Success Story
COMET

K1-MET
Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K1-Centres
COMET subproject, duration and type of project:
5.7 07/2012 – 06/2015, multi-firm

Thermomechanical modelling of Continuous Casting

The investigations are focused on mechanisms leading to surface- and subsurface-defects during continuous casting of steels. On the one hand, Submerged Split Chill Tensile tests were carried out to quantify the influence of chemical composition on the sensitivity of hot tears.
On the other hand, different heat treatments were tested to investigate the effect of thermal history on ductility behavior of various steel grades.

Motivation

The Continuous casting process is the most commercial method for steel production worldwide. Characteristic of this method is the liquid bulk covered by a solidified strand shell after leaving the mold. The ongoing solidification is done outside of the mold in the secondary cooling zone.

This process step represents a potential risk factor with regard to cracking. Especially the outer strand shell is affected most, since stresses caused by the deflection pulleys, the cooling water and the ferrostatic pressure from the liquid inside the shell must be carried by the strand shell. Additionally, the formation of cracks is favored due to different operating mechanism Sub-surface cracks are known to have their origin next to the solidification front in case of exceeding critical strains. This cracks still remain open through the moving solidification front or are filled by liquid steel. However, the chemical composition of liquid may differ to the solidified schell due to segregation. Thus, the remaining inhomogeneities in microstructure are potential weak spots with respect to further deformability.

On the other hand, cracks at the surface of slabs and blooms are mainly initiated at lower temperatures. Especially Ti- and Nb-microalloyed steel grades are well known crack-sensitive steel grades due to a pronounced ductility trough in a temperature between 1200 and 600°C. Therefore the low ductility may occurs at a temperature where the slab has to be deformed in the straightening zone

Nevertheless, a qualitatively assured production of just this steel grades is of great interest due to the excellent mechanical properties of the final product.

Prediction of critical strain to avoid hot tearing

Several investigations related to the occurrence of hot tearing were done at the Montanuniverstitaet Leoben. Therefore, laboratory tests called SSCT (Submerged Split Chill Tensile) as well as simulations with software solutions developed at the University were performed to obtain an estimation of critical strain values depending on steel composition and strains during continuous casting occuring at industrial process. A standardized database of critical strain values depending on steel composition and the improvement of hot tearing prediction during

bmwfw Federal Ministry of Science, Research and Economy
bmvit Austrian Ministry for Transport, Innovation and Technology

casting and welding with enhanced boundary conditions was developed. This investigation allowes the generation of crack indices to predict hot tear formation, depending on secondary cooling during casting, casting machine maintenance and steel composition

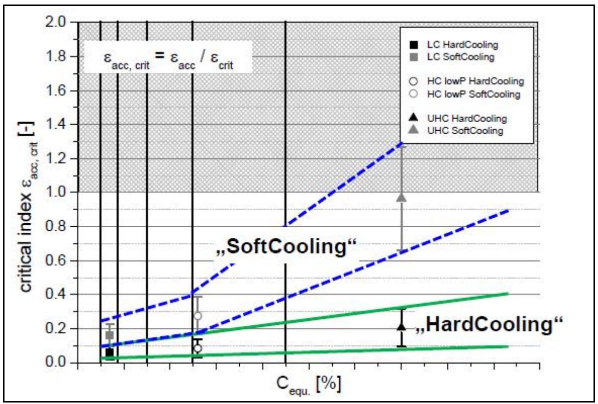

Fig. 1: Crack indices calculated for various steel types

Possibilities to improve the ductility

Mechanisms attributed to surface cracking were investigated at the Technical Universities in Vienna and Graz.

The main focus was to study the influence of the "Surface Structure Control Cooling" (SSCC) heat treatment on the second ductility minimum of micro-alloyed steel. The results of SSCC-tests were compared with a standardized heat treatment approximately reflecting the cooling behaviour of slabs produced by industrial processing. The characteristic of SSCC is a combination of phase transformation austenite=>ferrite followed by a re-transformation ferrite=>austenite carried out by a subsequent reheating sequence. This double phase transformation is known to influence the temperature-dependent ductility behaviour. Several laboratory tests were performed in thermo-mechanical simulators Gleeble 1500 and BETA 250-5. Various steels were isothermally tensile-tested to fracture at different temperatures in order to quantify the influence of chemical composition on ductility behaviour.

It was shown that the SSCC heat treatment results in a broadening of ductility trough at elevated test temperatures. However, the recovering of ductility at test temperatures below the transformation temperature Ar3 is significantly higher compared to the standardized heat treatment. These observations can be attributed to the effects of precipitates: Since the formation of (Nb,Ti)(C,N)-precipitates is highly influenced on cooling rate, SSCC heat treatment promotes the formation of fine dispersed particles inducing the formation of fine-grained ferrite and finally results in a recovery of ductility at lower temperatures. Additionally performed thermo-kinetic simulations are in line with experimental findings enabling the prediction of behaviour of further compositions.

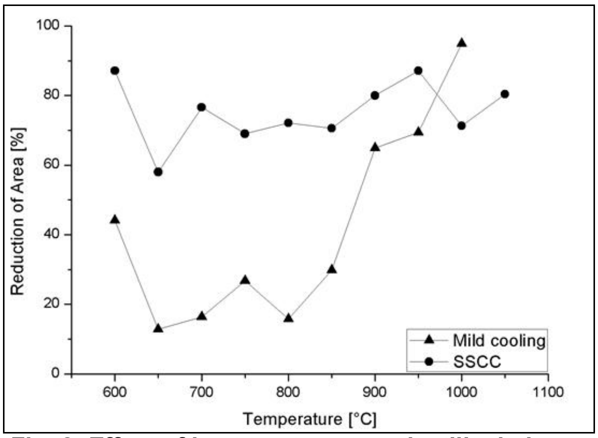

Fig. 2: Effect of heat treatment on ductility behaviour

Contact and information

K1-MET GmbH

voestalpine Straße 14
+43 (0) 732 6989 - 0
office@k1-met.com

Project coordinator
Sergiu Ilie T:

Project partners

Organisation	Country
voestalpine Stahl GmgH	Austria
voestalpine Stahl Donawitz	Austria
Montanuniversitaet Leoben	Austria
Technical University Vienna	Austria
Technical University Graz	Austria