INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

TEMPERATURE STABILITY OF CARBIDE-FREE NANOBAINITE WITH RESIDUAL AUSTENITE IN X37CRMOV5-1 STEEL

Szymon MARCINIAK[1a], Wiesław ŚWIĄTNICKI[1b]

[1]*Warsaw University of Technology, Faculty of Materials Science and Engineering,*

[a] szymon.marciniak@nanostal.eu, [b] wieslaw.swiatnicki@nanostal.eu

The aim of this study is study was to determine the temperature stability of a nanocrystalline structure in X37CrMoV5-1 hot-work tool steel. To obtain a nanocrystalline structure steel was subjected to austempering at 300°C, which is slightly higher than martensite start temperature Ms = 293 °C. As a result a carbide–free nanocrystalline bainite with residual austenite was obtained. The temperature stability of nanobainite was investigated during annealing in a range of temperatures between 400 and 600°C by use of dilatometric measurements. The transmission electron microscopy (TEM) observations and hardness tests were used to reveal the changes in the microstructure after annealing.

Chemical composition of X37CrMoV5-1 hot-work tool steel

	C [%]	Si [%]	Mn [%]	Cr [%]	Mo [%]	V [%]
X37CrMoV5-1	0.37	1.01	0.38	4.91	1.2	0.34

HEAT TREATMENT

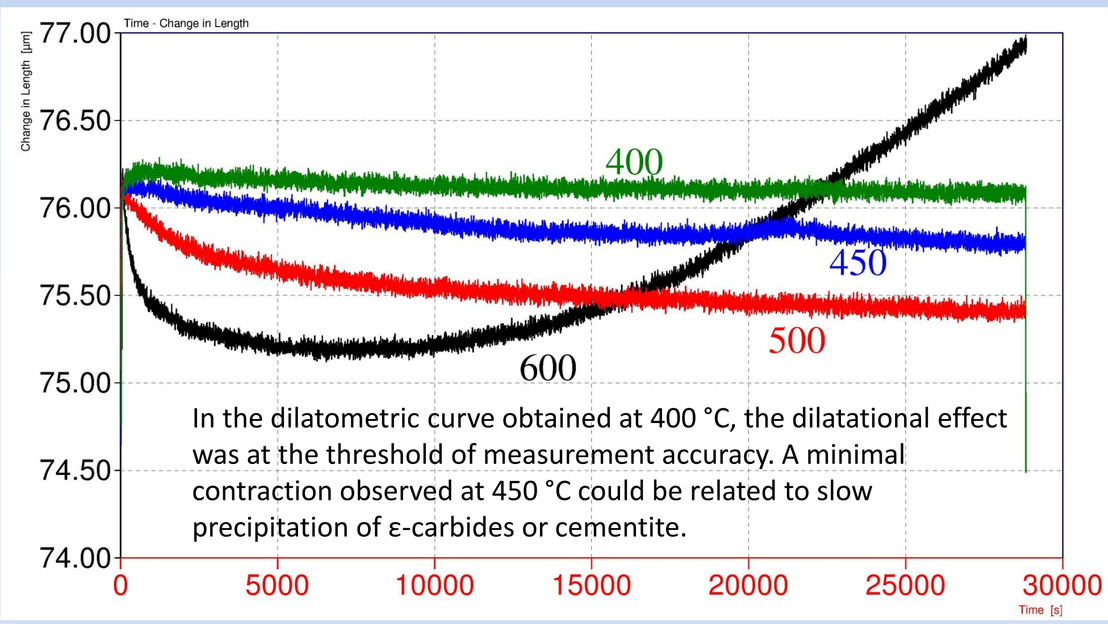
- Nanostructuring treatment: austempering at 300°C for 19 h. in liquid Sn

EXPERIMENTAL METHODS

- dilatometric measurements: quenching dilatometer Bähr DIL 805L
- hardness tests: Vickers method with a 2 kg load

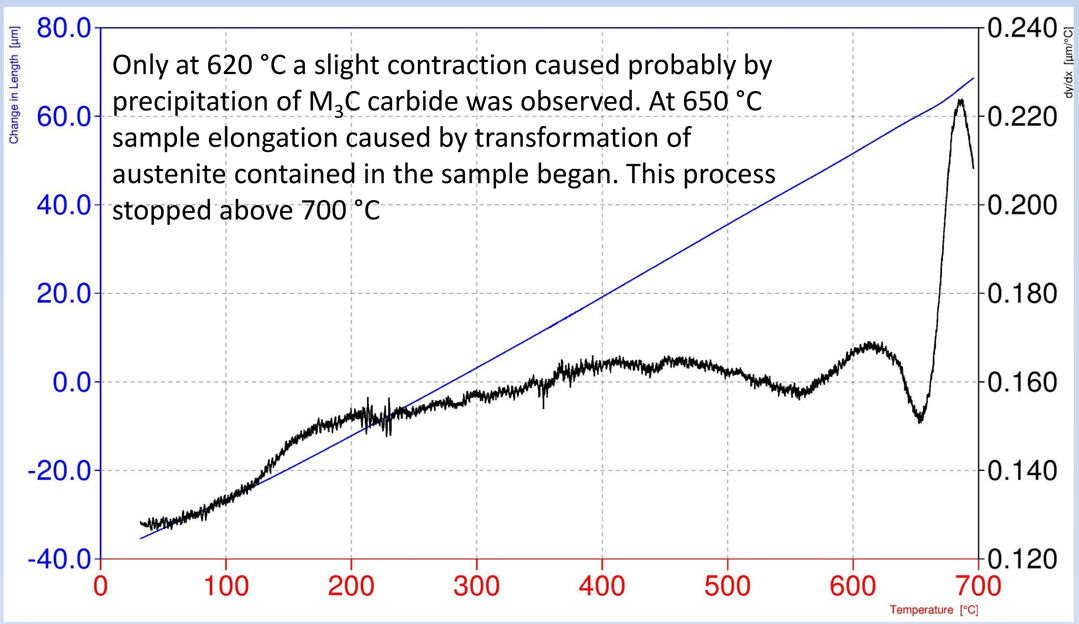
Mixture of carbide-free bainite and untransformed austenite in X37CrMoV5-1 steel after austempering at 300°C for 19 h. (*TEM micrograph - E. Skołek*)

Isothermal annealing

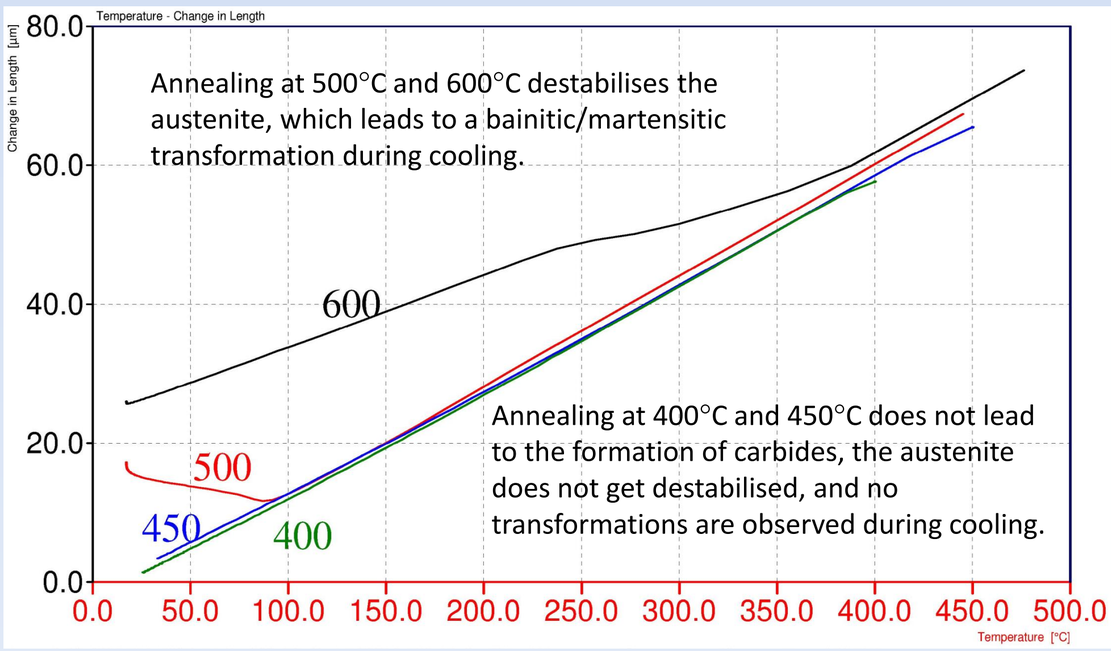


Dilatometric plot presenting a comparison of sample length changes during 8-hour isothermal annealing at various temperatures.

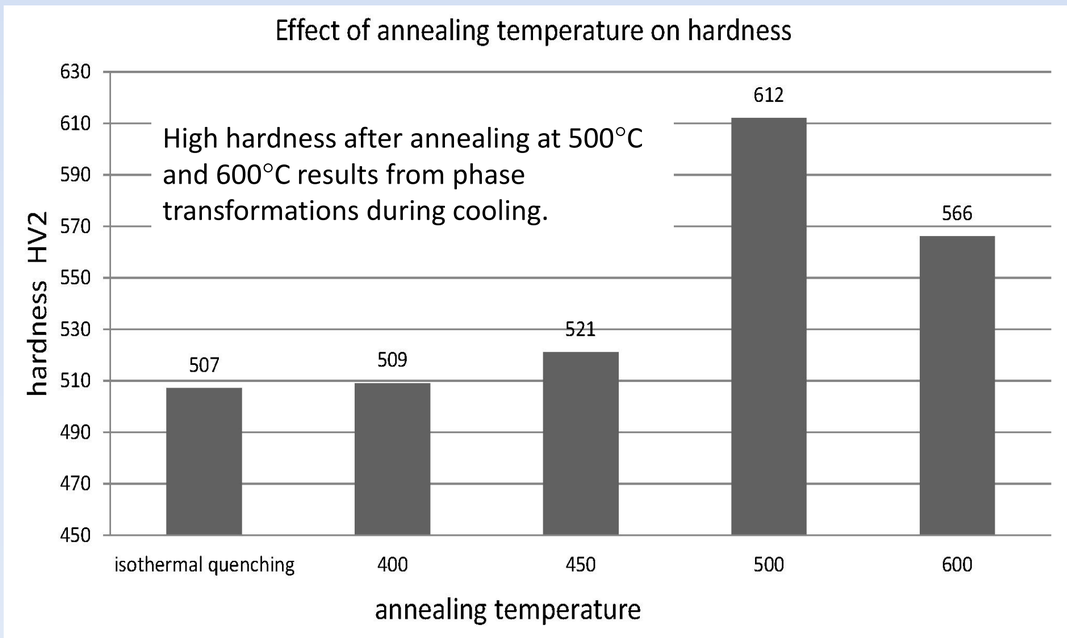
Continuous heating



Dilatometric plot with the differential curve presenting transformations that occur during continuous heating.



Dilatometric plot recorded during sample cooling after 8-hour isothermal annealing at various temperatures



Sample hardness relative to the temperature of 8-hour isothermal annealing

SUMMARY

- The structure of X37CrMoV5-1 steel subjected to isothermal quenching is stable up to 400 °C. Eight-hour annealing at 400 °C did not affect the hardness of the studied steel and caused small dilatometric effects only in its initial phase.
- During annealing at 400 °C the phenomenon of secondary hardness related to precipitation of carbides from carbon-supersaturated austenite was observed.
- At temperatures higher than 500 °C a decrease of the stability of residual austenite was observed. This results in a martensitic transformation during cooling to room temperature. The martensite formed significantly increases the steel's hardness but can have a negative influence on its plasticity and cracking resistance.
- The observed effects of residual austenite destabilisation and of secondary hardness, after they have been thoroughly studied, could find a use in modelling phase composition and properties of steels with a structure of carbide-free nanobainite.

NanoStal

ACKNOWLEDGEMENTS

The results presented in this paper have been obtained within the project "Production of nanocrystalline steels using phase transformations" – NANOSTAL (contract no. POIG 01.01.02-14-100/09 with the Polish Ministry of Science and Higher Education). The project is co-financed by the European Union from the European Regional Development Fund within Operational Programme Innovative Economy 2007-2013.