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Orthogonal Metal Cutting Simulation of Steel AISI 1045 via Smoothed Particle Hydrodynamic Method

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Abstract : Machining or metal cutting is one of the most widely used production processes in industry. The quality of the process and the resulting machined product depends on parameters like tool geometry, material, and cutting conditions. However, the relationships of these parameters to the cutting process are often based mostly on empirical knowledge. In this study, computer modeling and simulation using LS-DYNA software and a Smoothed Particle Hydrodynamic (SPH) methodology, was performed on the orthogonal metal cutting process to analyze three-dimensional deformation of AISI 1045 medium carbon steel during machining. The simulation was performed using the following constitutive models: the Power Law model, the Johnson-Cook model, and the Zerilli-Armstrong models (Z-A). The outcomes were compared against the simulated results obtained by Cenk Kiliçaslan using the Finite Element Method (FEM) and the empirical results of Jaspers and Filice. The analysis shows that the SPH method combined with the Zerilli-Armstrong constitutive model is a viable alternative to simulating the metal cutting process. The tangential force was overestimated by 7%, and the normal force was underestimated by 16% when compared with empirical values. The simulation values for flow stress versus strain at various temperatures were also validated against empirical values. The SPH method using the Z-A model has also proven to be robust against issues of time-scaling. Experimental work was also done to investigate the effects of friction, rake angle and tool tip radius on the simulation.

Keywords : metal cutting, smoothed particle hydrodynamics, constitutive models, experimental, cutting forces analyses
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