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NON-SMOOTH AND INTERMITTENT MODEL OF CUTTING PROCESS

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Nowadays, cutting process is still one of the most popular manufacturing method. An increased industrial competition has driven the need for manufacturers to reduce costs and increase dimensional accuracy. The efficiency of a machining operation is determined by the metal removal rates, cycle time, machine down time and tool wear. A primary factor that limits process efficiency in machining is a phenomenon called chatter. Chatter is a dynamic instability that can limit material removal rates, cause a poor surface finish and potentially damage the tool and/or the workpiece. From the historical point of view, machine tool chatter goes back almost 100 years, when Taylor, as the first, described this phenomenon [2]. After the extensive work of Tlusty et al. [5], Tobias [6] and Kudinov [3,4], the so-called regenerative effect has become the most commonly accepted explanation for machine tool chatter. However, much latter another chatter mechanism has been developed by Grabec [1]. This mechanism, called frictional chatter can cause interesting phenomena like deterministic chaos. The regenerative effect is related to the wavy workpiece surface generated by the previous cutting tooth passage. The frictional mechanism bases on dry friction between the tool and the workpiece.

For continuous cutting operations, like turning, the governing equation is relatively simple because the tool has one cutting tooth which still is in contact with a workpiece. In the case of milling, the direction of the cutting force is changing due to rotation of the multi-blade tool, and the cutting is interrupted as each tooth enters and leaves the workpiece. Consequently, the resulting equation of motion is a non-smooth and interrupted delay differential equation (DDE). That causes troubles during numerical calculations, especially for two degree of freedom model (2dof). Therefore, here system dynamics is analysed with the help of numerical methods using bifurcation diagrams, Poincare sections, Lyapunov exponents both for smoothing and originally non-smoothing model of milling. Moreover, the presented here model of cutting process takes into account both chatter mechanisms in order to investigate their interaction. Finally, some practical conclusions for cutting process are drawn from this study.

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