From traditional stone machining to intelligent manufacturing: new technologies and trends



Stone machining presents significant technological challenges due to variations in material structure and mechanical properties, high abrasiveness, and progressive tool wear. This invited lecture provides an overview of stone machining technologies, with particular emphasis on recent developments, process monitoring, and emerging trends. Special attention is given to indirect methods for monitoring tool wear and assessing workpiece hardness based on measurable process responses during stone machining. Such approaches provide valuable information on tool condition and material properties without interrupting the machining process, enabling improved process control and optimization. The lecture also addresses recent advances in CNC and robotic machining, CAD/CAM integration, sensor-based monitoring, and the increasing application of data-driven methods and artificial intelligence. These developments indicate a transition from conventional stone processing towards intelligent and adaptive manufacturing, with the potential to improve productivity, tool life, process reliability, and sustainability.
Stone machining; Tool wear monitoring; Workpiece hardness assessment; CNC machining; Process monitoring; Intelligent manufacturing

Miho Klaić graduated in Mechanical Engineering from the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, in 2012, specializing in Manufacturing Systems. His master's thesis, entitled Design of a Milling Machining Center for Stone Processing, focused on the development of a machine tool for stone machining applications.

In May 2013, he joined the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, as an assistant at the Department of Technology, Chair of Machine Tools. Alongside his teaching and research activities, he pursued doctoral studies and successfully defended his PhD dissertation in June 2018. His doctoral research, entitled Indirect Monitoring of Tool Wear and Workpiece Hardness in Stone Drilling, focused on the development and application of indirect methods for monitoring machining processes, particularly tool wear and workpiece properties during stone drilling.

In January 2022, he was appointed Assistant Professor at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb. In December 2023, he joined the Faculty of Maritime Studies at the University of Dubrovnik, where he continues his academic, research, and teaching activities.

His main areas of expertise include machine tool design, material removal processes, machining process monitoring, and the modeling and prediction of tool wear. His research interests include machining and manufacturing technologies applied to stone, metals, and composite materials, as well as the development and application of advanced monitoring, modeling, and simulation methods.

In addition to his research activities, Klaić is actively involved in teaching at the Faculty of Maritime Studies and the Department of Art and Restoration at the University of Dubrovnik. He also serves as an external collaborator at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.