INVESTIGATIONS ON THE CONTROLLED CONTACT CUTTING

By

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CERTIFICATE

This is to certify that the thesis entitled, 'INVESTIGATIONS ON THE CONTROLLED CONTACT CUTTING', being submitted by Mr. Rajinder Nath Mittal to the Indian Institute of Technology, Delhi for the award of the Degree of 'Doctor of Philosophy' in Mechanical Engineering, is a record of bonafide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis, which has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The present thesis is devoted to the study of mechanics of orthogonal and oblique cutting with controlled contact tools. The main aim of the present work is to predict the shear plane angles and study of tool forces, strains in the chip and residual deformations in the machined surface.

The first Chapter is an introductory chapter. Besides the historical review of the work done in the mechanics of orthogonal and oblique cutting, friction on the tool-chip interface and the secondary deformation are also discussed in this chapter. The earlier work done using controlled contact tools is critically reviewed.

In the second Chapter, thin zone model due to Merchant has been modified and using the minimum energy criterion, an expression for the shear angle φ for orthogonal controlled contact cutting has been obtained in terms of the process parameters and the actual chip-tool contact length in natural-contact cutting. Five different expressions for shear angle φ are obtained by using the value of natural chip-tool contact length based on the derivations of different researchers.

Chapter 3 describes the experimental work conducted to verify the theoretical model proposed in Chapter 2. The results of the experiments are analysed and compared with the theoretical results obtained by using the 5 solutions proposed in Chapter 2. It is found that the theoretically

predicted values of φ for controlled contact orthogonal cutting, in general, follow the similar trend of the values obtained experimentally. Further, the expression for shear angle φ using Hahn's expression or Oxley's expression for actual chip-tool contact length h_o has been found to give the values of shear angle φ closer to the experimental values. The reasons for the disparity in the various values of φ obtained by the proposed solutions are discussed. The theoretical predictions of φ based on the proposed solution have also been compared with the experimental results of other authors. The proposed solution is shown to be quite superior to the other existing solutions provided Hahn's or Oxley's expression for h_o is used.

Chapter 4 gives a solution to the problem of oblique controlled contact cutting. Here an expression for the overall rate of energy dissipation in controlled contact cutting is derived. This equation is solved numerically for determination of φ that corresponds to the conditions of minimum cutting energy. The effect of various cutting parameters on shear plane angle φ is predicted. The trends of various theoretical values such as φ. r_c, R_X etc. with respect to the ratio t_1/h are discussed.

Chapter 5 gives the details of the two sets of experiments conducted to verify the model postulated in Chapter 4. The experimental values of φ and r_c are computed and are plotted against the ratio of undeformed chip thickness to the length of chip-tool contact (i.e. t_1/h) for different values of rake angle α and angle of obliquity I. The trend of the experimental values is compared with the trend of theoretical values. The latter were computed by substituting, in the theoretical expressions the values of chip-tool friction angle β_0 and chip flow angle η_0 as obtained from the experimental data for the natural contact oblique cutting. The trends shown by the experimental and theoretical curves are discussed.

Chapter 6 of this thesis uses the printed grid technique for the study of deformation and presents photographs of the frozen chip attached to the work piece after the cut was abruptly stopped. The effective strains, angle of maximum elongation, shear angle φ, cutting ratio, depth of secondary deformation in chip and the depth of strained layer in the machined surface are studied and compared for cutting with tools having natural or controlled contact on the rake face. Effect of the depth of cut on the above parameters is also studied. It is observed that, in general, the depth of deformed layer in the machined surface is negligible in case of cutting with controlled contact tools even with depth of cut nearly upto 1.2 mm for all the values of α used in the experimental work. For a fixed value of α, it was observed that the effective strain in the chip and

and depth of secondary deformation in the chip are smaller for controlled contact tools but the value of the shear angle φ is more.

Lastly, the overall conclusions derivable on the basis of the present experimental and theoretical work along with some suggestions for further work are stated in Chapter-7.

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