

FE Analysis for Investment Casting and Computer Simulation: A Review

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Abstract— In the present paper a review for the experimental and finite element analysis techniques is adopted for Investment casting. Experimental Data taken for Solidification of investment Casting is modeled and meshed initially then validation is followed by comparing the experimental and modeled results. This helps to optimize the design criteria for investment casting. To overcome the problem of current gating /riser system and by comparing simulation results of optimized casting model with that of original model we can reduce the shrinkage porosity.

I. INTRODUCTION

Investment casting used for non-ferrous casting applications is increasingly used in the foundries today as an economically viable casting process. The conventional trial and error based investment casting design and process development is expensive and time consuming. Such a procedure also might lead to higher rejections and reduce production rate. Computer simulation procedure based process development and design can be used for rapid process development in a shorter time. Such a computer simulation based procedure, often using state of the art FINITE ELEMENT ANALYSIS based software systems can improve the quality and enhance productivity of the enterprise by way of faster development of new product FEM based simulation software systems help the designer to visualize the metal flow in the cavity, the temperature variations, the solidification progress, and the evolution of defects such as shrinkage porosities, cold shuts, hot tears and so on. Investment casting is widely use in the area like Aircraft engines, air frames, fuel systems, Agricultural equipment, Aerospace, missiles, ground support systems, Dentistry and dental tools, Stationary turbines, Computers and data processing Prosthetic appliance, Electronics, radar, Guns and small armaments Valves, Electrical equipment Textile equipment, Wire processing equipment, Transportation, diesel engines, Jewelry, Oil well drilling and auxiliary equipment, Bicycles and motorcycles etc.

II. REVIEW

To enhance the quality of cast component the solid model is analyzed and experimental results are compared with the finite element analysis results to optimize the design specification and parameter. Therefore this paper concentrates on the review of modeled and analyzed cast component.

S.Shamasundar et al, [1] analyzed a component of high quality, simultaneously at the same time reduced product cost and development time with the help of computer simulation. The development time can be very high in the

conventional trial and error based process design. In the current competitive environment, there is a need for the foundry and casting units to develop the components and the process at quick response times. Further, the costs of development also have to be kept low to be competitive. In these circumstances, Finite Element Analysis based computer simulations can be of immense value to the casting units. By computer simulation of the casting process, the flow of the molten metal in the cavity, the heat transformation, the solidification, grain formation, shrinkage and stress evolution can be visualized. The details are seen on the computer in graphical form, which helps the designers to visualize the defects in the process design, to analyze the causes for the defects. Further, the modified gating designs can be tried without resorting to the actual production of tool. Matthias Gumann et al, [2] used casting simulation software and found the problems due to filling; part cooling and effects of neighboring parts, and solidification are all identified and able to be corrected before the first pour. The filling order supplied hot metal to

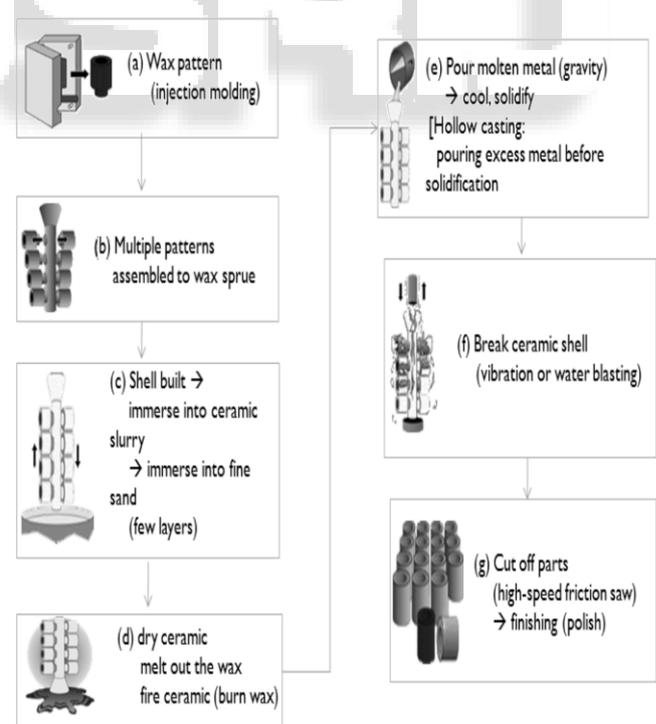


Fig. 1: Investment casting process

Extremely varied locations in the cavity, affecting feeding and heat transfer rates. The location of the part on the tree greatly affected the size of the defect. The bulky sections of the implants tended to hold heat much longer than the rest of the part; therefore, feeding paths back to the gate were cut

off prematurely, producing shrink defects. He made the conclusion that advanced casting simulation tools like Pro cast allow the foundry engineer to quickly bridge the gap between design and manufacturing. Optimization or improved efficiency during the manufacturing cycle leads to substantial time and cost savings. Computer analysis provides the means for verifying design ideas and viewing the effects of “what ifs” at minimal costs by avoiding time-consuming and expensive rework and retooling. Loic Calba et al,[3]simulation helps to achieve early confirmation of the component quality and metallurgy. Simulation must be a Concurrent Engineering tool rather than a process verification tool. Author had studied a thermal model, solid fraction analysis, macro porosity prediction. An advanced investigated on residual stress, deformation, hot tearing etc. Inter-dendritic shrinkage and gas porosities, microstructure, grain structure evolutions etc. can also be find out with the help of advanced metallurgical option. He concluded that Shorter development times and cost reductions (scrap costs, re-engineering costs) are required to the investment casting industry. Computer modeling with industrial and advanced solutions like Pro CAST is an efficient way to achieve these goals. Simulation can be used at the very early stage of the design conception (concurrent engineering with customers).Modeling the investment casting process step by step with first thermal only models, filling and solidification analysis before taking into account the full process complexity allows foundry engineers to develop a robust process. The process development lead time using virtual manufacturing proves always shorter than a traditional trial and error approach. Jorg Fischer et al,[4] He studied the advanced understanding of different thermal properties of 18K gold casting alloys, and how these properties influence solidification and susceptibility to porosity. The measurement of material property data reveals large differences in thermal properties for differently colored 18K gold alloys, especially with regard to thermal diffusivities. A satisfying agreement between experiment and simulation of the casting and solidification process is now obtained for some standard 18K gold alloys, in addition to sterling silver. The different thermal properties of alloys lead to largely different susceptibility to shrinkage porosity and demand for alloy-specific feed-spure design in order to obtain optimum casting quality. Computer simulation is an increasingly valuable tool that assists in identifying optimum feed-spure systems and process parameters aimed at the minimization of investment casting defects. Marco Aloe et al[5] He observed that beyond simply identifying shrinkage porosity and filling problems, numerical tools have been further developed to predict stresses, microstructures, defects and to model specific processes that can be used effectively by the foundry engineer early in the manufacturing process to save significant time and cost. He concluded that the effective use of computer analysis of the casting process has helped expand knowledge of the overall foundry process, and the role of such tools continues to grow both in design of the component and optimizing the process while producing a functional part under intended loading. The advancement in computer hardware available to run these programs with multiple CPU configuration, allows a fast turnaround time by increasing the speed of solution even on large size

models. Understanding stress and deformation, microstructure and mechanical properties, shrink and gas porosity as well as core blowing defects works its way back up the design chain to create more efficient parts and a more streamlined process, helping the foundry engineer get it right the first time around. As foundries are being pressurized to shorten delivery times and become more cost effective, computer modeling tools, like Pro CAST, which offer these advanced solutions, are becoming more popular in the foundry industry.



Fig. 2: Stainless steel shell casting component (Production part)

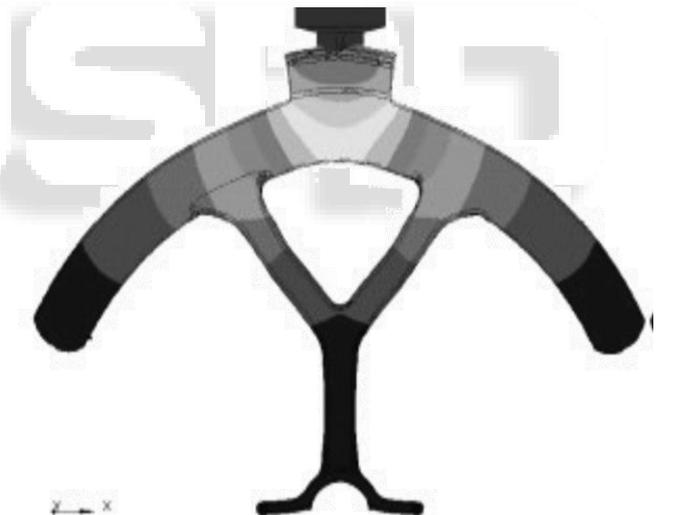


Fig. 3: Stainless steel shell casting component Simulated results (temperature field)

III. CONCLUSION

From critical literature review it is concluded that there is wide applicability of finite element analysis in the field of investment casting which solves the difficulty of defect in component and improves the quality of final solidified component. It can also reduced the defects.

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