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A Tool Tuning Approximation Method: Exploration of the System Dynamics and Its Impact on Milling Stability When Amending Tool Stickout

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Abstract : The shortest possible tool stickout has been the traditional go-to approach with expectations of increased stability and productivity. However, experimental studies at Danish Advanced Manufacturing Research Center (DAMRC) have proven that for some tool stickout lengths, there exist local productivity optimums when utilizing the Stability Lobe Diagrams for chatter avoidance. This contradicts with traditional logic and the best practices taught to machinists. This paper explores the vibrational characteristics and behaviour of a milling system over the tool stickout length. The experimental investigation has been conducted by tap testing multiple endmills where the tool stickout length has been varied. For each length, the modal parameters have been recorded and mapped to visualize behavioural tendencies. Furthermore, the paper explores the correlation between the modal parameters and the Stability Lobe Diagram to outline the influence and importance of each parameter in a multi-mode system. The insights are conceptualized into a tool tuning approximation solution. It builds on an almost linear change in the natural frequencies when amending tool stickout, which results in changed positions of the Chatter-free Stability Lobes. Furthermore, if the natural frequency of two modes become too close, it will onset of the dynamic absorber effect phenomenon. This phenomenon increases the critical stable depth of cut, allowing for a more stable milling process. Validation tests on the tool tuning approximation solution have shown varying success of the solution. This outlines the need for further research on the boundary conditions of the solution to understand at which conditions the tool tuning approximation solution is applicable. If the conditions get defined, the conceptualized tool tuning approximation solution outlines an approach for quick and roughly approximating tool stickouts with the potential for increased stiffness and optimized productivity.

Keywords : milling, modal parameters, stability lobes, tap testing, tool tuning
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