Improving material removal rate of high-speed milling tools using simulations

K. Madsen[1*], M. Malekan[1], and R. Aghababaei[1]

[1]Department of Solid Mechanics and Materials Engineering, Aarhus University, 8000 Aarhus C, Denmark

Maximizing material removal rate (MRR) is an efficient way to improve the efficiency of the milling operations during production. One can increase MRR by increasing the axial and/or radial engagement of the tool with the work piece as well as feed rate. However, this develops a higher degree of stresses and wear at the cutting edge, reducing the tool lifetime. Therefore, it is important to optimize the tool geometry to enhance the stress carrying capacity under a high running temperature.

First, we run a systematic set of finite element simulations to understand the extent of stress increase at the cutting edge as a function of axial and radial tool engagement and feed rate Our simulations showed out of three aforementioned parameters, increasing the feed rate causes a smaller increase in the cutting-edge stresses. Additionally, we showed that the degree of stresses on the cutting edge can be efficiently reduced by optimizing three geometrical parameters, i.e. helix angle, rake angle and cutting-edge radius. Finding the most optimum range for these three geometrical parameters, we manufactured 27 tools, differing in geometry, and tested them for milling stainless steel. All tools have the same MRR and removed a certain amount of materials within the same amount of time. The microscopic inspection of the degree of damage and wear along the cutting edge shows a good agreement with the simulations result, suggesting the optimal rake angle of 10 degree, the optimal helix angle of 32 degrees, and the optimal edge preparation of 10 μm.

The result of this study indicates that simulations are an efficient tool for designing the next generation of cutting tools. We anticipate that the use of simulations will lead to a faster and more efficient optimization of cutting tools and manufacturing processes.

Keywords: High-speed milling, Tool wear, Machining parameters, Simulations, Microscopic imaging

[*] karolinemadsen@outlook.com