Editorial

Thomas Lübben and Hans-Werner Zoch

IWT – Stiftung Institut für Werkstofftechnik,
Badgasteiner Straße 3, D-28359 Bremen, Germany
E-mail: luebben@iwt-bremen.de
E-mail: zoch@iwt-bremen.de

Janez Grum*

Faculty of Mechanical Engineering,
Aškerčeva 6, 1000 Ljubljana, Slovenia
E-mail: janez.grum@fs.uni-lj.si
*Corresponding author

Biographical notes: Hans-Werner Zoch is a Professor of Materials Science at the University Bremen, Managing Director of Foundation Institute of Materials Science, Coordinator of the Collaborative Research Center (CRC) 570 'Distortion Engineering' and Chairman of the 'International Conference on Distortion Engineering – IDE'. He is currently the President of the International Federation of Heat Treatment and Surface Engineering and member of the board of AWT, the German Association of Heat Treatment and Materials.

Thomas Lübben studied Physics at the University of Bremen. Since 1986 he has been working as a Scientist at the Foundation Institute of Materials Science Bremen, Department of Heat Treatment, as Manager of the work group Quenching and Simulation, and since 2001 as Managing Director of the CRC 570 'Distortion Engineering'.

Janez Grum is a Professor of Materials Science at the Faculty of Mechanical Engineering, University of Ljubljana, Slovenia. He is also the Founder and Editor-in-Chief of a new journal, the *International Journal of Microstructure and Materials Properties (IJMMP)*. He is the Editor of six NDT conference proceedings, five ASM, Marcel Dekker and Taylor&Francis book chapters and five books with several reprints. He has also published more than 200 refereed journal papers on heat treatment and surface engineering, laser materials processing and materials testing, including non-destructive testing.

Heat treatment aims at establishing a microstructure within a component that is able to withstand any loading conditions that arise from the function of the component. Since each microstructure has a specific volume it follows that heat treatment inevitably causes distortion, which does not need to be homogeneous in anisotropic initial microstructures. During heating, residual stresses existing in a component are released, most often followed by deformation. Inhomogeneous quenching conditions e.g., lead to temperature gradients in the part, which may create plastic deformation by reaching yield strength at temperature and/or volume increase by microstructural transformation. Distortion after heat treatment is thus dependent on all production steps, including the forming,

pre-heat-treatment, and machining operations. Therefore, distortion only can be controlled by optimising the entire manufacturing chain.

Microstructures far from equilibrium always have the highest strength. Therefore, an important step in the process of establishing the microstructure in steels is always cooling or quenching from austenitising temperature. Together with the material, the quenching characteristics determine the extent to which those quenched microstructures are attained. Each change in microstructure – the desired aim of every heat treatment – leads to a change in volume. Rapid temperature changes also generate temperature gradients leading to transformation stresses. Volume changes and thermal and transformation stresses determine distortion and plastic strains caused by heat treatment. The quenching characteristic is a crucial factor in the control of microstructure and distortion, which is the focus of extensive global research.

One should be aware that every material treatment produces certain residual-stress variations and that every machining process will also change residual-stress variations. Controlling volume changes and distortion of machine components as well as the knowledge of residual stresses in them are becoming increasingly important in practical applications to high-tech product's, particularly from the viewpoint of more adequate operating conditions and for economical reasons. The beginning of dealing with the organised treatment of distortion of machine components in steel quenching was the Thematic Conference in Chicago (1992) entitled 'Quenching and control of distortion' under the auspices of the American Society for Metals and organised by Prof. G.E. Totten. He further organised three more thematic conferences on 'Quenching and control of distortion' in Cleveland (1996), Prague (1999), and Beijing (2003).

Aiming at the quality control of the manufacturing of machine components the CRC distortion engineering was founded at the University of Bremen, Germany in 2001, with support of the 'Deutsche forschungsgemeinschaft' (DFG), which included a new integral approach to product quality. As a new scientific field the project was named Distortion Engineering (2001). It has been directing research to a reduction of distortion and, consequently, cost-effective manufacture of components.

The term distortion engineering today encompasses all the measures taken to control distortion, stretching from the production of the material, the optimisation of the production steps and heat treatment to the tailor-made use of distortion potentials.

The results of relevant studies on product quality control were presented at the 1st and 2nd International Conference on Distortion Engineering (IDE) in Bremen (2005 and 2008) and at the 5th International Conference on Quenching and Distortion and the European Conference on Heat Treatment in Berlin 2007, which was organised by Prof. J. Grosch, Dr. J. Kleff, Prof. H-W. Zoch and Dr. T. Lübben under the auspices of numerous domestic and international associations in the field of materials, heat treatment and surface engineering.

From the last Bremen Conference on Distortion Engineering 14 papers have been selected. They were reviewed for publication in *Int. Journal of Microstructure and Material Properties* and are presented in this double issue. They are from four fields of research:

- modelling of distortion related phenomena
- heat treatment simulation

- distortion after welding
- residual stresses and distortion in high strength aluminium alloys.

For the understanding of distortion generation and for the target-oriented application of compensation potentials heat treatment simulation is an essential tool. But the interacting mechanisms during a heat treatment process are very complex. Therefore, a lot of work concerning modelling of the corresponding effects is necessary. Especially transformation plasticity was identified as one of the most important effects for the generation of distortion especially for processes with smaller biot-number. All together eight papers dealing with this subjects were selected.

They cover the following topics:

- mechanism of transformation plasticity and unified constitutive equation
- effect of plasticity on isothermal bainitic kinetics
- effects of the austenite grain size on transformation plasticity
- effect of the random spatial distribution of nuclei on the transformation plasticity
- modelling of transformation plasticity supported by dilatometric data
- modelling of solid-state phase transformations during casting
- simulation tool for prediction residual stresses and distortion in nitrided parts
- simulation of heat treatment in general.

Another important topic of IDE 2008 was the distortion after welding processes. From this field of research three papers were chosen dealing with the following topics:

- numerical simulation and distortion optimisation of welded parts
- advanced numerical method for fast prediction of welding distortions
- influences of welding parameters on distortion.

Finally, results of the European-funded collaborative project concurrent approach to manufacturing induced part distortion in aerospace components (COMPACT) were selected. The corresponding three papers are covering the following topics:

- residual stress and part distortion in the civil airframe industry
- multi-disciplinary engineering as an integrated approach to part distortion engineering
- investigation of residual stress fields after shot peening of aluminium alloy surfaces.

We sincerely hope that the papers presented on ‘distortion engineering’ will be a valuable source of information to readers and engineers in their professional activities.

Special thanks are due to the authors contributing their papers to this special issue of the *IJMMP*. They are the results of the very critical work of reviewers and the authors. It can be said that the papers satisfy high standards quality.

Special thank goes to Dr. Thomas Lübben and Prof. Dr.-Ing. Hans-Werner Zoch from IWT – Stiftung Institut für Werkstofftechnik from Bremen who helped me to select the papers presented in the present special issue.