Editorial

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Biographical notes: 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 the *International Journal of Microstructure and Materials Properties* (IJMMP) and has been the Editor of the *Journal News of Society for Nondestructive Testing* by the Slovenian Society for Non-Destructive Testing, Ljubljana, Slovenia since 1994. He is also a member of the editorial board of several international journals. He is the Editor of six NDT conference proceedings, two ASM and Marcel Dekker book chapters and five books with several reprints. He has also published more than 200 refereed journal papers and more than 400 conference papers on heat treatment and surface engineering, laser materials processing and materials testing, including nondestructive testing.

The processes of steel heat treatment are closely related to the heating and overheating of different sizes and shapes of machine parts to an adequate temperature, which are then followed by quenching in a suitable quenching agent. With the heat-treatment processes applied to machine parts, engineers will often encounter numerous difficulties, which most often consist of volume changes of parts, their distortion and the presence of residual stresses. It is very important to know the volume changes of machine parts in the course of a heat treatment. If a part exceeds the right size, additional or final grinding to size will be needed. Even greater difficulties are encountered due to nonuniform cooling, *i.e.*, quenching, of the machine part and/or cooling of a machine part having an asymmetric shape since, in addition to volume changes, minor distortions will occur after heat treatment. Such minor distortions often require preliminary straightening of machine parts, which is followed by frequently exacting and time-consuming grinding.

In all the cases where, after heat treatment, not only volume changes but also distortion occurs, there are residual stresses in the machine part. The residual stresses due to thermal and thermochemical treatments of the machine part occur because of nonuniform microstructural changes across the entire cross-section. The residual stresses in the surface layer, if they are of a compressive character, are advantageous since they prevent the occurrence of new cracks and the possible propagation of the existing ones.

The results of heat treatment and surface engineering are most often presented as a microstructure analysis supported by a microchemical analysis. Both types of analysis are a basis for:

- understanding the volume changes of a machine part and possible distortion
- knowledge of the size and variation of hardness and residual stresses in the surface layer
- knowledge of the occurrence of cracks in the machine part after heat treatment.

The volume changes after heat treatment can be expected and can therefore be taken into account in the production of the machine part, so that the machine part concerned will be produced in the size that will provide, after heat treatment, the right size and no distortion.

The first three papers have been edited by Dr. Thomas Lübben from the Institute of Materials Science, Bremen. The papers deal with a change in size of the specimens after quenching of different steels on the basis of experiments and appropriate modelling. Gas quenching was carried out with a tool having decreased nozzles, a regulation of mass flow rate and a constant gas flow rate, which provided different cooling conditions.

The first paper, 'Validating the modelling of a gas-jet quenched carburised gear', discusses Computational Fluid Dynamics (CFD) modelling of cooling using nitrogen jets. It shows that an optimised array of high-velocity gas jets close to the material's surface could cool the part at a similar cooling rate to oil. When these optimised conditions were applied to an idealised gear form, the model suggested that it could be fully hardened if a nitrogen/hydrogen mixture was used. Physical experiments under exactly the same conditions were carried out to try to validate the model.

The second paper, 'Explanation of the origin of quench distortion and residual stress in specimens using computer simulation', discusses the measurement and modelling of distortion and internal residual stresses after quenching in specimens, *e.g.*, cylinders, disks and rings, have been performed for many years. As a result, patterns of distortion and stress distribution were identified in the typical shapes, steels and cooling conditions.

The third paper, 'Modelling phase transformations and material properties critical to the prediction of distortion during the heat treatment of steels', describes the recent development of models in the computer software JMatPro for the calculation of phase transformations and material properties critical to the prediction of distortion during heat treatment of steels. The success of these models is based on the accurate description of all the major phase transformations taking place, including the formation of ferrite, pearlite, bainite and martensite, as well as the calculation of the properties of different phases formed during the heat treatment process. One advantage of the current models is that they can be applied to many types of steels, including medium- to high-alloy types.

All the other papers were edited by Professor Dr. Leszek Wojnar from Cracow University of Technology, Poland. The next paper, titled 'The influence of $Mg_{17}Al_{12}$ phase volume fraction on the corrosion behaviour of AZ91 magnesium alloy', discusses the microstructure and the corrosion behaviour of AZ91 magnesium alloy in the as-cast and after heat treatment conditions. The microstructure of the cast alloy consists of an α-Mg phase matrix with a continuous and discontinuous β phase ($Mg_{17}Al_{12}$) at grain boundaries. The β phase dissolved in the matrix and after T5 treatment, discontinuous precipitation of the β phase along the grain boundaries was observed.

The next paper, titled 'Description of the homogeneity of material microstructures: using computer-aided analysis', presented and compared three methods for the quantitative description of particle spatial distribution, namely the linear covariance, radial distribution function and tessellation methods. A microstructure model was analysed using these methods. It was clearly shown that the particle spatial distribution and the quantitative parameters are interrelated.

The presented methods were applied to the quantitative description of the structure of an AlN-TiB_2 composite obtained via self-propagation high-temperature synthesis. Several parameters quantitatively describing the particle spatial distribution in the studied material were determined. The influence of the microstructural parameters on mechanical properties was determined.

The sixth paper, titled 'A 3D image analysis of intermetallic inclusions', presents an original way to study the evaluation of particles in different degrees of material deformation and the evaluation of its orientation. The goal of the study was to use the statistical distribution of parameters to expose the microstructural changes of crystal shapes caused by mechanical loading applied during the hot rolling process.

The next paper, titled 'Application of computer simulation in the stereology of materials', discusses systematic graphical classification and grain size estimation based on the combination of profile and intercept counts with the coefficient of profile area variation, simulation and estimation of double stochastic processes. The paper applies computer simulation to cavity formation under high-temperature creep loading, simulation of the intercrystalline fracture and the stereology of fracture surfaces.

The last paper, 'Impact of materials science and stereology on the design of experiments in concrete technology', studies experimental reliability in concrete technology. Such experiments rely heavily on correct fulfilment of the various sampling principles from stereology and materials science. Random sampling is uneconomical and technically difficult, and hence should be replaced by special sampling. It is indicated how efforts can be minimised. The cases of dispersed fibres and cracks are elaborated, making use of projections and sections.

Special thanks are due to the authors who contributed their papers to this issue of the IJMMP. This issue is also the result of the very critical work of the editors, Dr. Thomas Lübben and Professor Dr. Leszek Wojnar. It can be said that the papers satisfy a high standard of quality.

Our heartfelt thanks are due also to our co-workers, Mr. Franc Ravnik and Ms. Nevenka Majerle, who took care of the coordination among the reviewers and the authors, and prepared the papers for publication.

We sincerely hope that the papers presented on quenching and distortion and on the stereological analysis of microstructure in various applications will be a valuable source of information to researchers in various scientific fields and to practitioners in the field of materials and production.