Mechanistic Modelling of the Micro End Milling Operation

L. Uriarte¹, R. Bueno¹, O. Gonzalo¹, L.N. Lopez de Lacalle²
¹ Micro & Nanotechnologies Dep. – Fundacion Tekniker, Eibar, Spain
² Dpto. Ing. Mecánica, ETSII, Alameda Urquijo s/n, 48013, Bilbao, Spain
luriarte@tekniker.es

Abstract

The presented research work has developed a mechanistic model to predict the micromilling cutting forces and to estimate the tool deflection and the real tool-path during the micromilling process. Beginning from the conventional end milling cutting force model, based on six coefficients (three specific cutting force coefficients and three edge coefficients), several modifications are proposed to adapt it to the prediction of the micro milling cutting force. The three basic differences that arise from the drastic reduction in size and considered in the new approach are the following:

- The effect of the cutting edge radius is taken into account to define the minimum uncut chip thickness which determines the transition between cutting and ploughing regimes.
- As a result of high tool flexibility the balance between instantaneous cutting force and tool elastic restoring force is introduced, modifying the instantaneous chip thickness calculation.
- One additional axial force coefficient is introduced to consider the force executed by the material pushing the mill away from the machined surface. This force component becomes predominant when the axial depth of cut and the uncut chip thickness are very small. In this article it is denoted as predominant rejection effect.

The paper presents the experimental validation for the micro machining of steel using two-flute carbide micro end-mills with diameters from 0.1 to 0.3 mm. Finally, the conclusions and the weak points suitable for further research are exposed.