Application of laser techniques in surface engineering based on the finite element method

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Abstract

Statement of the problem

Surface engineering, in its basic assumptions, assumes the modification of the surface layer of materials by changing their physical properties by changing their structure or chemical composition. Thanks to the possibility of improving the properties of materials only in areas exposed to the greatest forces, it has become common to use materials with worse properties (implicitly more plastic) and therefore cheaper, and to improve their functional properties only in selected areas of the external surface. Initially, the surface engineering methods used were based on burners and furnaces designed to heat the external surfaces of the material and then carry out thermal or thermal-chemical treatment processes. These methods were characterized by low accuracy and uneven temperature distribution throughout the material. Only the invention and development of laser techniques and their application in materials engineering made it possible to obtain a surface layer with uniform properties and precisely determined using the parameters of the laser beam. Accurate determination of the parameters of the laser beam is possible thanks to calculations performed by computers coupled to the laser itself, which allow modification of parameters such as exposure time, beam power and the shape of the incident beam. Despite extensive material knowledge, there are still newer materials that may have properties other than those expected during surface treatment. For this reason, in order to save time and money even more, it has become popular to use computer simulations that determine, based on the parameters of the process, the changes taking place in the material in its during and parameters of the obtained surface layers.

Conclusion

Introduction of laser techniques into surface engineering made it possible to precisely produce surface layers and coatings while eliminating the costs associated with possible cooling of the processed material. With the development of computer techniques, it became possible not only to design the laser surface treatment processes themselves but also to predict the possible values obtained as a result.

Image

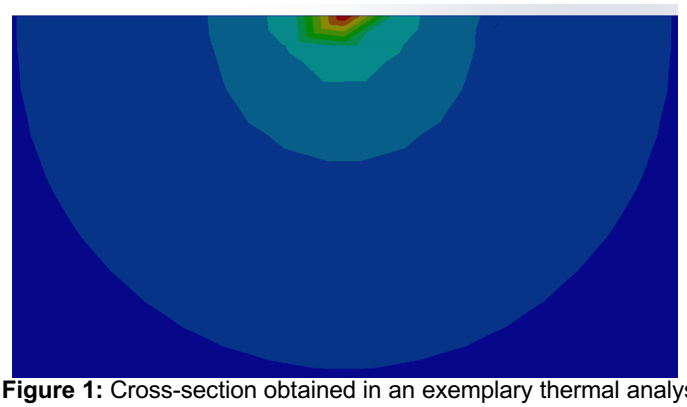

Figure 1: Cross-section obtained in an exemplary thermal analysis of the temperature distribution resulting from the impact of the laser beam on the material surface.

Recent Publications

1. Bonek M, Polishchuk O, Dziwis A (2024) Analysis of temperature distribution depending on the type of welding joint. ISBN 978-80-554-2076-9
2. Lomania Ł, Zach C, Kojm K, Towarnicki D, Trojnar R, Musialik M, Mikołejko W, Śliwa A, Sroka M, Dziwis A (2024) P Numerical analysis of the effect of environment and operating conditions on the performance of electric cables International Students Scientific Conference, 26th January 2024, ISBN 978-83-65138-39-2
3. Bonek M, Dziwis A, Mikołejko W, Śliwa A, Kusy M (2023) Analysis of stress distribution and deformation of a rocker arm in valvetrain of an internal combustion engine 26th International Seminar of Ph.D. Students. ISBN 978-80-554-1947-3
4. Dziwis A (2023) Innovative laser surface treatment applications DOI:10.34918/86320
5. Śliwa A, Mikołejko W, Dziwis A, Bonek M, Tilova E 2023) Static and fatigue numerical analysis of automotive spring ISBN 978-80-554-1947-3

Photograph

Biography

Prof. Mirosław Bonek is a researcher in the Department of Engineering Materials and Biomaterials at the Silesian University of Technology. His scientific area includes the analysis of the influence of laser treatment on the structure and properties of tool steels, corrosion-resistant steels, aluminum alloys and magnesium alloys. He is an author and co-author of ca. 190 scientific publications about description of phenomena related to structural changes, crystallization mechanisms and the impact of these changes on the properties of materials. His Hirsch index is 14. He is laureate of many national and international awards and he is and was a contractor of more than 20 research and didactic projects in Poland and in Slovakia, Ukraine, Turkey, Georgia and others. Hi is vice President of the Association of Alumni of the Silesian University of Technology.

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