Controller (PLC). Rheo pressure die casting process starts with the melting of aluminium alloy ingots or scraps in the melting furnace. When the temperature is stabilized, molten alloy is discharged from the bottom of the melting furnace and it falls on the upper part of the cooling slope. As the molten alloy touches the colder cooling slope, a significant numbers of tiny nuclei are formed and these nuclei are carried away with the molten alloy. As the molten alloy flows down the cooling slope, it loses its temperature and the temperature of molten alloy falls below liquidus temperature but stays well above the solidus temperature and solidification starts around the nuclei. Thus α-Al phase evolves and it grows as temperature of the melt decreases but the α-Al phase cannot grow with dendritic structure in the cooling slope due to shear stress developed between the flowing molten alloy layers as well as with cooling slope surface and the shape of the α-Al phase becomes non dendritic. This semi solid slurry is stored isothermally in the holding furnace where growth of the primary a-Al phase stabilizes to form the nearly globular grain slurry. This metered quantity of semi solid slurry is transferred by laddling unit into the pressure die casting machine to cast the component. Due to processing in the semi solid region, gas entrapment, micro

segregation and shrinkage cavity formation associated with conventional casting reduces considerably. Moreover, formation of globular grain improves the mechanical properties of the cast components.

1. Melting Furnace	5. Pressure Die Casting Machine
2. Cooling Slope	6. Control Unit
3. Holding Furnace	7. Hydraulic and pneumatic power pack

Fig: The developed rheo pressure die casting system (Front view)

A critical automobile component known as "Steering Knuckle" of steering-wheel assembly of SUV has been developed using rheo pressure die casting process. Steering knuckle is generally manufactured through ductile iron casting. But owing to improved properties achieved in rheo pressure die casting, the steering knuckle is developed out of A356 aluminium alloy to reduce its weight. The component is redesigned and mould of the component is manufactured accordingly. It is then cast through rheo pressure die casting process and machined. Finally, performance evaluation of the rheo pressure die cast steering knuckles have been carried out in the test rig of Mahindra & Mahindra and the results are very much satisfactory. A combination of considerable amount of ductility and strength is achieved in rheocast steering knuckle which is required for such components. Therefore, rheo pressure die cast aluminium alloy steering knuckle has potential to be used in place of steel/ductile iron knuckle in automobile application and thus providing substantial weight savings. The machined rheo pressure die cast steering knuckle and its micrograph are shown in figure 2. Besides the system, process and product development, in-depth experimental investigation along with CFD analysis have been carried out in this project to generate the knowledge about semi solid slurry formation in the cooling slope and die design concept for mould filling with semi solid slurry.

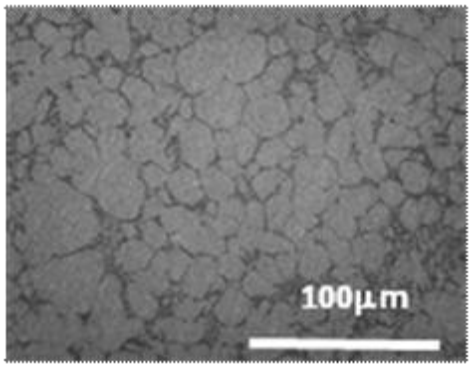

Fig.2: (a) Machined rheo pressure die cast steering knuckle, (b) Micrograpgh of rheo pressure die cast steering knuckle.