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Abstract

Laser polishing and structuring of tooling and functional surfaces

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Abstract:

Since its inception, laser polishing (LP) technology has been receiving an increasing attention as a plausible alternative to the conventional polishing techniques. The main driver behind the development of LP technology resides in the fact that >40% of the tooling cost is associated with high-cost and time-consuming manual polishing. By contrast, LP can significantly reduce these costs by the high level of automation and the precision provided through its coupling with CNC technology. Considering its potential applications in automotive, aerospace and biomedical industries, the Automotive Portfolio of the National Research Council (NRC), Canada has been actively engaged in the development of LP technology. Building on this activity, the main objective of the present report is to introduce some of the achievements and developments of LP technology at NRC over the past five years. This presentation will focus on detail description of the laser-based Â polishing and surface functionalization processes, their advantages and disadvantages with respect to the conventical abrasive polishing techniques, and examples of LP process technical implementations along with examples of LPed parts and functional surfaces, e.g. for controlled wettability, friction, adhesion, drag, and hydro-/aerodynamics. Then common understanding the process physics, process classification and its variants, material and surface characterization, and modeling capability will be presented. In addition, effect of most critical process parameters, laser type and characteristics, laser path trajectory, and process planning methodologies on achieved surface quality and physical-mechanical characteristics, e.g. gloss, micro-hardness, metallographic structures, corrosion resistance and others. Along these lines, a statistical digital twin of the laser micro-polishing process will be introduced as a thermodynamic transfer function with associated thermophysical model of the rapid melting-solidification of H13 tool steel as induced by continuous wave laser irradiation. In addition, the multi-process laser melting-based processing system will be analyzed from the perspective of Industry 4.0 integration. This avenue will be explored to better understand the possibility to couple the statistical digital twin of the LP process with the existing built-in sensing capabilities of the laser processing system (e.g. high-speed thermographic imaging), an effort regarded as the stepping stone towards the future additions of artificial intelligence, machine learning, multi-objective optimization, predictive control, and other aspects of smart manufacturing. Special attention will be placed on technical applications of the LP process in manufacturing tooling, molds and dies, medical implants, additive manufactured parts, optics, and others. The presentation will conclude with techno-economic analysis of the LP implementation, an outlook on the future of the technology, and technical and knowledge gaps that still need to be filled.

Biography:

Evgueni Bordatchev is a Senior Research Officer and a Team Leader for Microfabrication and Surface Functionalization group at the National Research Council of Canada, in London, Ontario, Canada. He received Master, PhD, and Doctor of Technical Science degrees in electro-mechanical engineering from Don State Technical University, Rostov-on-Don, Russia, in 1982, 1989 and 1996, respectively. Since 1998, he is with National Research Council demonstrating his national and international recognition as an expert in laser- and cutting-based high-precision micromachining, surface functionalization, laser polishing, micro/nano-optics,micro-opto-electro-mechanical systems/sensors, and micro-moulds/dies.

Publication of speakers:

- Performance of laser polishing in finishing of metallic surfaces
- Porosity and cutting forces: from macroscale to microscale machining correlations
- Influence of overlap between the laser beam tracks on surface quality in laser polishing of AISI H13 tool steel
- A fast-response thin film thermocouple to measure rapid surface temperature changes
- Neural network modeling and analysis of the material removal process during laser machining

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