Effect of increasing spindle speed at a constant chip load on cutting force behaviour of Hastelloy X

ABSTRACT

Cutting force is vital in machining nickel-based superalloys due to their excellent mechanical properties, thus creating difficulty in cutting. In the current scenario of metal machining, milling processes require high spindle speed and low chip load, which result in a low cutting force. However, low chip load not only result in low cutting force but also result in a low material removal rate (MRR). It is contrary to the ultimate high-speed machining (HSM) goal, which is to improve productivity and cost-effectiveness. Therefore, the emergence of an approach for achieving simultaneous low cutting force and high MRR is crucial. This paper presents the effect of increasing spindle speed at a constant chip load on the cutting force of Hastelloy X during half-immersion up-milling and half-immersion down-milling. In both half-immersions, the simulation results and experimental results are in good agreement. The percentage contribution of feed force, normal force and axial force to the resultant force can be arranged descendingly from high to low as axial force > normal force > axial force. Moreover, feed force, normal force, axial force and resultant force have a U-shaped behaviour. The spindle speed of 24,100 rpm and a chip load of 0.019 mm/tooth were found to achieve both low cutting force and high MRR.

Keyword: Spindle speed; Chip load; Cutting force; Hastelloy X; Half-immersion