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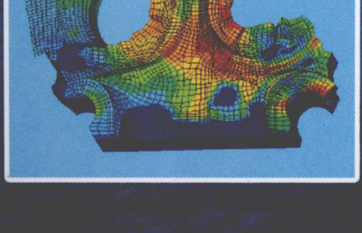
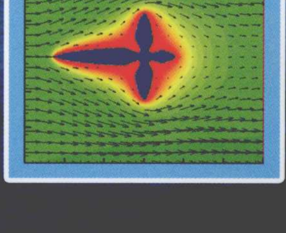
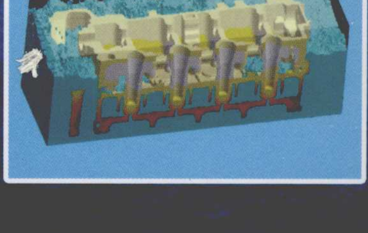
RECENT DEVELOPMENT OF MODELING OF CASTING AND SOLIDIFICATION PROCESSES

Edited by JIN Jun-ze
YAO Shan
HAO Hai
WANG Tong-min







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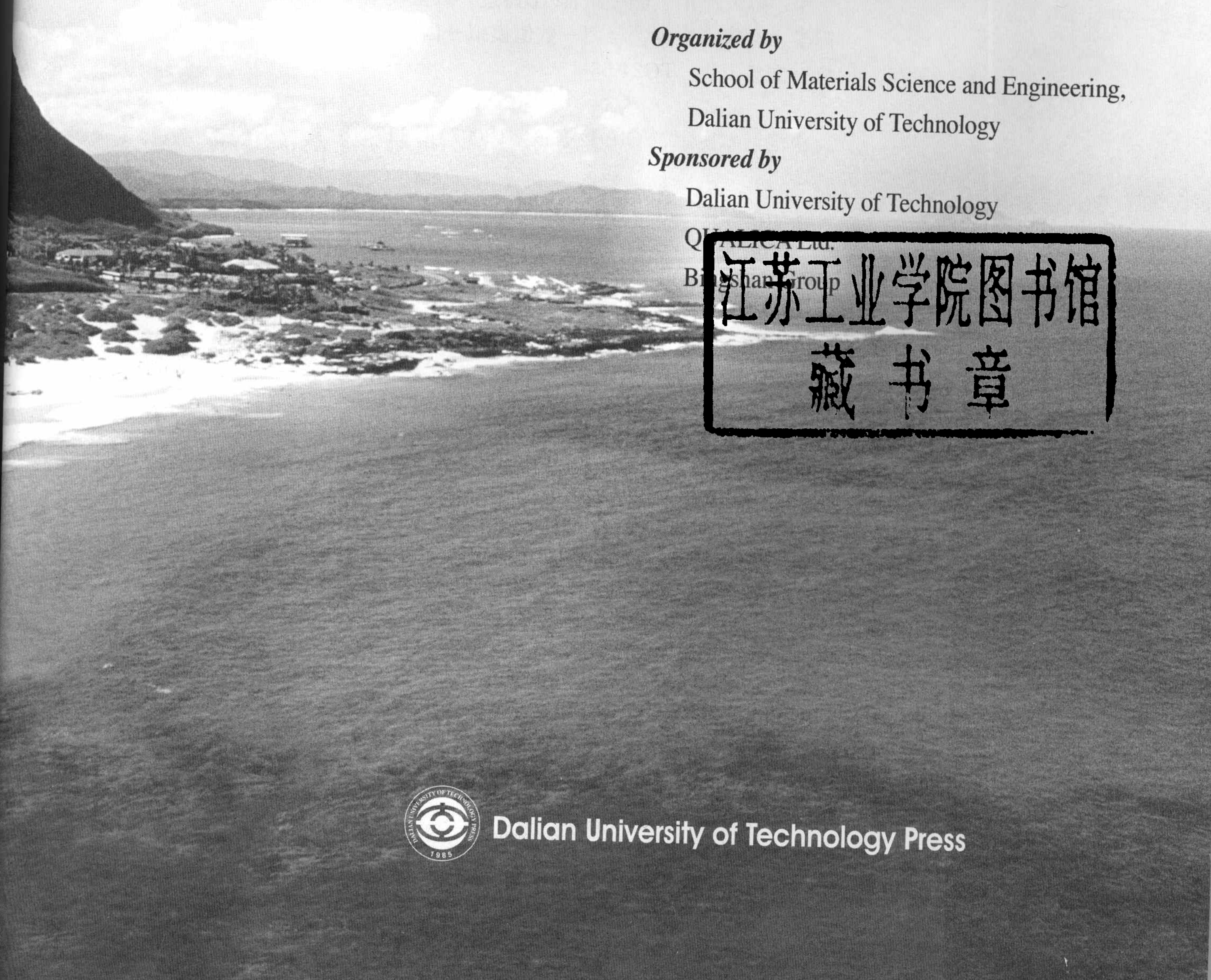

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Preface

The 7th Pacific Rim International Conference on Modeling of Casting and Solidification Process (MCSP7-2007) was held at Dalian University of Technology (DLUT) in Dalian, China on August 19 - 22, 2007. Following the tradition of the previous conferences held in Seoul (1991), Hitachi (1995), Beijing (1996), Seoul (1999), Nagoya (2002), and Kaohsiung (2004), MCSP7-2007 aims to provide both academics and industrialists with an interactive forum to promote and exchange ideas and interdisciplinary understanding of recent achievements in various fields of Modeling of Casting and Solidification Processes. This conference, in particular, examined the new knowledge pertinent to innovative casting and solidification processes for the 21st century through the eyes of the scientists and engineers.

Due to increasingly powerful computers and mathematical techniques, the materials science and engineering community finds itself on the verge of another revolution. With simulation, scientists and engineers will guide advanced materials/processes development and will be able to understand how materials form, how they behave under changing conditions, and how they can be optimized for improved performance.

This proceedings contains papers on various casting and solidification processes that involve mold filling, heat transfer and solidification, stress and deformation, microstructure and defect, materials properties measurement and experimental validation. Many papers describe models of virtually every phenomenon important to casting using a wide range of modeling tools and commercial software. The 87 papers are divided into sessions according to the main casting phenomenon modeled. It is believed that these papers have represented the developments in the fields of modeling of casting and solidification processes in current status, and will also offer a guideline for scientists and engineers who are interested in these fields.

The editor gratefully acknowledges the members from DLUT in planning the conference, QUALICA Ltd. and DLUT for funding, organizing committee for reviewing the papers, conference secretariat for editing the proceedings, authors for their papers, and attendees for their participation in MCSP7-2007.

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RECENT DEVELOPMENT AND CHALLENGES OF CAE IN CASTING

Itsuo Ohnaka[1], Akira Sugiyama[1], Jindong Zhu[2] and Toshihiko Murakami[3]

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[3]QUALICA Inc. , Hirakata-shi, Japan

Keywords: Computer Aided Engineering, Casting Defects, Direct observation

Abstract

Although the CAE is becoming more and more popular in producing castings, there are still many challenges we are facing. This paper presents our recent simulation development and applications such as mold filling, porosity defect estimation, including direct observation of mold filling and comparison with numerical simulation. The comparison revealed problems in the current CAE, such as the importance of consideration of surface tension and wetting of melt with mold, gas generation on the mold, and gas entrapment during mold filling.

Introduction

Computer Aided Engineering (CAE) in casting has been greatly developed in recent years and rather widely used in foundries. It seems that commercial codes can simulate all phenomena in casting. However, it is reported [1] that all commercial codes tested showed different results in terms of filling rate of pouring cup, degree of flow turbulence, the finally-filled region, degree of porosity, and, in particular, the degree of surface defects, suggesting that the accuracy is not clear and it is still difficult to estimate correctly and economically various casting defects. This paper presents our recent experiences and discusses the challenges.

Mold Filling

The mold filling simulation is very important, because many casting defects originate during mold filling. From the mold filling simulation foundry engineers predict entrapment of gas and inclusions, misrun, temperature distribution after mold filling for the initial condition of solidification simulation, etc.

Fig.1 demonstrates an application of mold filling simulation to a steel casting cast in a sand mold [2]. They estimate the entrapment of air and inclusions from the flow pattern; in particular, the free surface collision and vortices. However, it requires a skill and time. Therefore, most recent codes can show the entrapped gas after mold filling.

However, because the accuracy is not clear, we have been directly observing the mold flow in sand molds and in High-Pressure Die-Casting(HPDC) [3-6]. For, example, Fig.2 shows an example of direct observation of cast iron in a furan mold, comparing with numerical simulation. Such observation revealed that the details of the flow are different each time and, of course, the simulation cannot simulate such variation. Further, the surface tension of the melt and its wetting with mold considerably affect mold filling simulation results, as shown in Fig.2.

Here the surface tension force was considered on the melt surface;

$$P_S = \sigma k \tag{1}$$

σ : surface tension, k : curvature

If the surface tension is not considered, the gas gap, P in Fig.2, between the melt and the mold quickly disappears, contradicting against the observation (a). The importance of the surface tension was the same in the HPDC.

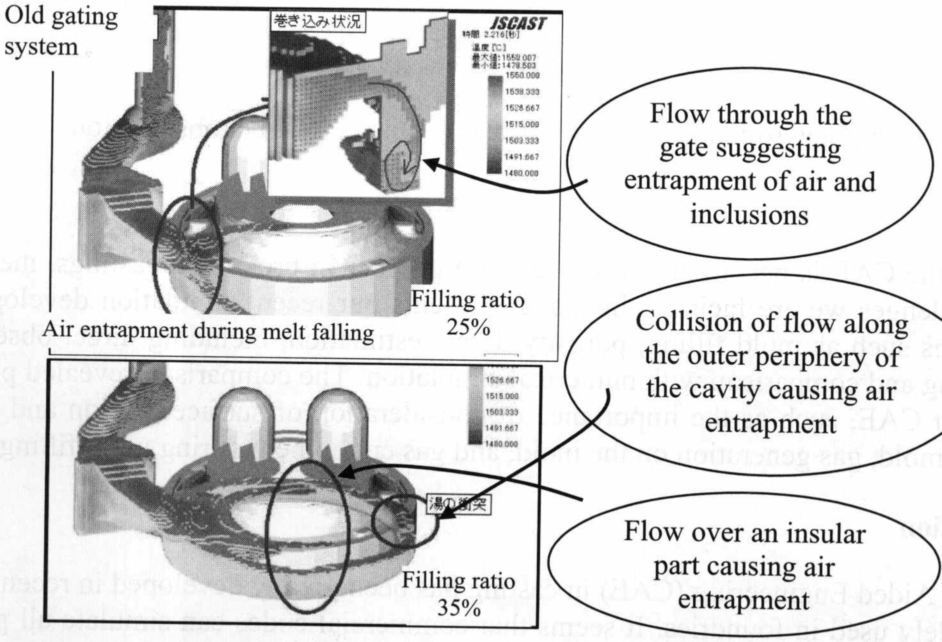
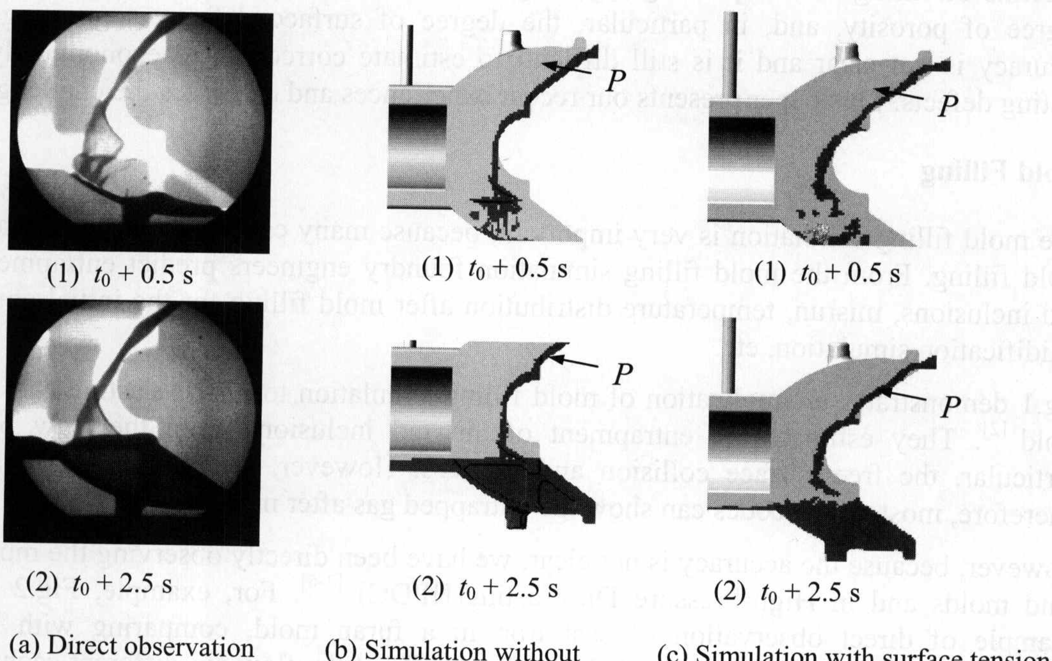


Fig.1 Example of mold filling simulation (Kashiwara [2])



(a) Direct observation (b) Simulation without surface tension (c) Simulation with surface tension

Fig.2 Example of direct observation of mold filling
(t_0 is the time when the melt appeared in the observation flame.)