

ABSTRACT

Machining is an important metal removal process in manufacturing. In spite of the considerable effort, past and present, that has been expended by scientists and engineers on metal cutting research, the mechanics of this process is not yet fully understood. This is clearly a limitation to improvement of the technology of conventional metal-cutting processes or to the development of new methods for use with materials difficult to machine. Hence metal-cutting research is a challenging field and it is currently attracting the attention of workers in the field of plasticity of metals as well as those concerned with the more immediate problems in practice.

The ultimate aim of an analysis of the mechanics of metal cutting is to understand the basic phenomena, to predict how the chip deforms and what forces and power are required for a given material and for a given cutting condition. The nature of stress distribution at the chip-tool interface plays a predominant role in the mechanics of metal-cutting. Even-though a great deal of sincere attempts on experimental investigations to determine stress distributions have been reported, no complete analytical study has been reported so far to determine stress-distribution at the chip-tool interface.

In the present investigation, attempt has been made to develop a class of slipline field solutions for orthogonal cutting or without elastic contact beyond the

plastic contact zone. Two different frictional boundary conditions has been assumed. In some cases, the interface friction is represented by a constant friction factor m ($\tau = mk$). In other cases, the interface friction has been assumed to obey coulomb's law ($\tau = \mu\sigma_n$). The slipline fields analysed in this study were proposed earlier by Dewhurst[55] and Kudo[34]. Solutions to Dewhurst's field have been obtained with the assumption of coulomb friction with and without the assumption an elastic contact length. For Kudo's fields with the chip boundary defined by a concave α -line and a convex β -line kinematically and statically admissible solutions have been obtained for the above two friction conditions with the assumption of an elastic contact length beyond the zone of plastic contact with prescribed normal stress distribution(parabolic or exponential).

When interface friction is assumed to obey coulomb's law, the angular relation between α and β lines bordering the slipping region becomes non-linear. The fields in this case are analysed by a linear approximation to the above non-linear relation as suggested by Dewhurst[65]. The limit of validity of the slipline field solutions have been examined by applying Hill's overstressing criteria[15].

At low coefficient of friction, the interface friction is limited to slipping contact only. At high coefficient of friction both sticking and slipping zones are predicted at the chip/tool interface and the slipline fields are modified to take care of this boundary condition.

The non-dimensional cutting force, thrust force, cutting ratio, chip-curvature, contact length, sticking length and sticking ratio are predicted and compared with experimental data. The stress-distributions are also predicted at the chip-tool interface.

A slipline field solution for machining with a tool with step-type chip breaker has been carried out assuming a constant friction factor at the chip-tool interface for different positions of chip-breaker. The non-dimensionalised cutting force, thrust force, the force exerted by the chip-breaker on the chip, chip-curvature, cutting ratio and contact length are predicted. For any given feed the analysis predicts when chip-forming action of chip-breaker starts. The variation of different machining parameters computed from the present theory agrees with the experimental observations.

