Modelling of Oscillation Marks in Continuous Casting - Short Term Scientific Mission - Scientific Report

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STSM Purpose The motivation for this scientific mission was to work on mathematical modelling of the formation of oscillation marks in the continuous casting of steel with Dr. Michael Vynnycky.

Report

The motivation for this scientific mission was primarily to work on mathematical modelling of the formation of oscillation marks in the continuous casting of steel with Dr. Michael Vynnycky. Continuous casting has been developed industrially worldwide since the 1950s as a high-throughput method for producing, amongst other things, metal billets, blooms and slabs; more than 90% of the world's steel is produced this way, amounting globally to more than one billion tonnes of steel cast per year. This scientific mission will aid the completion of my PhD and foster collaboration with Dr. Vynnycky who is an expert in the field of modelling metal casting.

This scientific mission began on February 16th and ended on March 15th. On this mission I worked closely with Dr. Michael Vynnycky, an expert in the field of mathematical modelling of metal casting. This mainly

involved trying to improve a model for the formation of fold-type oscillation marks in the continuous casting of steel. This initial model was formed during my visit to KTH in 2015 [1] and has been sent to Royal Society Open Science for review.

In our old model we did not consider a varying viscosity for molten flux fluid flow in the casting process. Our new model takes the fluid viscosity as a function of temperature, based on experimental data observed by a PhD student of Dr. Vynnycky in KTH. It turns out based on experimental results for flux viscosity that a linear profile can be assumed with temperature. Implementing this linear profile into our model will allow us to determine analytic results for the oscillation mark profile with varying flux viscosity. I also was able to complete some numerical computation that arose from my previous work with Dr. Vynnycky. I have formulated an initial numerical scheme using MATLAB. This numerical work showed that we can indeed have a negative 'flux of flux' while obtaining a valid solution for the oscillation mark profile, which was not obvious from our previous work.

I plan to be able to develop this varying flux viscosity model into a journal publication by the end of 2016. I hope to be able to include this into my presentation which has been accepted at the MACSI organised mini-symposium on moving boundary problems in industry at ECMI 2016 at the University of Santiago de Compostela (USC).

In addition to this work, I was also able to network and liase with students and staff at KTH. I was able to meet with Saud Saleem, who provided valuable experimental data for my work. I met experts in the field of metal casting Dr. Bo Rogberg and Dr. Hasse Fredriksson, both of whom possess years of metallurgy experience. I had the opportunity to experience first hand the experimental work on metals that is undertaken in KTH. Moreover my work is of significance to the division of casting of metals in KTH. My model can be used by metal casting experts who do not specialise in the mathematical modelling aspect of metallurgy.

Dr. Vynnycky has close ties to the University of Limerick and plans to visit in May 2016 to present a seminar. We will continue to work together while he is in Limerick. I then plan to continue my visits to KTH as a part of my PhD project with at least two more STSM visits to KTH before October 2018.

The funding for this STSM has greatly aided my research and my research plan for the completion of my PhD. The allocation of €2,000 has aided me in staying for an extended period of time in Stockholm. This added funding has allowed me to budget more money for future visits which I plan to complete before October 2018.

References

[1] Vynnycky M, Saleem S, Devine KM, Florio BJ, Mitchell SL and O'Brien SBG. 2016. On the formation of fold-type oscillation marks in the continuous casting of steel. *Under review*