

Status and Future Directions of Adaptive, Smart and Sustainable Machining Systems for Aerospace Applications

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Abstract (300 word limit)

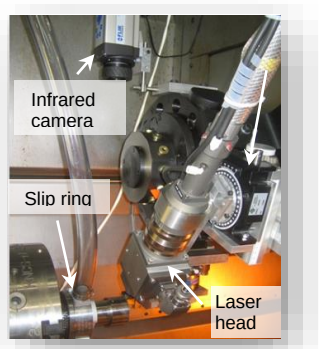
Manufacturing remains the largest and most important wealth generating sector. Within this sector, material removal is a key technology in the aerospace and automotive industries, contributing to more than $200 billion to the economy in North America on annual basis. The demand for high productivity and high accuracy is steadily increasing, along with the increasing attention to the impact on the environment. In this work, only conventional machining processes are discussed, although a number of nonconventional processes are in demand in the aerospace industry.

A system approach to the machining system is presented in terms of its elements (machine, tool, workpiece and fixture), properties (materials, configuration, contact interfaces) and interactions (dynamic, tribological, thermal, thermo-elastic) to set the framework for predicting the system response (quality attributes and machining-induced defects) to the operational input (controlled cutting conditions and uncontrolled dynamic-tribo-thermo-elastic self-induced changes).

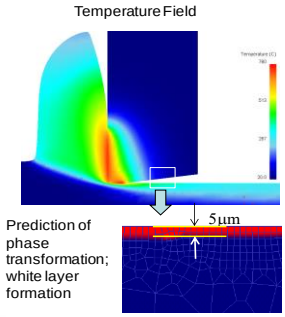
The paper provides a critical assessment of the current status of smart and sustainable material removal technologies, and the research effort towards the development of new and hybrid machining strategies and processes for: (a) high speed/high performance machining, sustainable manufacturing and tool life management, (b) machining of composites, stacked materials, (c) high performance/ superabrasive advanced grinding and polishing, (d) physics-based modeling and simulation of the machining system to achieve a virtual machining environment for the realization of the "first part correct" philosophy, and (e) adaptive machining, where model-based control systems of the part-machine tool interaction and process monitoring allow the industry achieve unmanned "closed machining".

Key enabling technologies have been identified to achieve these terminal objectives. This include new processes for achieving micro-nano-sized microstructure components, and to deal with new materials. Other new trends include the integration of non-conventional technologies towards the development of new hybrid multifunctional machining processes.

Key words: Smart machining systems, adaptive machining, sustainable machining, Virtual machining



Laser Assisted Machining



Finite element simulation of phase transformation and residual stresses

Recent Publications

1. Hassan, M., Sadek, A., Damir, A., **Attia, M. H.**, and Thomson, V., "A Novel Approach for Real-Time Prediction and Prevention of Tool Chipping in Intermittent Turning Machining," accepted for publication in Annals of CIRP, 2018.
2. Jawahir, I.S., **Attia, M. H**., Biermann, D., Duflou, J., Klocke, F., Meyer, D., et al., "Cryogenic manufacturing processes," Keynote Paper, CIRP Annals - Manufacturing Technology, vol. 65, pp. 713-736, 2016.
3. M'Saoubi, R., Axinte, D., Soo, S.L., Nobeld, C., **Attia, M.H**., Kappmeyer, G., Engin, S., and Simh, W-M., High performance cutting of advanced aerospace alloys and composite materials, Keynote Paper, CIRP Annals - Manufacturing Technology, Vol. 64 (2), 2015, pp. 557–580.
4. Hassan, M., Sadek, A., Attia, M.H., and Thomson, V., "A Novel Generalized Approach for Real-Time Tool condition Monitoring", ASME Trans, J. Manufacturing Science and Engineering, 2017,140(2):021010-021010-8. doi:10.1115/ 1.4037553.
5. Sultana, I., Shi, Z., **Attia, M. H**., and Thomson, V., "A New Hybrid Oscillatory Orbital Process for Drilling of Composites Using Superabrasive Diamond Tools," CIRP Annals- Manufacturing Technology, vol. 65, pp. 141-144, 2016.
6. Hassan, M., Sadek, A., Attia, M.H., and Thomson, V., Intelligent Machining: Real-Time Tool Condition Monitoring and Intelligent Adaptive Control Systems," Journal of Machine Engineering, 2018, Vol. 18, No. 1, 5-17.

Biography

Helmi Attia is Principal Research Officer, Manager of Advanced Material Removal Processes at the National Research Council Canada, and Adjunct Professor of Mechanical Engineering, McGill University. Helmi is Fellow of CIRP (College International pour la Recherche en Productique), Fellow SME (Society of Manufacturing Engineers) and Fellow ASME (American Society of Mechanical Engineers). He is the recipient of 'Queen Elizabeth II Diamond Jubilee Medal' (2013) and the 'ASME Blackall Machine Tools and Gage Award' (1989). Helmi is on the editorial board of number of international journals. To his credit, he authored/coauthored some 250 papers in archival journals and refereed conference proceedings.

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