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Efficient modeling of ultrasonic welding of composite through a time homogenization framework

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Among the different welding techniques for thermoplastic materials, ultrasonic welding is of particular interest because of its energy efficiency and rapidity. In this process, triangular "energy directors", are molded on one of the plates to be welded. The assembly is then placed under a tool called sonotrode, which applies simultaneously a constant load and a harmonic ultrasonic compression. The triangular shape, the weakest part, concentrates the deformation and induces heating because of the high viscous dissipation at those frequencies (20 kHz). The director then melts and flows at the interface and the welding can be obtained. Like in every welding process, the modeling of the ultrasonic technique is a complex multi-physical problem but the unique feature of this process is that the high frequency of the loading makes any direct calculation unaffordable. To circumvent this problem, a time-homogenization technique was proposed by Levy et al. that provides a mathematically basis for such type of problem. It takes advantage of the good time scales separation between the welding time (1 s) and the period of the ultrasonic vibration (50 μs). The homogenization method enables to transform the initial coupled thermo-mechanical problem into three problems, where the short time-scale can be solved separately from the long time-scale. In this work, two applications of this type of modeling are presented for the simulation of US welding: one in the case of an energy director based technique and another one in the case of a recently proposed energy director free approach.

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Recycling of WC (Co) drilling and milling tools by controlled plasma oxidation of used CVD-diamond coatings without damage to tooth edge

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The CVD-diamond coated WC (Co) tools have been widely utilized for dry drilling, milling and machining of CFRP (Carbon Fiber Reinforced Plastics) and CFRTP (Carbon Fiber Reinforced Thermo-Plastics) in airplane and automotive industries. The severe mechanical interaction between hard diamond coatings and carbon fibers often results in damage and deterioration of diamond films; e.g. a single diamond coated tool is damaged only after continuous drilling of 10 to 20 holes. The tooth-structure, fine machined WC (Co) tool substrate costs so much that it must be recycled after complete removal of used diamond films without damage to the WC (Co) substrate. In the present paper, the high density plasma oxidation method is proposed to make complete ashing of the used CVD-diamond coatings from the WC (Co) tooth surfaces and to adjust the bare WC (Co) tooth surfaces for nucleation of CVD-diamonds in recoating. The ashing rate by the present method reaches to more than 10 m/hr and the shrinkage of tooth edge is limited to be less than 1 μm. No diamond residuals are detected by the Raman spectroscopy; SEM observation reveals that the nucleation sites by decobalting for growth of diamond films are recovered by this processing. The plasma oxidation behavior is discussed through the quantitative plasma diagnosis; the emissive-light optical spectroscopy provides a population of oxygen activates species and the Langmuir probe measurement works to describe the spatial distribution of electron and ion densities. The effect of tooth structure and tooth shape on the oxygen ashing process is also discussed to describe the oxygen plasma state around the tooth surfaces.

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