Dynamics of Chip Formation during Orthogonal Cutting of Titanium Alloy Ti-6Al-4V

M.Cotterell[1], G.Byrne[2]
[1]Cork Institute of Technology, Mechanical Engineering Department, Bishopstown, Cork, IRELAND
[2]University College Dublin, School of Electrical, Electronic & Mechanical Engineering, Belfield, Dublin 4, IRELAND
mcotterell@cit.ie

Abstract

In this investigation polished and etched disks of Titanium Alloy Ti-6Al-4V were machined in a series of continuous and interrupted orthogonal cutting tests on a specially adapted lathe. A high speed imaging system with a long distance microscope lens allowed direct observation of the chip formation zone (circa 1mm by 0.2 mm). Frame rates from 20,000 to 50,000 frames per second were used to record the chip formation cycle over a range cutting speeds from 4 to 120m/min and at feed rates of 0.05, 0.075 and 0.1 mm. Illumination was critical to avoid image blurring. In this investigation metal halide light sources and a strobed Copper vapour laser were used. Light delivery was achieved by a liquid light guide and fibre optic cable respectively.

Visual images of the chip formation cycle were synchronised with high speed recording of the cutting and feed forces. Segmented chips were observed throughout the investigation and image analysis of the recorded videos allowed the determination of important parameters such as the chip velocity, the shear angle, the segmentation frequency, the critical strain required to initiate shear band formation and the shear strain occurring within shear bands. Constitutive models of material behaviour were reviewed with the objective of determining the critical strain to initiate thermoplastic shear. Analysis of the results supports the thermoplastic shear models proposed by Komanduri (and others) as the controlling mechanism for chip segmentation in Ti-6Al-4V alloys.