Global Trends Spotlight
8:00 am - 9:30 am  
Session Chair: Dr. Raymond Donahue

State of the Art and the Role of Innovation in the Recovery of the Die Casting Industry in the European and Italian System

New Trends for Aluminium Alloys for Die Casting

Digital HPDC New Platforms for Monitoring and Forecasting Quality and Costs

An Innovative Experience: HPDC & LPDC School in Brescia

Aluminium in Alfa Romeo’s Giulia, R&S in Low Pressure Casting at OMR Group

Structural
9:45 am - 11:15 am  
Session Chair: Hal Gerber

Impact of HPDC Process Parameters on Microstructure and Mechanical Properties of Aural™ 2 in the F and T5 Conditions

D. Levasseur, F. Chiesa (Centre de métallurgie du Québec); F. Breton (Rio Tinto)

Structural aluminum High Pressure Vacuum Die Casting (HPVDC) is the fastest growing foundry sector in North America. This growth is mainly due to the automotive sector which increasingly replace steel assembly by one-piece aluminum HPVDC parts (shock tower, cross members, rear door panel, etc.). The choice of a structural alloy is based on the published mechanical properties from each supplier, however these mechanical properties are rarely met everywhere in the casting. Moreover, the effect of HPVDC process parameters on the solidification structure and mechanical properties are not well known and must be studied in order to assist foundries in developing their process, meet specifications and optimize their cost efficiency. This study aims at determining the effect of alloy pouring temperature, die temperature and gate velocity on the mechanical properties of Rio Tinto’s Aural™ 2 alloy in the F and T5 conditions. Yield strength, tensile strength and elongation were measured for the 12 combinations of casting parameters and statistically analysed using 3-way ANOVA. The effects of single factors and interactions were highlighted by this technique. The microstructure of the castings was studied in order to establish the relationship between process parameters, microstructure and tensile properties of HPDC parts.

Effect of Cooling Rate on the Micro-Constituents of the Structural HPDC Aluminum Alloy Silafont 36

I. McAdams, Q. Han (Purdue University)

Structural HPDC is becoming a more prevalent subcategory of HPDC over the last 25 years due to the desire to convert automotive structural components from steel to aluminum. However, there is a lack of fundamental microstructure research on the current alloy. The current paper performed experiments on Silafont 36 under different cooling conditions in order to investigate phase formation with particular attention to the SDAS. The results show that the phase formations were refined yet consistent from slow cooling to rapid cooling. Also, the Al-Mg-Si intermetallic was identified within the microstructure for both slow and fast cooling conditions. Finally, curves were presented for the SDAS as a function of solidification time and cooling rate.

New Developments in Die Casting Alloys for Structural Castings

S. Wiesner, R. Klos (Rheinfelden Alloys); V. Anthony (Nikkei MC)

This paper is about two alloys recently developed by RHEINFELDEN ALLOYS dedicated for high pressure die cast structural parts for automotive car bodies. The first having a AlMg4Fe2 composition (Castaduct-42) relies on a completely different eutectic composition formed by a combination of around 4,2 % Mg and around 1,6 % Fe. This guarantees very good castability which is similar to eutectic Al-Si alloys. Si is at a minimum level. In basically all existing foundry alloys Fe is an impurity that reduces mechanical properties and castability through Fe containing needles in the microstructure. In this new alloy Fe is an alloying element and does not negatively impact the properties. The achievable mechanical properties in the as cast state are comparable to typical Al-Si-Mg type alloys with full T7 heat treatment.

The second is AlMg6Si2MnZr (Magsimal-plus) which is a further development of the Rheinfelden’s well-known high strength alloy AlMg5Si2Mn (Magsimal-59). This new alloy Magsimal-plus provides even higher strength at a similarly high ductility making it the highest strength HP-DC alloy for structural parts actually available. AlMg6Si2MnZr (Magsimal-plus) due to dispersoid hardening with Mo and Zr in the Magsimal type alloy is offering yield strength values up to 200-240 MPa (29-35 ksi) in F and T5 temper while still having 10% elongation.
Initial Development of Machine Learning Algorithms to Predict Casting Defects in High-Pressure Die Casting

D. Blondheim, Jr. (Mercury Marine)

Data giants like IBM, Google, Amazon, and Facebook have been using big data and machine learning algorithms for years and, in some cases, decades to help drive extraordinary results and insight for their companies and customers. The high-pressure die cast industry lives in a data-rich world. A review of the die casting process reveals hundreds to thousands of variables that may affect the process or equipment, and therefore, the quality of a casting. Some of these variables are easily measured, while others are technically difficult. This purpose of this paper is to review the approach used at Mercury Marine’s Casting Business Unit (a division of Brunswick Corporation) to experiment with big data from the high-pressure die casting process and then test its application in machine learning algorithms to improve the understanding of the casting process. Data sources for the analysis include thermal images of die steel after spray and shot end process parameters collected during the production cycle. The results of these initial algorithms will be reviewed to show the effectiveness of utilizing the data to help predict casting defects and what future areas of development, data collection, and improvement are needed.

Optimizing Die Cooling Using Pulsed Spray & Lube Residuals on Die Surface Using Lube Spray Methods

K. Blowers (Purdue University & FCA); M. Rakita, A. Koehler, D. Lee, M. Landa, Q. Han (Purdue University); D. Gettinger, A. Hughes, C. Daugherty (FCA)

In high pressure die casting (HPDC), it is necessary to apply a lubricant onto the surface of the die to prevent soldering and to decrease the cycle time of the casting process. Traditional methods use a continuous spraying method to apply the lubricant; this can be wasteful. This research examines the ability of a pulse spray application process to apply die lubricant onto the die surface. A previous study at Purdue University concluded that the pulsed spray method of die lubricant application could result in a significant reduction of the amount of spray runoff and consumption of die lubricant, leading to large cost reductions. This paper expands upon that research and presents findings for spray frequencies of 10Hz to 100Hz and increments of 10Hz.
Robotic Automation of 3D Scanning for Die Casting Quality Control

M. Kang, J. Hwang (ARIS Technology)

In this paper, we seek to provide a comprehensive overview of how 3D scanning can be utilized to provide die casting companies with an efficient and comprehensive quality control solution. We start by exploring the current state of 3D scanning and how robotic automation of 3D scanning can help overcome its perceived limitations in achieving this stated goal. We then use a reference system, equipped with a 6-axis robot and a 3D scanner and powered through ARIS's QC automation software, to perform a case study on a die cast part, provided by one of the NADCA member companies. A full inspection report is generated for this part, with a range of annotations that are needed to ensure quality. Then, a gage R&R study is performed on the measurements, where the precision (repeatability and reproducibility) is tested and compared against well-accepted industry standards. This precision test seeks to inform whether automated 3D scanning systems can be deployed in-production, instead of in-lab, leading to significant cost savings. In addition, we test if automated 3D scanning solution leads to lower cycle time, higher inspection rate, and higher data quality, and therefore increased ROI compared to existing systems and processes.

Die Surface Engineering

3:30 pm - 5:15 pm
Session Chair: Peter Ried

Hot Isostatic Pressing of Core Pin coated with PVD Ceramic Coating

Y. Liu, Q. Han (Purdue University); Corey Vian, A Reiff (FCA); C. Chen, Z. Guo (University of Science and Technology Beijing)

This work examines the effect of Hot Isostatic Pressing (HIP) technology on the adhesion of PVD ceramic coating on H-13 steel matrix and on the service life of the core pins under the accelerated soldering testing conditions. Samples with a ceramic coating were heated up to various temperatures for 2 hours under argon protection. These samples were then characterized using an accelerated testing method for their service life in molten A380 alloy, and using Rockwell hardness tester for examining the toughness of the coatings. Experimental results obtained under the accelerated testing conditions suggest that the use of commercial coatings such as BALINIT® ALCRO-NA, BALINIT® D, BALINIT® FUTURA NANO, and BALINIT® LUMENA extend the service life of core pins by 12-150 times. Hipping of these PVD coating extends the service life of these coatings by another 20%. Rockwell hardness testing indicates that much less cracking is formed near the indentation dents on the coatings subject to HIP-ing. It is believed that HIPing of the coated core pins increases the adhesion between the ceramic coating and the H-13 core pins and is beneficial in extending the service life of the coating under die casting conditions.

Additive Remanufacturing of Die Casting Dies by Applying Electron-Beam Deposit Welding with In Situ Heat Treatment

T. Schuchardt, S. Müller, K. Dilger (Braunschweig University of Technology)

High pressure die casting dies made of hot work tool steels like AISI H13 are cyclically exposed to severe thermal, mechanical, chemical and tribological loads during operation. These loads lead to different defects, hence degrading the quality of die surfaces and consequently the quality of cast surfaces. In case of an unexpected production stop caused by critical defects, a remanufacturing by deposit welding is often an appropriate method to make the tool operational again. Currently, TIG or plasma welding processes are mainly used for repair welding routines. However, these welding techniques often exhibit an insufficient process-reliability and poor metallurgical properties. Hence, the primary objective of this work is to enable electron-beam welding technology as a deposit welding technology for an economic regeneration of locally damaged die casting dies made of hot work tool steels. Using this production method enables to establish a flexible, adequate temperature control of the material, resulting in advanced metallurgical properties and improved mechanical properties of the hot work tool steel. The article provides an overview of the qualified filler materials and their achieved mechanical properties. Furthermore, different welding parameters and strategies for the generation of multi-layer systems and experimental limits of the parameters welding speed and wire feed speed are depicted. The article also shows the possibility of in situ pre- and post-heat treatment by using different deflection techniques of the electron beam. The results form the basis for a continuous production chain for regenerating worn cavity surfaces. As an alternative repair welding technique, it is in direct competition with existing manual and semi-automatic welding processes. In order to establish this method, the focus for further analysis and research will be on a higher degree of automation.

AMC Results from a Series of Plant Trials to Evaluate the Impact of PVD Processed AlCrN Thin-Film Die Coatings to Minimize Die Lubrication

B. Wang, G. Bourne, J. Song, M Kaufman, S. Midson (Colorado School of Mines); A. Monroe (Mercury Marines); A Korenyi-Both (Tribologix)

A paper published at the NADCA 2016 Congress introduced the concept of using PDV thin-film coatings to reduce or eliminate die lubrication during the die casting process. Reducing die lubrication has the potential of...
making significant improvements to the die casting process, including reducing residual porosity and entrapped gasses in the castings, lowering production costs, extending die life, and reducing housekeeping issues.

The results of laboratory testing and initial plant trials suggested that an AlCrN coating applied to the die has the potential for dramatically reducing die lubricant. The objective of this paper is to provide an update on plant trials performed to evaluate the ability of PVD coatings to minimize die lubrication during conventional die casting. To date, 11,652 shots have been produced using a die coated with AlCrN, with die spraying reduced by between 83-to-92% compared with the amount of spray used for an uncoated version of the same die. In addition to reducing spray, it has been possible to reduce the cycle time by about 12%, and T6 heat treating trials suggested that the reduction of spray decreased the amount of gasses entrapped in the castings. Additional details of the plant trials are presented.

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