# Parallel simulation of cast processes in WinCast

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WinCast is a software for simulation of cast metal solidification. The program is solving Furie equation by FE method to calculate temperature distribution in the casting and in the mould during solidification. Iterative solution of equation system proceeds using Gauss-Seidel method and Matser-Slave conception for parallel calculation. Parallel calculation could be done with effective decrease of time till 8 processors in a network.

Computer aided simulation of foundry technologies helps to reduce manufacturing costs and to increase yield and casting quality. One of the most advanced software tool for this purpose has been developed by RWP GmbH, Germany. RWP provides inside WinCast software the full line of Finite-Element-Analysis (FEA) for casting analysis, which includes fluid flow, solidification, residual stress as well as stress coming from an exterior load and a visualization of final distortion. With special validated stress package customer could accurately predict hot tearing, hot cracking and part and mold distortion. The results demonstrate the filling front, solidification, location of the last areas to fill and the last areas to solidify. It's possible, therefore, to predict the location of potential shrinkage porosity and to calculate its volume. Moreover, the grain microstructure could be estimated and, the distortion due to residual stress and the resulting dimensional changes in the casting could be measured. TFB is a core module of WinCast, which determines the temperature distribution during casting process based on a finite-element-method and a Gauss-Seidel solver.

With the increasing demand for even higher precision of the simulation results on one hand, and a growing need for even larger data sets on the other hand, the parallelisation of temperature feild module became inevitable. In the past, only computer centres possessed the computational resources to perform parallel computation on dedicated supercomputers. However, since high-performance computing has found its way from research into computational engineering, also smaller companies started to request for increasingly powerful systems, and thus for distributed solutions.

The finite element preprocessing module of WinCast decomposes the three dimensional casting part by dividing it into horizontal slices. When modelling the resulting layers into finite elements and finally re-meshing the structures, the complete part is represented as a Finite-Element-Model (FEM) image in memory. The basic element used in WinCast is a five faces prism. Thus, the generated meshes are composed of layers of clustered wedges. The nature of prisms offers good clustering capabilities and the layered style allows to model even fine onion skins in order to manage high temperature gradients, as they frequently emerge especially in casting simulations.

The core task of a casting simulation program is to compute the temperature distribution in the virtual mould at ascending time steps. In the case of WinCast, this operation is done by the TFB module. Thereby, the basic heat transfer equation is stated by the law of heat conduction, also known as Fourier's law. When discretising the partial differential equation by using finite element analysis and considering the boundary conditions, the problem could be reduced to solve one linear equation system per examined time step.

One common approach to parallelise an existing code is the master-slave concept. The reason for MPI decision was the fact that the TFB module contains a lot of GUI-based user interaction and I/O operation parts besides the numerical solver algorithm. Thus, when choosing this approach, the master can handle all those non-parallelisable interactions, while the slaves get just active when entering the solving routine.

Certain users of WinCast have insistently requested a parallelised TFB module, in order to reduce the main processing time, for example, from about 2 hours down to 20 minutes by using the 8 node compute cluster. Such time saving means fast search of true technology for complicated cast parts.