The Lost Foam Casting Process

The Foseco Ferrous Foundryman's Handbook is a practical reference book for all those concerned with making castings in any of the commonly used alloys, by any of the usual moulding methods. International SI units are used throughout, but in almost all cases conversions to the more familiar Metric and Imperial units are given. Wherever possible, Casting Alloy Specifications include equivalent specifications for several countries as well as international specifications. Individual chapters cover the casting of light alloys, copper-based alloys, all types of cast-iron and steel. For each group of alloys, specifications and typical applications are described, together with details of melting practice, metal treatment and casting practice. Sand moulding materials, including green sand and chemically bonded sands are also included.

Foundry engineering, Foundry equipment, Production metallurgy, Casting (process), Loams, Patterns, Machine tools

Previous research, conducted under DOE Contracts DE-FC07-89ID12869, 93ID12230 and DE-FC07-95ID113358 made significant advances in understanding the Lost Foam Casting (LFC) Process and clearly identified areas where additional developments were needed to improve the process and make it more functional in industrial environments. The current project focused on eight tasks listed as follows: Task 1. Computational Model for the Process and Data Base to Support the Model; Task 2. Casting Dimensional Accuracy; Task 3. Pattern Production; Task 4. Improved Pattern Materials; Task 5. Coating Control; Task 6. In-Plant Case Studies; Task 7. Energy and the Environmental Data; and Task 8. Technology Transfer. This report summarizes the work done on all tasks in the period of October 1, 1999 through September 30, 2004. The results obtained in each task and subtask are summarized in this Executive Summary provided in subsequent sections of the report.

This project was a subtask of Energy Saving Melting and Revert Reduction Technology (Energy SMARRT) Program. Through this project, technologies, such as computer modeling, pattern quality control, casting quality control and marketing tools, were developed to advance the Lost Foam Casting process application and provide greater energy savings. These technologies have improved (1) production efficiency, (2) mechanical properties, and (3) marketability of lost foam castings. All three reduce energy consumption in the metals casting industry. This report summarizes the work done on all tasks in the period of January 1, 2004 through June 30, 2011. Current (2011) annual energy saving estimates based on commercial introduction in 2011 and a market penetration of 97% by 2020 is 5.02 trillion BTU's/year and 6.46 trillion BTU's/year with 100% market penetration by 2023. Along with these energy savings, reduction of scrap and improvement in casting yield will result in a reduction of the environmental emissions associated with the melting and pouring of the metal which will be saved as a result of this technology. The average annual estimate of CO_2 reduction per year through 2020 is 0.03 Million Metric Tons of Carbon Equivalent (MM TCE).

This text seeks to provide a comprehensive technical foundation and practical examples for casting process modelling technology. It highlights fundamental theory for solidification and useful applications for industrial production. It also details shape and ingot castings, semi-solid metalworking, and spray forming.

Lost Foam Casting (LFC) is a metal casting technology that facilitates fabrication of near-net shape metal castings using expanded polystyrene (EPS) foam patterns that are coated with refractory slurry and is effective for producing aluminum or iron castings of complicated geometry. However, the LFC process can produce considerable amount of scrap due to casting defects. Removing the EPS thermal decomposition products through the ceramic coating ahead of the advancing metal front during the liquid metal pour is a key factor in obtaining a defect free casting. Developing a fundamental understanding of foam degradation mechanism is essential in improving LFC process. Modeling of the LFC process till date has completely neglected the effect of styrene on the overall thermal degradation of EPS foam. The dissolution effect of styrene is investigated by presenting the thermodynamic principles of polymer solution theory along with experiments to verify its impact on polystyrene degradation. By subjecting EPS Foam samples directly either to thermal radiation or to styrene vapor, it is demonstrated that styrene's solubility of polystyrene significantly alters the degradation mechanism of EPS foam in LFC process and thus can control the metal fill process leading to reduction of defects in castings. LFC process uses expanded polystyrene foam patterns in which isomers of pentane are used as blowing agents to achieve the expansion. In order to expand polystyrene, steam is used as a heat source and the expansion process takes place via conduction of heat from the surface of unexpanded polystyrene beads into the bulk. Pentane isomers are volatile organic compounds and green house gases that are either liberated directly into the atmosphere or combusted using expensive setup. The environmental impact of the current process using pentane as an expansion agent has been considered and a new method for manufacturing of EPS foam has been developed with benign expansion agent. Laboratory experiments are demonstrated where PS pellets are successfully expanded into foam. Novel heating technology using microwave radiation is proposed and implemented in order to achieve efficient volumetric heating for the manufacturing of foam with target density.

Previous research made significant advances in understanding the Lost Foam Casting (LFC) Process and clearly identified areas where additional research was needed to improve the process and make it more functional in an industrial environment. The current project focused on eight tasks listed as follows: Task 1--pyrolysis defects and sand distortion; Task 2--bronze casting technology; Task 3--steel casting technology; Task 4--sand filling and compaction; Task 5--coating technology; Task 6--precision pattern production; Task 7--computational modeling; and Task 8--project management and technology transfer. This report summarizes the work done under the current contract in all eight tasks in the period of October 1, 1995 through December 31, 1997.

Previous research made significant advances in understanding the Lost Foam Casting (LFC) Process and clearly identified areas where additional research was needed to improve the process and make it more functional in an industrial environment. The current project focused on five areas listed as follows: Task 1: Precision Pattern Production;

Task 2: Pattern Coating Consistency; Task 3: Sand Fill and Compaction Effects; Task 4: Pattern Gating; and Task 5: Mechanical Properties of Castings. This report summarizes the work done under the current contract in all five areas. Twenty-eight (28) companies jointly participate in the project. These companies represent a variety of disciplines, including pattern designers, pattern producers, coating manufacturers, plant design companies, compaction equipment manufacturers, casting producers, and casting buyers. This report summarizes the work done in the past two years and the conclusions drawn from the work.

With the increased emphasis on vehicle weight reduction, production of near-net shape components by lost foam casting will make significant inroad into the next-generation of engineering component designs. The lost foam casting process is a cost effective method for producing complex castings using an expandable polystyrene pattern and un-bonded sand. The use of un-bonded molding media in the lost foam process will impose less constraint on the solidifying casting, making hot tearing less prevalent. This is especially true in Al-Mg and Al-Cu alloy systems that are prone to hot tearing when poured in rigid molds partially due to their long freezing range. Some of the unique advantages of using the lost foam casting process are closer dimensional tolerance, higher casting yield, and the elimination of sand cores and binders. Most of the aluminum alloys poured using the lost foam process are based on the Al-Si system. Very limited research work has been performed with Al-Mg and Al-Cu type alloys. With the increased emphasis on vehicle weight reduction, and given the high-strength-to-weight-ratio of magnesium, significant weight savings can be achieved by casting thin-wall (? 3 mm) engineering components from both aluminum- and magnesium-base alloys.

"The thermal decomposition products and kinetic behavior of foam patterns constructed with expanded polystyrene (EPS) and expanded polystyrene/polymethylmethacrylate (EPS/PMMA) copolymers were evaluated in support of the lost foam casting (LFC) process development. This research specifically investigated the effects of high temperature and radiant heat transfer to the foamed polymer patterns that are exposed to the molten metal during the steel casting process"--Abstract, leaf iii.

This project takes a fresh look at the "white side" of the lost foam casting process. We have developed the gel front hypothesis for foam pyrolysis behavior and the magnetic metal pump method for controlling lost foam casting metal fill event. The subject of this report is work done in the improvement of the Lost Foam Casting Process. The original objective of this project was to improve the control of metal fill by understanding the influence of foam pattern and coating properties on the metal fill event. Relevant pattern properties could then be controlled, providing control of the metal fill event. One of the original premises of this project was that the process of metal fill was relatively well understood. Considerable previous work had been done to develop fluid mechanical and heat transfer models of the process. If we could just incorporate measured pattern properties into these models we would be able predict accurately the metal fill event. As we began to study the pyrolysis behavior of EPS during the metal fill event, we discovered that the chemical nature of this event had been completely overlooked in previous research. Styrene is the most prevalent breakdown product of EPS pyrolysis and it is a solvent for polystyrene. Much of the styrene generated by foam pyrolysis diffuses into intact foam, producing a molten gel of mechanically entangled polystyrene molecules. Much of the work of our project has centered on validation of this concept and producing a qualitative model of the behavior of EPS foam undergoing pyrolysis in a confined environment. A conclusion of this report is that styrene dissolution in EPS is a key phenomenon in the pyrolysis process and deserves considerable further study. While it is possible to continue to model the metal fill event parametrically using empirical data, we recommend that work be undertaken by qualified researchers to directly characterize and quantify this phenomenon for the benefit of modelers, researchers, and workers in the field. Another original premise of this project was that foam pattern and coating properties could be used to efficiently control metal fill. After studying the structure of EPS foam in detail for the period of this contract, we have come to the conclusion that EPS foam has an inherent variability at a scale that influences metal fill behavior. This does not allow for the detailed fine control of the process that we originally envisioned. We therefore have sought other methods for the control of the metal fill event. Of those, we now believe that the magnetic metal pump shows the most promise. We have conducted two casting trials using this method and preliminary results are very encouraging. A conclusion of our report is that, while every effort should continue to be made to produce uniform foam and coatings, the use of the magnetic metal pump should be encouraged and closed loop control mechanisms should be developed for this pouring method.

"Lost foam casting process has been widely adopted to manufacture complex parts without the need for cores. Numeric modeling of expanded polystyrene (EPS) foam displacement is only recently reaching a point where it can provide useful insight in helping optimize design and process variables. The objective of this thesis study was to develop an understanding of the pattern replacement mechanism in the lost foam casting process in steels"--Abstract, leaf iii.

Major casting processing advancements have been made in experimental and simulation areas. Newly developed advanced casting technologies allow foundry researchers to explore detailed phenomena associated with new casting process parameters helping to produce defect-free castings with good quality. Moreover, increased computational power allows foundry technologists to simulate advanced casting processes to reduce casting defects. In view of rapid expansion of knowledge and capability in the exciting field of casting technology, it is possible to develop new casting techniques. This book is intended to discuss many casting processing technologies. It is devoted to advanced casting processing technologies like ductile casting production and thermal analysis, casting of metal matrix composites by vortex stir casting technique, aluminum DC casting, evaporative casting process, and so on. This book entitled Advanced Casting Technologies has been organized into seven chapters and categorized into four sections. Section 1 discusses the production of ductile iron casting and thermal analysis. Section 2 depicts aluminum casting. Section 3 describes the casting manufacturing aspects of functionally graded materials and evaporative casting process. Section 4 explains about the vortex stir casting technique to process metal matrix composite castings. All the chapters discussed in detail the processing steps, process parameters involved in the individual casting technique, and also its applications. The goal of the book is to provide details on the recent casting technologies.

Contributed papers presented at the conference held at Central Mechanical Engineering Research Institute, Durgapur.

“Materials Science in Manufacturing focuses on materials science and materials processing primarily for engineering and technology students preparing for careers in manufacturing. The text also serves as a useful reference on materials science for the practitioner engaged in manufacturing as well as the beginning graduate student. Integrates theoretical understanding and current practices to provide a resource for students preparing for advanced study or career in industry. Also serves as a useful resource to the practitioner who works with diverse materials and processes, but is not a specialist in materials science. This book covers a wider range of materials and processes than is customary in the elementary materials science books. This book covers a wider range of materials and processes than is customary in the elementary materials science books. * Detailed explanations of theories, concepts, principles and practices of materials and processes of manufacturing through richly illustrated text * Includes new topics such as nanomaterials and nanomanufacturing, not covered in most similar works * Focuses on the interrelationship between Materials Science, Processing Science, and Manufacturing Technology

Popular Mechanics inspires, instructs and influences readers to help them master the modern world. Whether it’s practical DIY home-improvement tips, gadgets and digital technology, information on the newest cars or the latest breakthroughs in science -- PM is the ultimate guide to our high-tech lifestyle.

This study investigates the possibility of fabricating periodic cellular materials (PCMs) via the lost foam casting (LFC) process using aluminum alloy A356 and magnesium alloy AZ91. This approach combines the structural efficiency of PCM architectures with the processing advantages of near-net-shape LFC. An initial feasibility study fabricated corrugated A356 panels. This was followed by a study of casting variables such as pattern design, vacuum assistance, and alloying additions in order to improve the fillability of the small cross-section struts. Finally, integrated pyramidal sandwich panels having different relative densities were subjected to artificial aging treatments and subsequently tested in uniaxial compression. The A356 PCMs experienced a continuous increase after yielding while the AZ91 PCMs exhibited strut fracture after peak strength. The results showed the compressive yield strengths of this study are comparable with those previously reported PCMs produced by different fabrication methods.

Reviewing an extensive array of procedures in hot and cold forming, casting, heat treatment, machining, and surface engineering of steel and aluminum, this comprehensive reference explores a vast range of processes relating to metallurgical component design-enhancing the production and the properties of engineered components while reducing manufacturing costs. It surveys the role of computer simulation in alloy design and its impact on material structure and mechanical properties such as fatigue and wear. It also discusses alloy design for various materials, including steel, iron, aluminum, magnesium, titanium, super alloy compositions and copper.

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