Novel Cavitation Fluid Jet Polishing Process Based on Negative Pressure Effects

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Abstract: Traditional abrasive fluid jet polishing (FJP) is limited by its high-pressure equipment, unstable material removal rate, and applicability to ultra-smooth surfaces because of the evident air turbulence, fluid expansion, and a large polishing spot in high-pressure FJP. This paper presents a novel cavitation fluid jet polishing (CFJP) method and process based on FJP technology. It can implement high-efficiency polishing on small-scale surfaces in a low-pressure environment. CFJP uses the purposely designed polishing equipment with a sealed chamber, which can generate a cavitation effect in negative pressure environment. Moreover, the collapse of cavitation bubbles can spray out a high-energy microjet and shock wave to enhance the material removal. Its feasibility is verified through researching the flow behavior and the cavitation results of the negative pressure cavitation machining of pure water in reversing suction flow. The mechanism is analyzed through a computational fluid dynamics simulation. Thus, its cavitation and surface removal mechanisms in the vertical CFJP and inclined CFJP are studied. A series of polishing experiments on different materials and polishing parameters are conducted to validate its polishing performance compared with FJP. The maximum removal depth increases, and surface roughness gradually decreases with increasing negative outlet pressures. The surface becomes smooth with the increase of polishing time. The experimental results confirm that the CFJP process can realize a high material removal rate and smooth surface with low energy consumption in the low-pressure environment, together with compatible surface roughness to FJP.

Key words: Cavitation fluid jet polishing; negative pressure; cavitation bubble; material removal; Computational fluid dynamic; Abrasive jet