Temperature and Microstructural Effects on the fracture Toughness Properties of As-Cast DP800 Steel Slabs

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Introduction

The process of continuous casting DP800 steel slabs can occasionally result in the adverse occurrences of clinking and reheat cracking. Clinking is defined as brittle fracture occurring during cool down of slabs often during slab yards following continuous casting [1], while reheat cracking can occur when a cold charged slab is reheated for further processing. Cracks due to clinking and reheat cracking often grow transversely, perpendicular to the casting direction. Both clinking and reheat cracking can adversely result in material loss and potential production shutdown.

Continuously cast slabs are subject to macrostructural and microstructural inhomogeneity owing to non-uniform cooling rates during the casting process. This results in three solidification regions: the chill zone, columnar zone, and equiaxed zone [2]. Variation in microstructure strongly indicates variation in the fracture properties of a DP800 slab. The motivation of this investigation is to ascertain the underlying mechanisms behind clinking and reheat cracking, for potential mitigation. The influences of microstructure and temperature on the fracture toughness of as-cast DP800 slabs were explored during this study.

Method

A sample of material was extracted from the centre of an as-cast DP800 steel slab for the purpose of examining the slab's solidification microstructure, shown in Fig. 1. This was done to determine the sizes of the three solidification zones, the phases present throughout the slab, as well as to evaluate the degree of inhomogeneity present through the thickness of a DP800 slab. Casting defects such as centreline porosity and segregation were also examined.

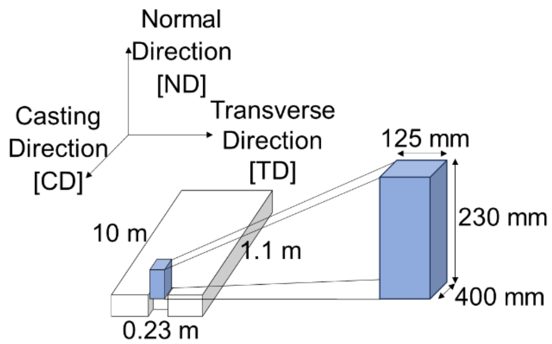

Fig. 1: Showing the position of the extracted material (blue), as well as the dimensions of the slab and block.

Charpy V-notched (CVN) impact samples were extracted from each solidification zone and were tested using the ISO-14556 standard. These were orientated with an expected crack propagation plane which was normal to the casting direction as shown in Fig. 2. Charpy impact tests have been conducted at different depths within a DP800 slab's 230mm thickness, at temperatures close to half of the material's melting point, T_m, shown in Fig. 3.

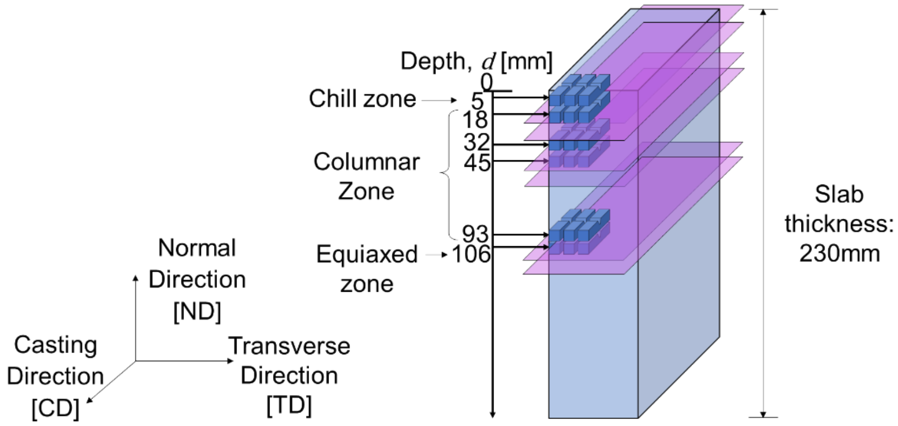

Fig. 2: Illustration of the position (depth) and orientation of Charpy samples tested.

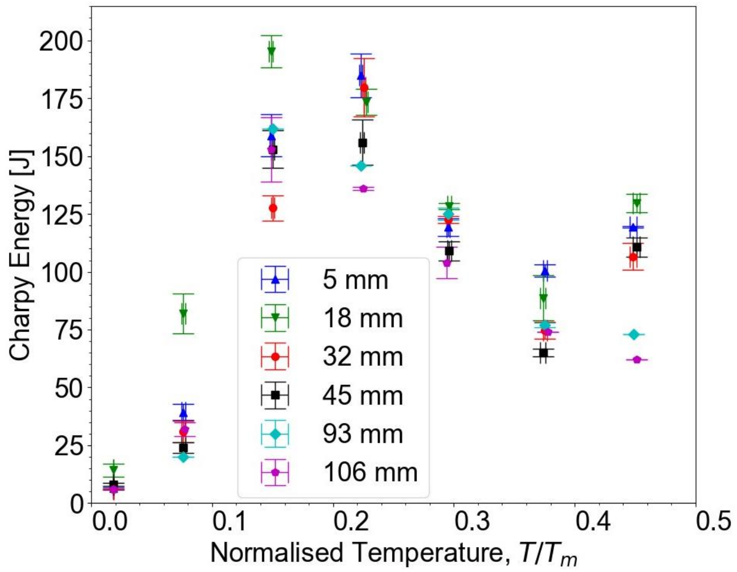

Fig. 3: Charpy impact energy temperature trend at different depths in a DP800 slab's thickness.

Conclusions

The notable presence of a ductile-to-brittle transition is accompanied by a notable reduction in ductility shown between $0.3T_m$ and $0.5T_m$ present in four of the depths tested, though further tests are required to confidently determine the influence of depth on ductile to brittle transition temperature. This ductility trough at this temperature can be a critical factor in fracture during slab reheat. J_{IC} fracture toughness tests have been conducted to corroborate the findings of transition temperature and ductility trough.

References

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