

**CFD MODELLING AND  
MATHEMATICAL OPTIMISATION OF  
A CONTINUOUS CASTER  
SUBMERGED ENTRY NOZZLE**

submitted in partial fulfillment of the requirements for the degree of

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## SUMMARY

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### **CFD Modelling and Mathematical Optimisation of a Continuous Caster Submerged Entry Nozzle**

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#### **Abstract:**

In the continuous casting of steel, the Submerged Entry Nozzle (SEN), in particular the SEN geometry, has a primary influence on the flow pattern: the SEN controls the speed, direction and other characteristics of the jet entering the mould. The SEN is however relatively inexpensive to change (in comparison with other continuous casting equipment). Thus; there is a feasible incentive to exactly understand and predict the flow of molten steel through the SEN and into the mould, in order to maximise the quality of the steel by altering the design of the SEN.

By changing the SEN geometry and SEN design, the flow pattern in the mould will also change: it is thus possible to obtain an optimum SEN design if (or when) the desired flow patterns and/or certain predetermined temperature distributions are achieved.

Expensive and risky plant trials were traditionally utilised to “perfect” continuous casting processes. As opposed to the plant trials, this dissertation is concerned with the Computational Fluid Dynamics (CFD) modelling of the SEN and mould, which, when used in conjunction with the Mathematical Optimiser LS-OPT, will enable the optimisation of the SEN design to achieve desired results. The CFD models are experimentally verified and validated using 40%-scaled (designed and built in-house) and full-scale water model tests.

This dissertation proves that the CFD modelling of the SEN and mould can be quite useful for optimisation and parametric studies, especially when automated model generation (geometry, mesh and solution procedures) is utilised. The importance of obtaining reliable and physically correct CFD results is also emphasised; hence the need for CFD model verification using water modelling.

**Keywords:** Submerged Entry Nozzle (SEN), mould, continuous casting, CFD modelling, scaled water model, CFD validation and verification with water modelling, mathematical optimisation, parametric studies.

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## OPSOMMING

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### **Berekeningsvloeimeganika-modellering en Wiskundige Optimering van ‘n Stringgietry se Ondergedompelde Spuitstuk**

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#### **Opsomming:**

Die ondergedompelde spuitstuk (OS voortaan) in die staal-stringgietryproses het ‘n primêre invloed op die vloeipatrone binne-in die gietstukvolume: die OS beheer die spoed, rigting en ander karakteristieke van die spuitstraal wat die gietstukvolume binnestroom vanuit die OS se poorte. Tog is die OS relatief goedkoop om te verander in vergelyking met ander toerusting in die stringgietryproses. Gevolglik is daar ‘n dryfveer om presies die vloei deur die OS tot in die gietstukvolume te voorspel, ten einde die kwaliteit van die vervaardigde staal te maksimeer, deur slegs die ontwerp van OS stelselmatig te verander.

Deur die OS geometrie en ontwerp te wysig, sal die vloeipatrone ook verander: gevolglik sal dit moontlik wees om ‘n optimum OS te ontwerp sodra die verlangde vloeipatrone en/of temperatuurverspreidings verkry word.

Duur en riskante aanlegtoetse (van onder andere nuwe OS ontwerpe) was die tradisionele metode om ontwikkelingswerk vir die stringgietryproses te verrig. Hierteenoor, besig hierdie verhandeling hom met die berekeningsvloeimeganika (alombekend as CFD) modellering van die OS en gietstukvolume. Tesame met die Wiskundige Optimeringspakket, LS-OPT, kan ‘n OS ontwerp die resultaat wees van ‘n optimeringsoefening – waar sekere voorafbepaalde resultate aan voldoen sal word deur die optimum OS ontwerp. Die CFD modelle wat gebruik is tydens die

optimering, word eksperimenteel bevestig met behulp van watermodeltoetse (40%-skaal watermodel wat intern ontwerp en opgerig is), asook eksterne volskaal watermodeltoetse.

Hierdie verhandeling bevestig dat CFD modellering baie handig te pas kan wees vir die optimering en parametriese studies van die OS ontwerp, veral wanneer outomatiese modelgenerasie (geometrie, maas en CFD oplossingsprosedure) gebruik word. Die belangrikheid om betroubare en korrekte CFD resultate te gebruik vir optimeringsdoeleindes word ook beaam; daarom die behoefte aan gereelde CFD model eksperimentele bevestiging (met behulp van watermodeltoetse).

**Sleutelwoorde:** Ondergedompelde spuitstuk, kontinue staalgietproses (oftewel stringgietproses), berekeningsvloeimeganika (CFD) modellering, eksperimentele bevestiging van CFD modelle, watermodeltoetse, geskaalde watermodeltoetse, Wiskundige optimering, parametriese studies.

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---

<sup>1</sup> Department of Mechanical and Aeronautical Engineering, School of Engineering, University of Pretoria, South Africa.

<sup>2</sup> THRIP: The Technology and Human Resources for Industry Programme (of South Africa)

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