# Discussion

## Discussion on "Observation of the Mold-Filling Process of a Large Hydro-turbine Guide Vane Casting"

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The authors are to be congratulated on their success in improving their 10-t steel casting. This was clearly as the outcome of significant hard work, making changes in the hope of improvement in the absence of rules for guidance for the design of the filling system.

The authors might be interested to learn that rules for the design of filling systems for casting are now fully developed and tested in numerous foundries around the world.[1] The rules are relatively simple and permit an exact, dimensioned solution to be achieved the first time, delivering a casting that can be completely free from defects the first time in the 6000 years of casting history. The rules have been shown to apply to castings from approximately 1 to 50,000 kg. Had these rules been applied in this case, a lower cost and instant solution would have been obtained, which would have been immensely superior in terms of absence of defects; no costly upgrading work in the weld shop would have been required.

The authors can find an example of a steel backup roll weighing 50 t filled by direct contact with the ladle to avoid air entrainment. It fell via a single hyperbolically tapered downrunner and entered the casting by a single tangential ingate.[1] The pour took 8 minutes. During this time, the melt rose in the mold, circulating gently like a gramophone record, with a clean mirror-like surface as opposed to the normal slag-covered mess.

The purpose of this short note is to draw the attention of readers to the fact that these hard-working and dedicated authors are not alone in their lack of awareness of existing solutions. Clearly, the highly qualified reviewers of this article did not know. Also, few foundries in the Western world yet know of these developments. In addition, practically all researchers in alloy development also remain completely and regrettably unaware.

The lack of awareness by researchers is especially serious because nearly all alloy developments are made in vacuum–induction furnaces, whose standard design ensures that the melt must usually fall a distance of at least 1 m into a mold. This uncontrolled fall, leading to a turbulent fill of the mold, is a disaster for the alloy. The vacuum is not sufficiently good to prevent the oxidation of the melt during the pour, so the oxide on the surface of the falling liquid is entrained as a folded over (*i.e.*, doubled) oxide, which I call a bifilm. This entrainment of oxides effectively fills the liquid with cracks, which are inherited by the solidified casting. It means that all of our alloy development work in metallurgy is seriously defective, and must, in the due course of time, be repeated if the real potential of the alloys is to be achieved. This vast waste of resources is currently hindering the proper development of metallurgy and engineering.

The good news is that the new concepts that have been developed to improve the filling of castings are gradually being taken up by a few foundries around the world. Where the ultimate filling designs (counter gravity using pressurized furnaces or pumps) have been properly adopted the achievement of world beating properties is easily demonstrated.[1,2] It is sobering to reflect that these industrial advances are far ahead of anything being currently achieved in universities, and therefore must be translated into the laboratory.

It is of little comfort to me to acknowledge that my books are the only texts I can recommend at this time. I have no choice but to recommend them.

### REFERENCES

1. J. Campbell: *Complete Casting Handbook*, 2 due 2015nd ed., Elsevier, New York, NY, 2011.
2. J. Campbell: *Quality Castings: An Account of the Development of the Cosworth Casting Process*, American Foundry Society, Schaumburg, IL, 2015.

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