An analytical approach to optimize Sinusoidal Spindle Speed Variation in Milling

P. Albertelli[1], M. Leonesio[2], G. Bianchi[2], M. Monno[1]

[1]Politecnico of Milan, Department of Mechanical Engineering, Via La Masa 34, 20158 Milano - MUSP Lab, loc. Le Mose, 29100 Piacenza, Italy

[2]Institute of Industrial Technology and Automation - CNR, V.le Lombardia 20/A, 20131 Milano, Italy

paolo.albertelli@polimi.it

Abstract

Spindle Speed Variation (SSV) has been shown to be an effective method for chatter suppression. In particular, Sinusoidal Spindle Speed Variation (S^3V) is commonly considered the most effective implementation of this technique [1]. Nevertheless, its effectiveness strongly depends on a proper choice of sinusoidal component parameters (i.e. amplitude and frequency) and on the nominal spindle speed.

The key of the Sinusoidal Spindle Speed Variation (S^3V) efficacy is the phase shift between inner and outer chip thickness modulation when chatter is impending. Chatter can be suppressed or enlarged by provoking different phase shift. Concerning the optimum phase shift [2], literature is sometimes unsound and a definitive clear treatment is undoubtedly opportune.

In this paper, the relationship between the worst phase shift and spindle speed is analyzed for a 2D milling operation. Then, considering the basic case of one dominant vibration mode for the planar displacement dynamics, a function is proposed to measure a heuristic distance between the actual phase shift, that would occur if the instantaneous value of cutting speed were kept constant, and the worst phase shift condition previously identified. Such function is used for an effective analysis of S^3V parameters effect.

Finally, the whole approach is properly validated by means of dynamic time-domain cutting simulations.

Keywords

Spindle Speed Variation, Chatter, Cutting Dynamics