Intercritical annealing optimisation in a segregation neutralised dual-phase steel, benchmarked against a commercial DP800

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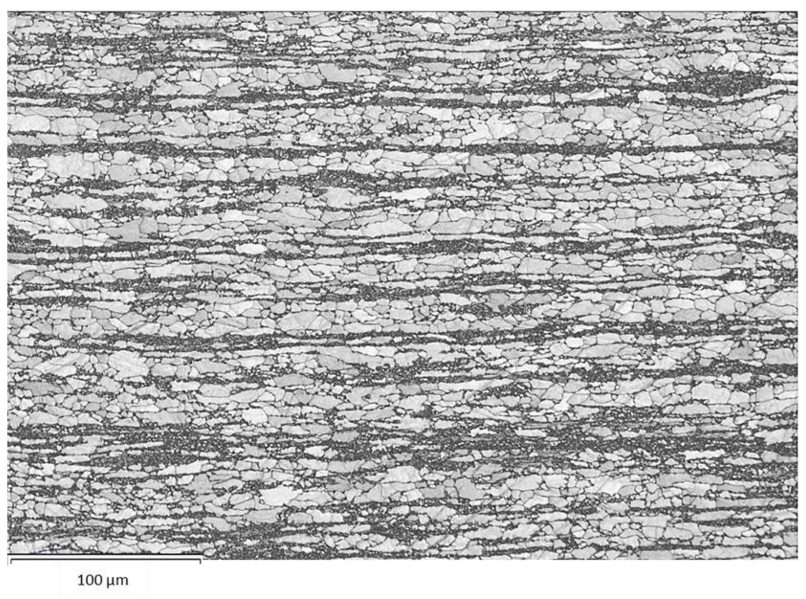
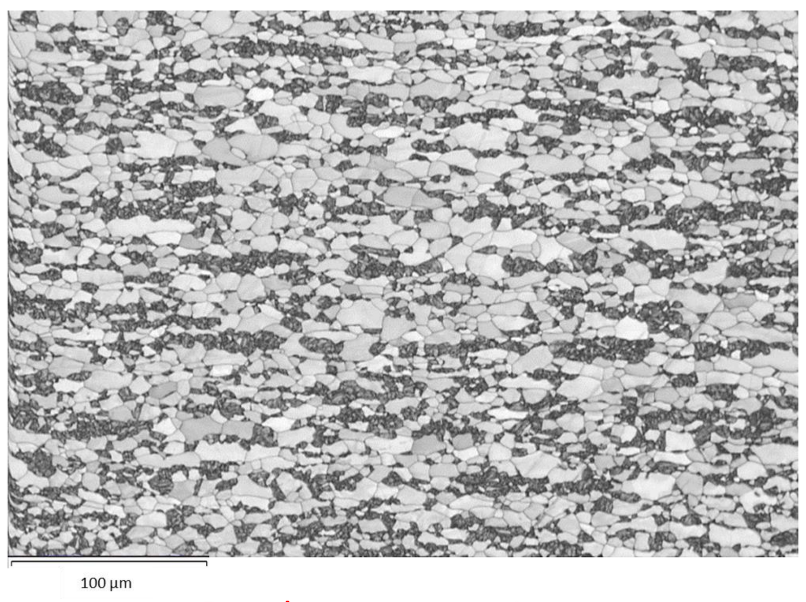
Introduction

What is segregation neutralised dual-phase steel?

- Dual phase (DP) steels, used in the automotive industry, are typified by their ferrite and so-called banded martensite.
- Banded morphology of martensite results in anisotropy of tensile properties and reduced ductility.
- The concept of changing the morphology of martensite from banded to random was used to improve the mechanical properties in DP steels.

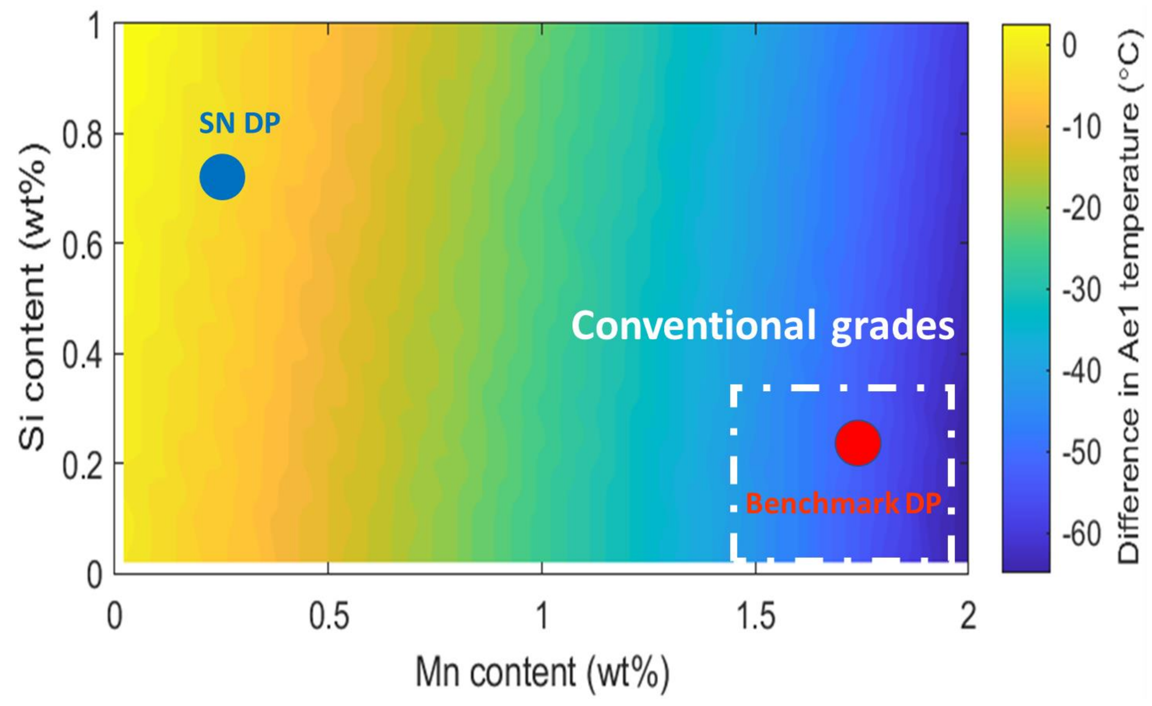


Banded martensite



Random martensite

- Band morphology of martensite is due to the micro-segregation of Mn during solidification and subsequent rolling.
- Mn as an austenite stabilising element decreases the Ae_1 temperature in the segregated regions, therefore these regions become martensite.
- To randomise the morphology of martensite, the idea of balancing Mn with Si (ferrite stabilising element) in the micro-segregated regions was employed to introduce a "Segregation neutralised (SN)" DP steel grade.

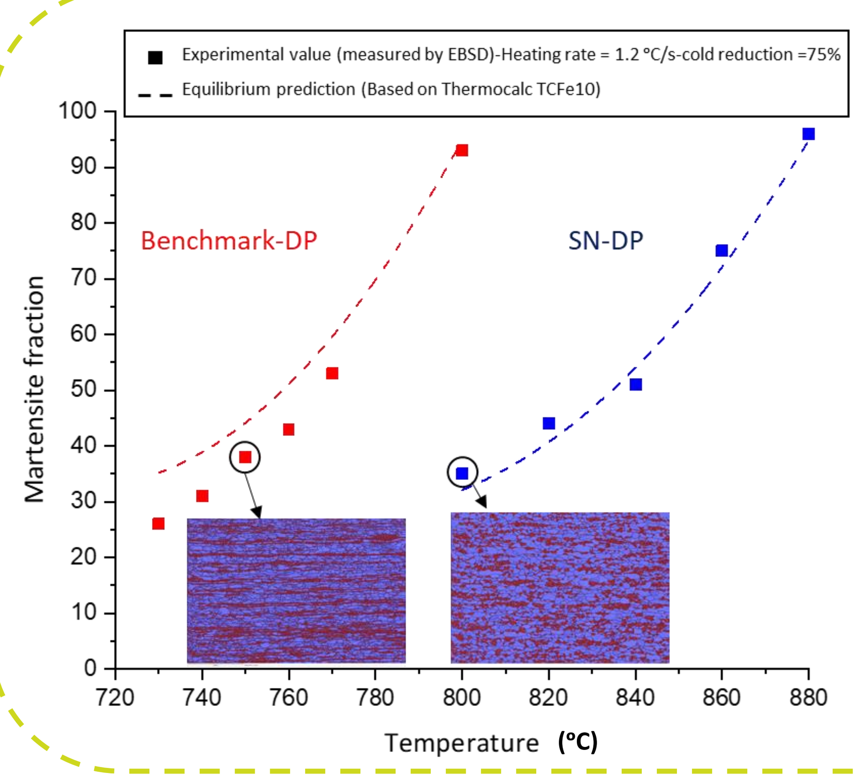


The effect of Mn and Si content on difference in Ae_1 temperature in the segregated and non-segregated regions

Intercritical annealing design

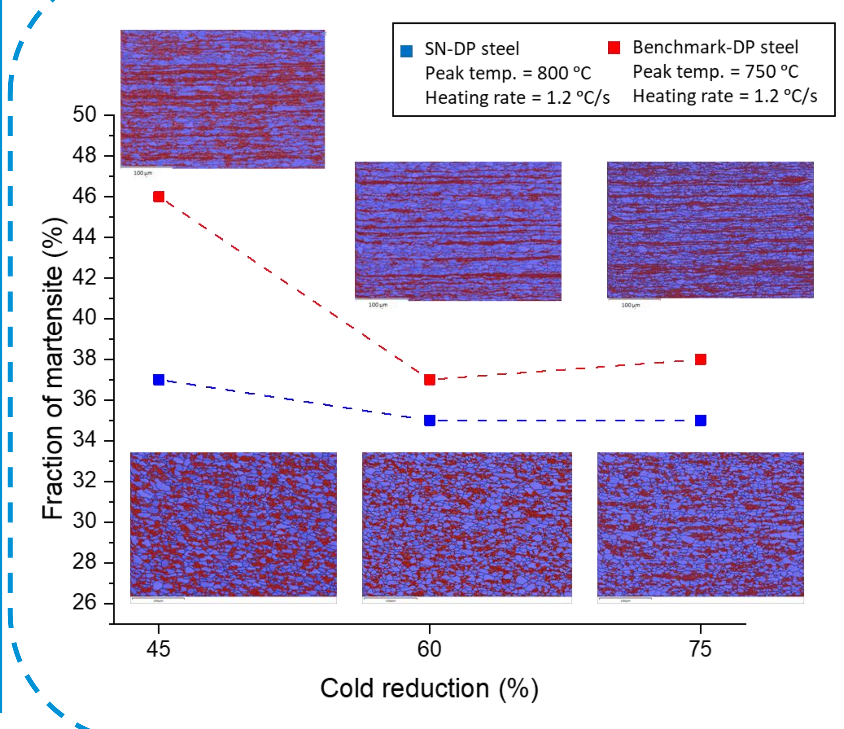
To achieve the required microstructure, cold rolling and annealing parameters should be optimised

Peak temperature



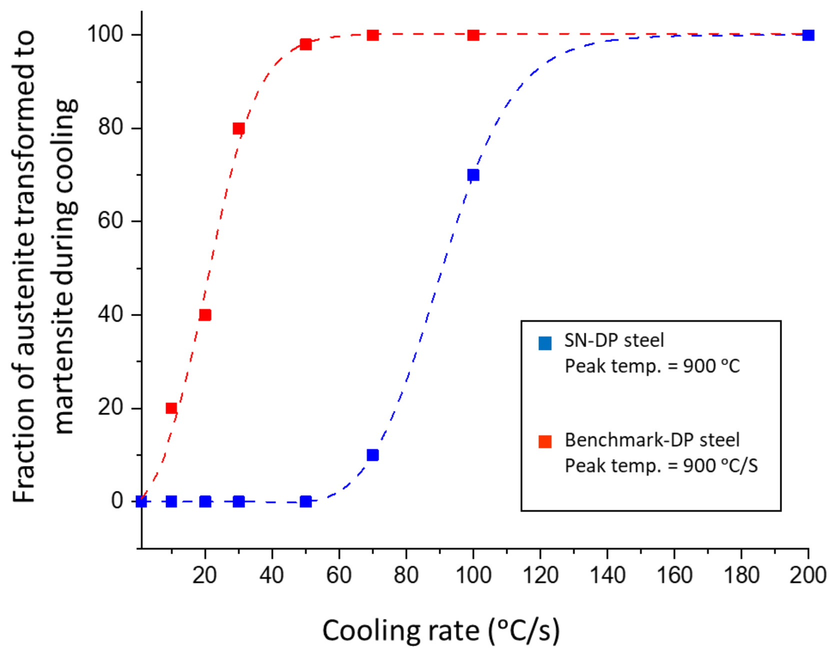
Temperature range for austenitisation is higher in SN-DP compared to Benchmark-DP

Cold roll reduction



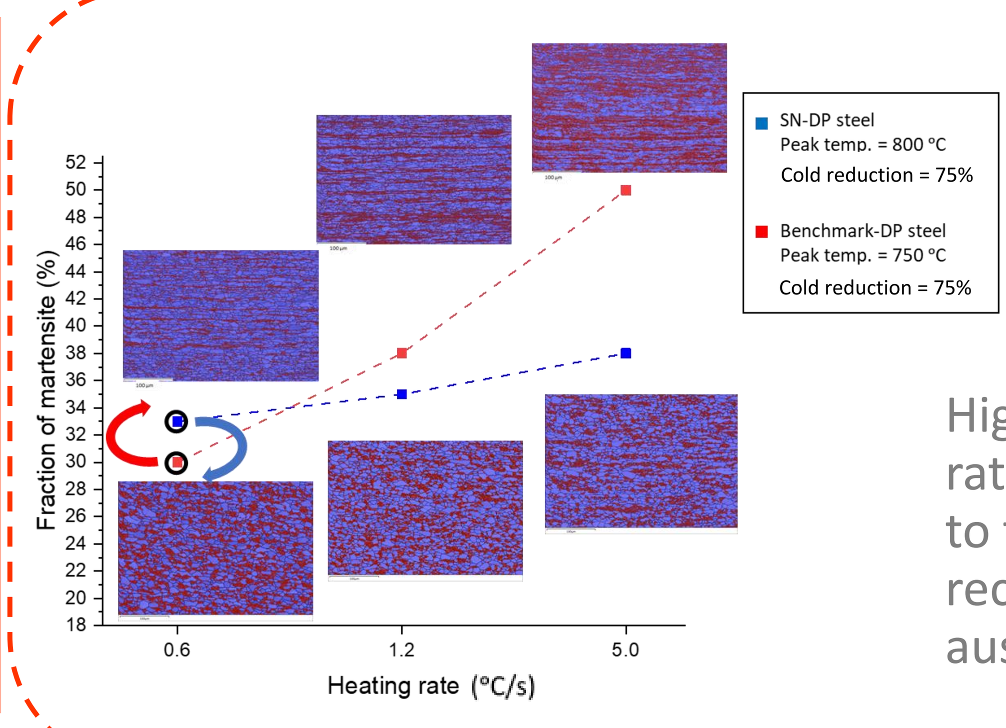
Higher sensitivity to cold reduction in Benchmark-DP due to the higher overlap between recrystallisation and austenitisation

Cooling rate



Higher cooling rate is needed for SN-DP to achieve a ferritic-martensitic DP microstructure

Heating rate

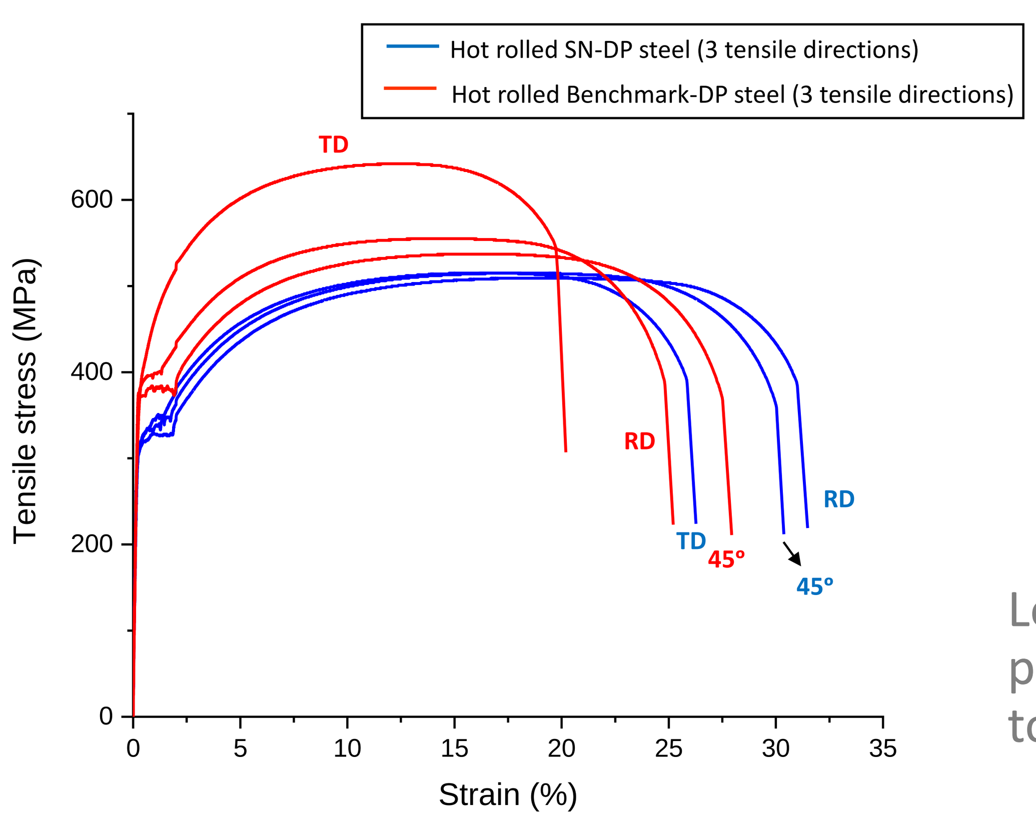


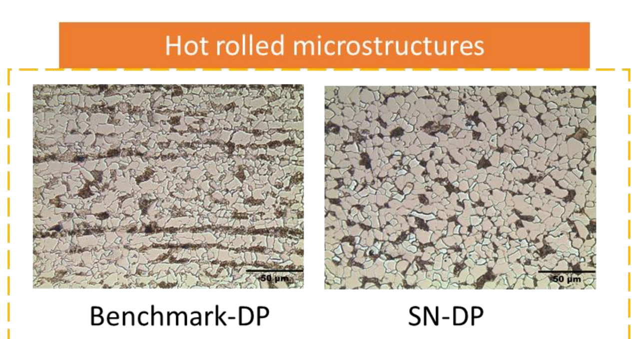
Higher sensitivity to heating rate in Benchmark-DP due to the lower fraction of recrystallised ferrite before austenitisation

Tensile properties

Desired mechanical properties are uniformity in straining with respect to tensile orientations and high elongation

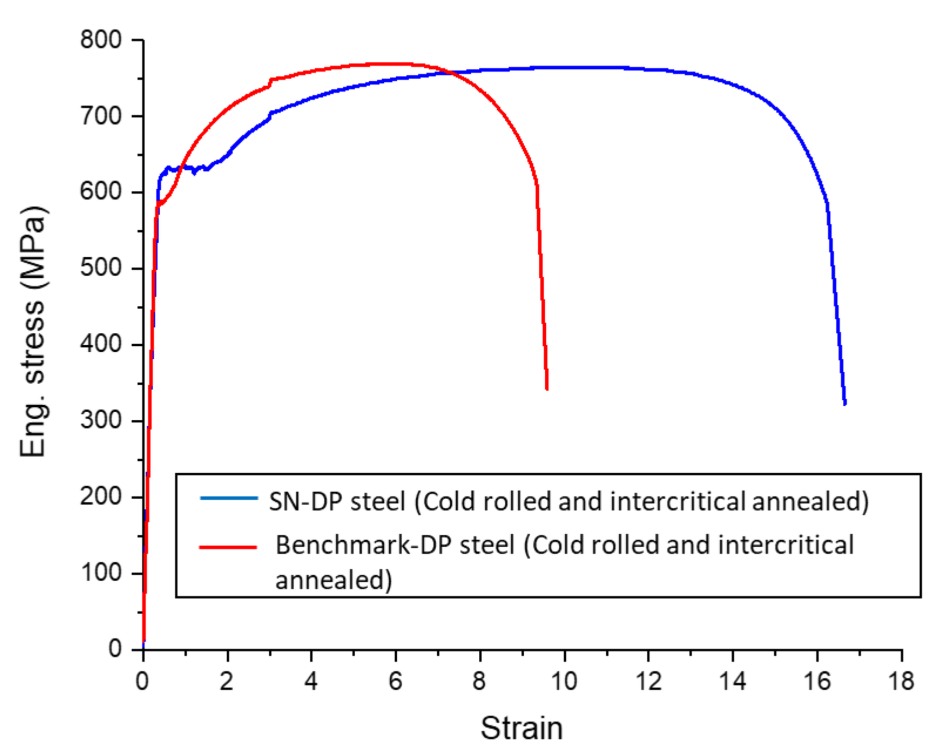
Hot rolled condition





Lower anisotropy in tensile properties of hot rolled SN-DP due to random morphology of pearlite

Final condition



Higher ductility in SN-DP steel for an equivalent strength

Conclusion

Although the tensile properties show significant improvement of SN-DP in the uniformity and ductility, a high cooling rate is needed to achieve martensite, therefore further work will be composition design to maintain the uniformity/ductility but get improved hardenability.