Session Chairperson UBE MACHINERY CORPORATION, LTD.
Kousei Murakami

JD18-19

Influence of Local Squeeze Process and Working Pressure on the Shrinkage Defect Control for High Pressure Die Casting

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This study describes an example of applying the local squeeze process into the casting simulation software. Besides the discussion on decreased shrinkage porosity induced by the movement and working pressure from a squeeze pin, we also analyzed the stress distribution affected by solid fraction of melt. Furthermore, we validated how the distance between the cavity and a squeeze pin affects the shrinkage porosity. As a result, this methodology predicts size of the porosity very well.

JD18-20

Ladle pouring simulation of die casting using particle-based method with oxide film model

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Particle-based computational methods, such as the Smoothed Particle Hydrodynamics (SPH) method, do not require numerical mesh. Because of the mesh-less characteristics, they are suitable for the numerical simulation including the free surface or moving boundary. In the casting process, the SPH method is expected to make simulations of pouring with free surface more accurate. On the other hand, the pouring experiment with water and that with molten aluminum alloy show totally difference of filling time and wave shape, despite the same degree of kinematic viscosity and little occurrence of solidification. For molten aluminum alloy, it is thought that the flow behavior is different because it has different characteristics from water, such as forming an oxide film on the surface even before solidification. The aim of our research is to construct a numerical model, which reproduce the effect of the oxide film by SPH method. We report the result of validation of this model by comparing the experimental results and our simulation results.

JD18-21

Flow analysis of thin-walled die-cast products by particle method.

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Particle-based analysis method, such as the Smoothed Particle Hydrodynamics (SPH) methods is suitable for analysing the items including free boundary and moving boundary due to it does not necessary numerical mesh. In recent years, examples of applying the particle method to the casting process are also being announced, and its application can be expected in the future. On the other hand, application to a large die cast product has not been reported due to it costs more calculation cost compare to conventional methods. We analyze the process about pouring by the ladle by the particle method so far and reported the sufficient reproducibility of the waveform of the molten metal surface. In this report, we tried to apply to actual die casting products. The target product is a panel shape and its size is 450 mm × 550 mm × 1.2 mm. We compare the filling behavior of actual products with the analysis results by short shot. And report the cases where calculation of filling behavior of larger thin walled products was succeeded by various adjustments also in the particle method.

JD18-22

Model Based Design of cast-filling for Celebrate Driving

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Celebrate Driving is the most precious essence in MAZDA manufacturing. It provides our customer to brightness of life in their driving experience. Trying to limit of weight reduction is important task in our division, we make thinner casting with high pressure die-cast process. Model Based Development (MBD) means a common approach in MAZDA. That makes trial manufacture completely and justifiable quality by Computer Aided Engineering. Breaking through the relation between thin-wall design and fillable on MBD, we could achieve SKYACTIV engine lighter weight than usual. This paper introduces the instance that we constructed Production Model about cast-filling in cavity. It was made possible by both improving accuracy of simulation and developing the verification technology of fillable.

JD18-23

Numerical modeling of cold flake entrapment

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Cold flakes entrapped into die cavities decrease mechanical properties of the casting products significantly. Therefore cold flakes have to be minimized. Even though many counter-measures have been taken, such as control of process parameters like pouring temperatures and injection conditions, and shape optimization of plunger-tips and flow dividers, effects of those counter-measures are still not clear. In this study, the formation and the moving behavior of cold flakes are simulated numerically. In our model, first, it is assumed that cold flakes are formed at the triple point (plunger-tip, inner-surface of sleeve and solid shell). Then, effects of gravity, buoyancy force and drag force are considered in the calculation of cold flake moving. Furthermore, when a cold flake is larger than the mesh size, multiple representative points are used to track the cold flake, and it is also assumed that when the distance of adjacent points is larger than a critical value, the cold flake will be broken into smaller pieces.

Session Chairperson Sato Research Institute for Foundry Technology
Dr. Kenji Sato

JD18-24

Flow Simulation and Experiment for Preventing Defects in Die Casting

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In die casting, there are some defects such as generation of air bubbled by molten metal during filling and blow molding due to solidification shrinkage. As a result, Dimensional accuracy, durability and mechanical properties are deteriorated. In order to reduce these, it is necessary to normalize the flow behavior of the molten metal in the mold, however internal phenomena still do not deviate the stage of fundamental research. As a previous study for preventing these problems, Aida et al. directly observed the injection behavior of the gate using a transparent mold. In addition, in order to observe the fluid behavior in the mold, there are cases where transparent acrylic molds are made and water visualization experiments are conducted. Against such a background, detailed investigation of blowholes was carried out by X-ray CT in order to elucidate the cause of internal defects in this study. Moreover, a simulation of molten metal flow was carried out, and the result by X-ray CT and the defect analysis were compared and evaluated.

JD18-25

Photography of atomization phenomena in HPDC and development of simulation system for atomized flow by LES-VOF method

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In high-pressure die casting, the ingate metal flow is defined by the J Factor. At higher J Factor, the metal flow becomes atomized flow, which has been reported to improve the quality of the product. However, the micro-scale atomized flow has not been elucidated. Thus, we used pulsed laser transmission measurements to photograph micro-level molten aluminum injected into an open space, thus revealing the atomization process of metal flow. Furthermore, we newly developed simulation system in order clarify how the atomized metal flows within a cavity. The system simulates the atomization process through a highly accurate finite volume method coupling a large eddy simulation (LES) and volume of fluid (VOF) method. The system was developed by reproducing photograph results for injecting into an open space. The state of the atomized flow within the cavity was investigated using a simplified tabular model. As a result, we demonstrated that the atomized flow at the gate flows in the cavity to the final filling areas as a multiphase flow of aluminum and fine air bubbles.

JD18-26

Reduction to Porosity and Non-metallic Inclusions by Pre-fill and Transition point control injection in Large-sized Die-cast Products with proper J-Factor and Injection Parameters

Yamaha Motor Co., Ltd. (Retired; 2014) ●Yamada Youji

The current high pressure die casting (HPDC) is believed, that enable to reduce drive down manufacturing cost by its high productivity and ensure a steady supply at stable prices. However, the HPDC during injection technical process included a large volume of air is captured in the die, which leads to porosity and non-metallic inclusions. To accurately define HPDC quality requirement by J-factor, it should be developed the criteria for transition of flow regimes based on gate geometry and gate velocity on the assumption that the molten metal density, viscosity and surface tension are constant. The J-factor was classified as continuous jet flow at low velocities, coarse jet flow at intermediate velocities, and atomized particle jet flow at high velocities. The criteria of flow transition from coarse particle jet flow to atomized jet flow is called transition point (J=250 as S.I.), that porosity volume is exponentially decreased and accomplishes prime quality of flow regime in the atomized particle jet flow. However, it remained to be elucidated that quality requirement of die cast mold building and machine injection configurations which advocate for J-factor researcher J.F. Wallace after 43 years. For better understanding of the criteria. To better understand the criteria for transition of flow regimes in the die cast design and machine injection configuration condition, I studied large-sized die cast product of injection parameters that occurred atomized particle jet flow near the PQ2 and J-factor indicated configuration conditions, and compared die cast empirical condition and calculate theoretical values. These result provide new sight that it possible to foresee to occurring atomized particle jet flow and PQ2 configuration before design phase.

Session Chairperson RYOBI Limited
Dr. Eng. Akihito Hasuno

JD18-27

Formation Mechanism for Blister of Zinc Alloy Die Casting

Sato Research Institute for Foundry Technology ●Dr. Kenji Sato

A blister is caused by a pin hole, a blow hole and soluble gas of a metal matrix. To investigate the formation mechanism for the blister, JIS ZDC2 zinc alloy specimen was produced using a hot chamber die casting machine with two different casting conditions; using a commercial oil based die lubricant and lubricant-free. The gas content was evaluated by a blister test and the porosity amount was estimated by measuring the density of the specimen. The porosity amount increases with increasing the initial porosity and also rising the test temperature. The porosity of die casting using the oil based die lubricant more expands than that of the lubricant-free. X-ray topography image of the specimen clearly shows that the small porosity largely expands after the test. A diameter of the gas bubble of the melt is governed by the surface tension and the casting pressure on the solidification. Therefore the small porosity applies extremely high inner pressure. The expansion mechanism for the blister is discussed with two parameters; the strength of the alloy matrix at the elevated temperature and wall thickness of the gas hole of die casting considering the inner pressure of the hole.

JD18-28

Aluminium Alloy for Die Cast with High Corrosion Resistance

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Along with weight and cost reduction for automobile parts and general parts, the usage of aluminium die cast product is spreading. ADC12, well-known as aluminium alloy diecasting, is put to practical use in a wide range of fields because of its excellent castability, machinability and high strength, but surface treatment is necessary when used under corrosive environment due to its low corrosion resistance. On the other hand, ADC5 and ADC6 have high corrosion resistance, but it is difficult to apply these to product with complex shape due to their poor castability. Based on these backgrounds, new aluminium alloy for diecasting which has high corrosion resistance and excellent castability was developed. In addition, the effect of trace elements on corrosion resistance in this alloy system was also investigated.

JD18-29

Development of the Heat Resistant Magnesium Alloy Excellent in Castability and Recyclability

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Magnesium alloys have the characteristic with high specific tensile strength and lightweight property, it is widely used for auto mobile industry. The conventional alloys AZ91 (Mg-9%Al-1%Zn) , AM60 (Mg-6%Al-0.3%Mn) and AM50 (Mg-5%Al-0.3%Mn) are currently used in engine covers, steering wheels and sheet frames. The application of these alloys is limited to components operating at temperature below 120 - 130°C, because those creep resistance and strength at high temperature are low. Therefore, several series of heat-resistant magnesium alloys such as Mg-Al-RE, Mg-Al-Si, Mg-Al-Ca and Mg-Al-Sr have been developed from the late 1990s, and there are applied as a suitable material for weight reduction of the engine and power train parts in automotive field. However, these alloys still have problem of castability, recyclability and heat resistance in an industrial use. Therefore, We had developed new diecasting alloy to solve such a problem in several years ago. This paper describes the characteristics of the new heat resistant magnesium alloy AJX931(Mg-9%Al-3%Sr-1%Ca), which is excellent in castability and recyclability.