Editorial

George Totten

Department of Mechanical and Materials Engineering,
Portland State University,
P.O. Box 751, Portland, OR 97207, USA
Email: GETotten@gmail.com

Thomas Lübben

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

Imre Felde

John von Neumann Faculty of Informatics,
Obuda University,
Bécsi way 96/b, Budapest, 1034, Hungary
Email: felde.imre@nik.uni-obuda.hu

Janez Grum

Faculty of Mechanical Engineering,
University of Ljubljana,
Aškerčeva 6, 1000 Ljubljana
Email: janez.grum@fs.uni-lj.si

Biographical notes: George Totten received his BS and MS from Fairleigh Dickinson University in New Jersey and his PhD from New York University, USA. He is a Fellow of ASM International, SAE, ASTM and IFHTS. He has co-authored approximately 30 books and over 500 patents and publication on various aspects of heat treatment, quenching, hydraulic, lubrication and tribology. He is a former President of the International Federation of Heat Treatment and Surface Engineering (IFHTSE). Currently, he is a Research Professor at Portland State University in Portland, Oregon, USA.

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'.

Imre Felde received his BS from Bánki Donát Polytechnic and MS from Eötvös Lóránd University of Sciences in Budapest, and his PhD from Miskolc University. He currently works as Vice-Dean at Faculty of Informatics, Obuda University. He has published and co-authored more than 80 papers on various aspects of heat treatment, laser cladding, modelling of phase transformation, numerical simulation of laser material processing and quenching.

Janez Grum is a Professor of Materials Science at the Faculty of Mechanical Engineering, University of Ljubljana, Slovenia. He is Founder and Editor-in-Chief of *International Journal of Microstructure and Materials Properties*. He is a Member of several international journal editor board members, editor of six NDT Conference Proceedings, 14 ASM Marcel Dekker, CRC Press: Taylor & Francis, Kluwer Academic Publishers and Springer book chapters and seven books with several reprints. He has also published more than 230 refereed journal papers and than 400 conference papers.

Machine elements are made of different materials, sometimes only mechanically processed and often also heat-treated. Initially, the material can be cast or kneaded. Components are often made using other manufacturing processes such as welding, too. In every initial material or blank, there is a certain field of residual stresses, their magnitude depending on the pre-treatments used. Every casting, regardless of the casting process used, has certain residual stresses, which depend on the alloy's chemical composition, conditions of casting and conditions of cooling. The magnitude and distribution of residual stresses is modified by subsequent mechanical or heat treatments. Turning always produces tensile residual stresses in the surface layer. The origin and distribution of residual stresses always depends on the material type, conditions of turning and state of the cutting tool. Surface hardening of machine elements always yields compressive residual stresses. For machine elements, we must consider the magnitude and distribution of residual stresses in the surface layer, where the stresses are always the greatest in a component under load. The technology must be selected so as to ensure maximum compressive residual stresses in the surface layer. Compressive stresses on the surface/in the surface layer prohibit both the growth of existing cracks and new cracks from forming.

In heat treatments such as hardening, the initial austenitic microstructure is transformed into a martensitic structure by quenching at a supercritical rate. The heat-treatment conditions depend on the material type, machine element's mass and shape, as well as on the quenching medium, which must ensure the critical rate of cooling for a given mass. The shape of machine elements often causes non-homogeneous quenching conditions, leading to distortions. If the quenching process is not planned adequately, it may lead to internal stresses in the machine elements that exceed the yield stress at a given temperature, causing distortions and the presence of residual stresses. The machine element may even break if the internal stresses during the cooling are greater than the material's strength. Furthermore, in heat treatments such as hardening, the complex shape of machine elements often causes temperature differences in cooling, additionally influencing the magnitude and distribution of internal stresses.

Internal stresses in a machine element may come into existence, e.g., due to volume changes during cooling, microstructural transformations or temperature differences. When the machine elements get distorted, the bent parts have to be mechanically straightened after hardening on presses. A common alternative is to design the machine element with an excess of material, which is then removed mechanically after the heat-treatment in order to achieve the right dimensions. However, this option brings additional costs of correcting the distorted machine element to the right dimensions by grinding.

The impact of distortion on mechanical parts, resulting from heat treatment, was demonstrated through an ongoing research on size changes, internal and residual stresses, and distortion. The most important guidelines and information are elaborated in the book by Bernard S. Lement, "Distortion in Tool Steels", which was published with the American Society for Metals in 1959. About 180 pages of the book deal with individual tool steel type groups. The significance of this data on volume changes and distortion is evident: correct construction and optimal heat treatment can help improve product quality.

Only a few years later, Karl-Erik Thelning, Swedish engineer and consultant with A.B. Bofors, wrote a book titled "Steel and its Heat-Treatment-Bofors Handbook", supported by A.B. Bofors and the Swedish Institute for Metals Research, and published in 1967 in Swedish. Due to the big response, it was translated into English in 1978 and published with Butterworths Publication. Over 100 pages of the seventh chapter on the "Dimensional changes during hardening and tempering" are dedicated to the influence of various heat-treatment methods and conditions on volume changes and distortion. A substantial part of this section delves into size changes of tool steels and sprockets.

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 products, 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 Professor 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 by Professor P. Mayr and followed by Professor H.W. Zoch 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 and last 5th Bremen Conference on Distortion Engineering (2015).

This issue contains the following papers:

- Relationship between the quench delay time and tensile properties for various section thicknesses of AA 7075 Al alloy
- Influence of cooling medium and cooling conditions on hardness and distortions after steel quenching
- Investigation of the effects of transverse inertia on SHPB experiments
- Heat transfer and quench performance of aqueous CuO nanofluids during immersion quenching
- Performance assessment of vegetable oil and mineral oil blends during heat treatment of medium carbon steel
- Inverse quench-hardening phenomena in steels and their origin
- Determination of heat transfer coefficients for complex spray cooling arrangements
- Sound emission phenomena analysis at boundary layer during steel quenching
- Flow conditioning in heat treatment gas quenching
- Liquid quenchant database: determination of heat transfer coefficient during quenching
- Estimation of temporospatial boundary conditions using a particle swarm optimisation technique
- Different ways of monitoring the main quenching parameters will ensure the quality of heat treatment process.

We sincerely hope that the papers presented on “Quenching and control of distortion” 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 a result of very critical work of reviewers and the authors.