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Casting directly from a computer model by using advanced simulation software *FLOW-3D* Cast ®

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Abstract

ConiferRob ® - A patternless casting technique, originally conceived at VTT Technical Research Centre of Finland and further developed at its spin-off company, Simtech Systems, offers up to 40% savings in product development costs, and up to two months shorter development times compared to conventional techniques. Savings of this order can be very valuable on today's highly competitive markets. Casting simulation is commonly used for designing of casting systems. However, most of the software are today old fashioned and predicting just shrinkage porosity. Flow Science, VTT and Simtech have developed new software called *FLOW*-3D Cast ® , which can simulate surface defects, air entrainment, filters, core gas problems and even a cavitation.

Key words: High Precision, Simulation, Robotic, Machining,

1. Introduction

Simtech's patternless casting technology allows developers to completely by-pass one of the main stages in traditional casting: the making of casting patterns. The advantages of this approach are best appreciated when several prototypes are required for a short production run, or when products vary slightly in detail.

The technology achieves this by using a robot to prepare a mould directly from a CAD model, or from an existing spare part or artist's model. Using the relevant control data, the operator directs the robot to machine the shape into a mould made of hardened sand, which is then cast in the normal way.

When the test casting is satisfactory, the same robot can be used for making the casting tools needed for mass production.

The use of casting simulation software is widespread in Finnish foundries, with around 90% already using such systems. The *FLOW*-3D Cast ® system allows the simulation of the physical phenomena which take place in the casting process as molten metal enters to the cavity and cools down to room temperature. It allows designers to experiment with different forms for metal components without the need to create real-scale pilots.

The casting system is designed with the advanced simulation technics. New casting simulation program has been introduced which is using multi- and unstructured grid technoly. Program is based on world famous FLOW-3D software.

2. ConiferRob - Precision control

Simtech Systems' ConiferRob® precision software fills the process gap between machining path generation systems, such as CAD systems, and industrial robots running machining programs.

ConiferRob ® can convert and move a machining program in *.apt format into a robot for execution both quickly and safely.

In addition to optimum accuracy, the positioning of work pieces can also be easily designed and reviewed with the help of ConiferRob® – as its reachability analysis options allow potential positioning problems to be identified and ensure that the final positioning selected will work in practice.

Manual corrections to the machining path can also be made, while the software's animation and collision detection features help check a program for safety before execution.

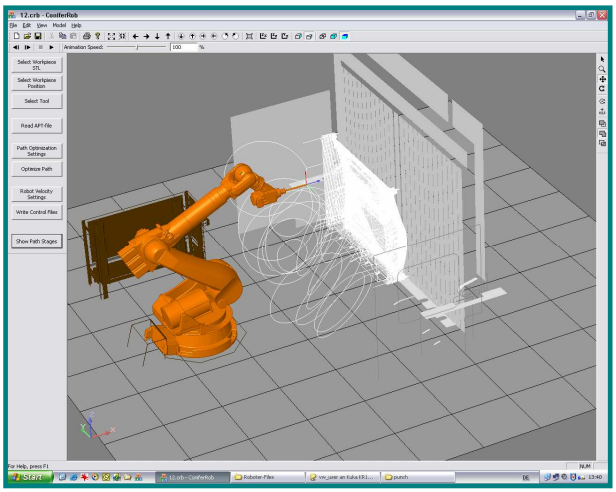

Fig 1. *ConiferRob* ® programme enables user to do robotic offline machining with automatically optimized paths together with very high precision collision detection.

2.1. Very real savings

Using Simtech's technique, prototypes and products can be cast quickly from the most appropriate materials and submitted to designers for approval and subsequent testing.

This can trim up to two months off the time normally required for design and manufacture, and cut the development costs of cast products by anything from 10% to 40%. Savings like this can be very valuable on today's highly competitive market.

Laboratory trials designed to compare the benefits of patternless casting against those of conventional casting – when producing cast components for a prototype hydraulic hammer – have shown that the total cost of bringing prototypes to market and the time required can be around two-thirds less using Simtech technology.

ConiferRob ® is critical here, as it converts machining paths obtained from CAD systems directly into a robot program and optimises robot performance for accuracy and minimum wear. It also controls the positioning of the work piece in the robot cell, and ensures operational safety using visual inspection and automatic collision detection

2.2. Safer too

The benefits of Simtech's technology are not limited to time and money, however. As it imposes no restrictions on the shape of objects to be cast in the way that conventional techniques do, engineers can take advantage of a multitude of new design opportunities. Customers can also test their product prototypes much more freely.

The technology can also be applied to other areas of manufacturing that work with complicated shapes and extreme dimensions in materials other than metal, such as plastic injection moulding.

Occupational safety is also improved, as mould production takes place in a closed robot cell, which prevents the migration of potentially hazardous particles into employees' respiratory tracts and dust into ambient foundry air.

3. *FLOW-3D* Cast software for foundries

FLOW-3D Cast ® is divided into different solver modules with increasing capabilities according to the process. It also offers accessory modules for e.g. materials data and designing. FLOW-3D Cast ® uses 3D CFD (computational fluid dynamic) simulation software as a calculation engine. The program is based on the fundamental laws of mass, momentum and energy conservation. 3D CFD has been supplied with a large variety of auxiliary physical models.

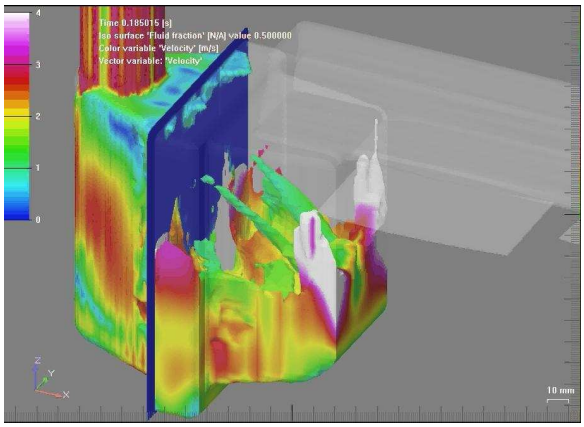

Fig 2. Sheetmetal Cut

Fluid flow simulations are less widely used. One of the reasons is that only a few of the codes can adequately simulate highly dynamic flows. On the other hand, all of the known methods require a significant degree of human effort during the pre-processing phase of the simulation process. This excludes the everyday practical use of such methods, when complicated geometries are utilised: The enmeshing process takes simply too long and often calculation meshes must be fixed in order to achieve converged solutions. Furthermore, although the casting geometry has been received from the workshop, adding the channels may involve considerable effort. For these reasons, many foundries tend to trust to their empirical knowledge[1]. However, fluid flow simulations should be used in many instances, e.g. in aluminium die casting, which is particularly because flow momentum plays a crucial role in the mould filling process due the high velocity of the liquid metal. Inertia effects may cause splashing, jetting or undesirable filling of the metal flow into mould cavity. When considering complex parts, the

accurate prediction of mould filling behaviour using only empirical knowledge is virtually impossible[2].

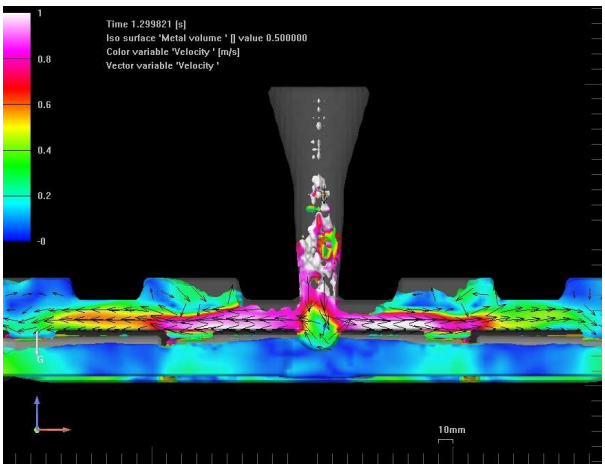

Fig 3. Velocity vectors and air entrainment in the channels.

3.1. Wide range of castings processes

- Steel iron, aluminium, magnesium copper and other metals,
- Sand casting,
- High and low pressure die casting ,
- Lost foam casting,
- Tilt pour casting ,
- Centrifugal casting,
- Composite matrix inserts and filters,
- Semi-solid and thixocasting
- Composite matrix inserts and filters
- Location of inclusion, folds and laps
- Sand core blowing
- Hot cracking criterion
- Deformation and stresses
- Inverse module to calculate material para- meters from experimental data
- IDS-program to calculate material
- parameters for steels
- Design Expert for creating a casting sys- tem for a product by utilising STL-files

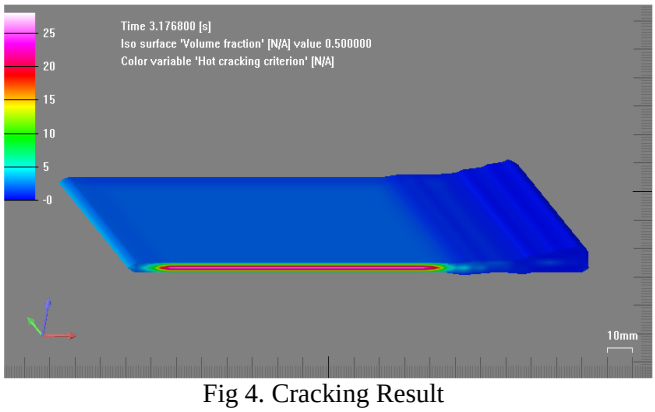

Fig 4. Cracking Result

4. Conclusions

4.1. FLOW-3D Cast®

Innovative Aspects:

Very effective software in turbulence modelling of two phase flows - predict the sharp interface between the molten metal and air during the filling. This is very essential when the flow fronts are breaking and small droplets are emerging into die cavity.

Easy to use interface allowing operators to use it without extensive training. Possibility to include all necessary tools for casting simulations.

Main Advantages:

Casting simulation using 3D CFD (computational fluid dynamic) algorithms is becoming an important part of the casting process in the modern foundry, allowing time optimization and cost reduction by simulating what will happen during the actual casting of molten metal at design time, experimenting alternative solutions without the need to set up trial and error.

4.2. ConiferRob

Innovative Aspects:

Fully isolated, automated casting cell for manufacturing components and billets

Short lead-time to market using digital product information and automation

No pattern costs, ideal for prototypes, small series and spare parts

Possibility to create a whole host of complicated mould shapes

Modular moulds and new forms at lower cost

Main Advantages:

Integration of state-of-the-art robot technology to moulding technology to create a flexible prototype manufacturing system.

Technology Keywords:

Design and Modelling /Prototypes Industrial Engineering / Processes / Manufacturing Techniques

4.2.1. Helping create the Audi A5

In one of its most recent projects, Simtech has worked with Mühlbauer Maschinenbau, a German robotic integrator, and automotive manufacturer Audi to further develop its technology for automotive needs.

As part of this, Mühlbauer Maschinenbau has developed a range of new spindles designed for machining in sand, as commercial spindles are unsuitable for this type of work; while Audi has developed new sand machining-specific tools. Some of these innovations have already been patented.

The result of this work can be seen in the sleek lines and eye-catching design of the new Audi A5, which was prototyped exclusively with the help of Simtech's technology.

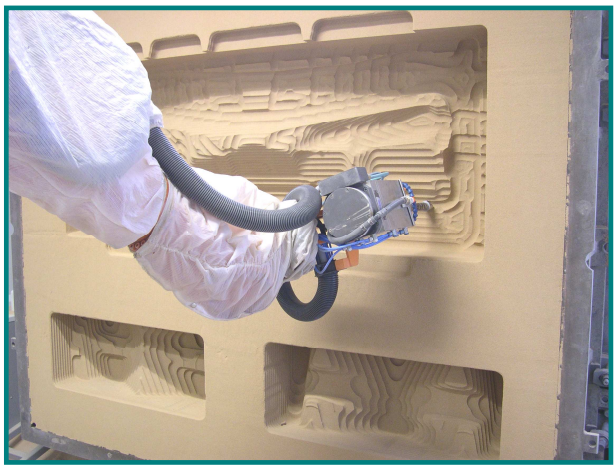

Fig 5. Robotic machining of prototype cars tooling frames in Audi cell at Ingolstadt in Germany

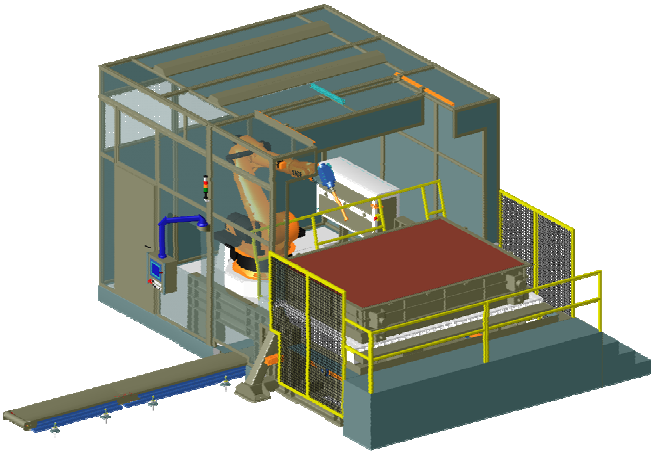

Fig 6. Digital Pattern Shop delivered by Mühlbauer Machinenbau GmbH and Simtech Systems Inc Oy to Audi prototype factory in Ingolstadt Germany.

Fig 7. Audi's new A5 was completely prototyped using ConiferRob® software. Photo courtesy of Audi AG.

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