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FEM Simulation of Tool Wear and Edge Radius Effects on Residual Stress in High Speed Machining of Inconel718

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Abstract : Tool wear and tool geometry have significant effects on the residual stresses in the component produced by high-speed machining. In this paper, Coupled Eulerian and Lagrangian (CEL) model is adopted to investigate the residual stress in high-speed machining of Inconel718 with a CBN170 cutting tool. The result shows that the mesh with the smallest size of 5 um yields cutting forces and chip morphology in close agreement with the experimental data. The analysis of thermal loading and mechanical loading are performed to study the effect of segmented chip morphology on the machined surface topography and residual stress distribution. The effects of cutting edge radius and flank wear on residual stresses formation and distribution on the workpiece were also investigated. It is found that the temperature within 100um depth of the machined surface increases drastically due to the more friction heat generation with the contact area of tool and workpiece increasing when a larger edge radius and flank wear are used. With the depth further increasing, the temperature drops rapidly for all cases due to the low conductivity of Inconel718. Consequently, higher and deeper tensile residual stress is generated on the superficial. Furthermore, an increased depth of plastic deformation and compressive residual stress is noticed in the subsurface, which is attributed to the reduction of the yield strength under the thermal effect. Besides, the ploughing effect produced by a larger tool edge radius contributes more than flank wear. The magnitude variation of the compressive residual stress caused by various edge radius and flank wear have a totally opposite trend, which depends on the magnitude of the ploughing and friction pressure acting on the machined surface.

Keywords : Coupled Eulerian Lagrangian, segmented chip, residual stress, tool wear, edge radius, Inconel718
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