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PROPERTIES OF LOW CARBON HIGH MANGANESE STEEL AFTER COLD ROLLING AND ANNEALING

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ABSTRACT

Twinning Induced Plasticity steel, or TWIP steel, has had increased interest in recent years from various industry sectors. This is due to it being light weight, strong, and ductile; which are all properties that are useful in the automotive and aerospace industries. These steels potentially can offer lighter weight vehicles and parts with increased strength and other mechanical properties. This combination could offer greater fuel efficiency and performance while at the same time improving the safety features of the vehicle. This paper deals with the description of the behaviour of high manganese steel after cold rolling and subsequent annealing. Impacts on microstructure, phase composition, yield strength and tensile strength are described.

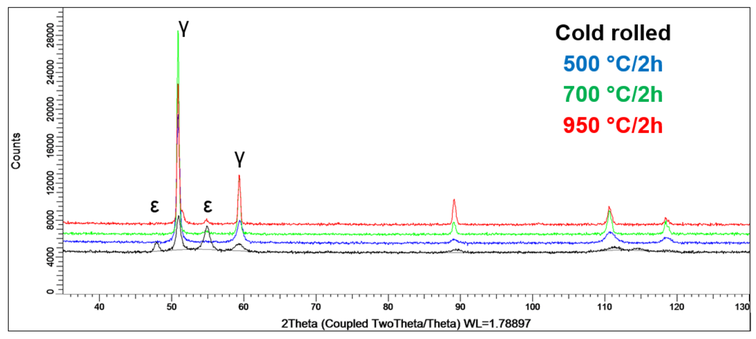
Experimental material

The heat was manufactured in a vacuum induction furnace and cast into a round ingot mould. After cooling, the ingot was reheated in a furnace to the forging temperature of 1100 °C. In a universal hydraulic press, the ingot was then forged into a slab of 280×130 mm cross-section. The slab was then hot-rolled to strip of a final thickness of 4 mm. The rolled strip was annealed at 950 °C for 2 hours. After grinding, the annealed strip was rolled passes to the final thickness of 1.5 mm. The rolled strip was annealed at 950 °C for 2 hours. After grinding, the annealed strip was rolled in six passes to the final thickness of 1.5 mm.

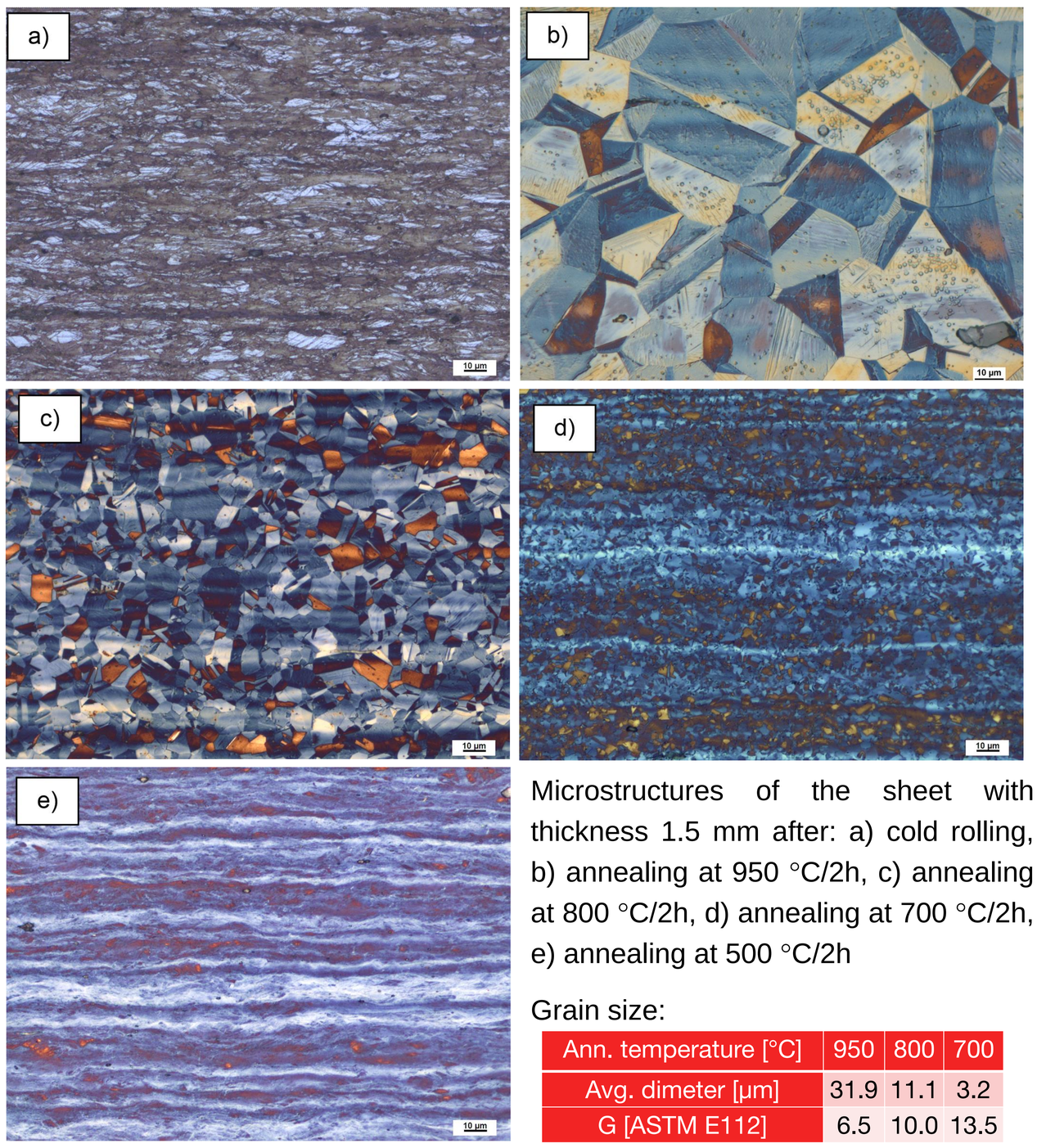
Heat nr.	Element [wt. %]				
	C	Mn	Si	Al	Fe
V16/89	0.12	28.53	1.57	0.78	Bal.

X-RAY DIFFRACTION of phases

Phase [volume %]	Annealing temperature [°C]			
	Cold rolled	950	700	500
γ - austenite	34.8	88.5	95.6	100
ε - martensite	65.2	11.5	4.4	x



MICROSTRUCTURE



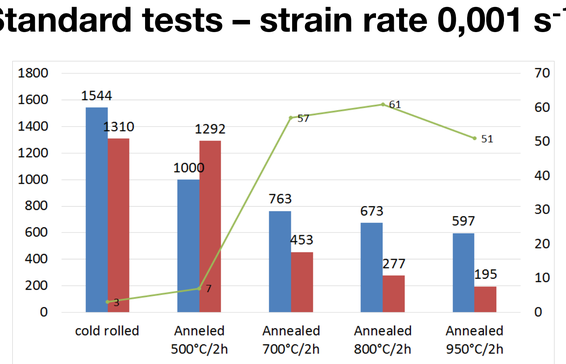
Microstructures of the sheet with thickness 1.5 mm after: a) cold rolling, b) annealing at 950 °C/2h, c) annealing at 800 °C/2h, d) annealing at 700 °C/2h, e) annealing at 500 °C/2h

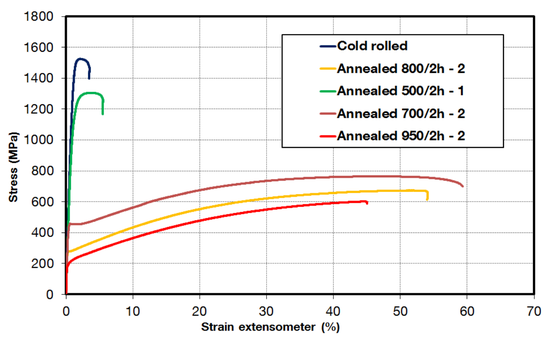
Grain size:

Ann. temperature [°C]	950	800	700
Avg. dimeter [µm]	31.9	11.1	3.2
G [ASTM E112]	6.5	10.0	13.5

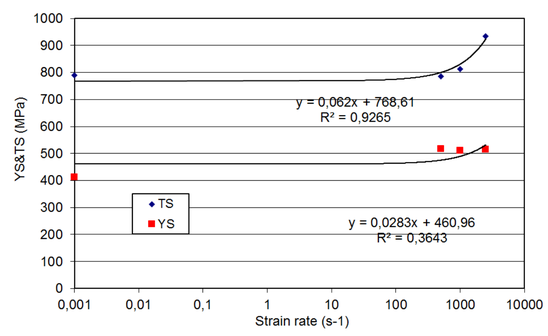
MECHANICAL PROPERTIES

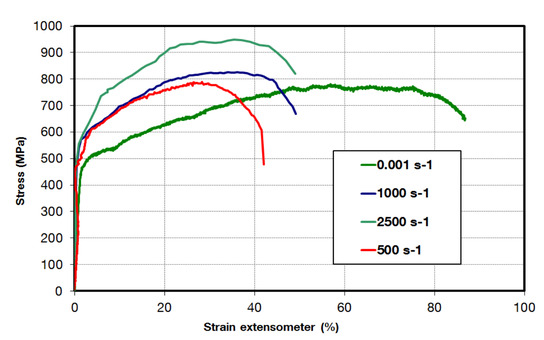
Standard tests – strain rate 0,001 s^{-1}





Dynamic tests – strain rate 500 – 2500 s^{-1}





CONCLUSION

Microstructural and mechanical properties of the experimental heat of low carbon high manganese TWIP steel were studied. This steel shows austenitic microstructure in the annealed condition with the low volume fraction of ε martensite. Annealing of this steel at 700°C for 2 hours (from cold rolled state) leads to very good combination of mechanical properties with 760 MPa of TS, 453 MPa of YS and 57 % of uniform elongation. This state shows very fine grained microstructure with grain diameter below 3.3 µm (Grain size = 13.5 according to ASTM E112). The high strain rates tests show typical increasing of yield and especially the tensile strength up to 940 MPa at highest strain rate 2500 s^{-1} where the total elongation still reaches a good value of 40 %.

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