Evaluation of Cutting Force in Orthogonal Cutting by Experimental Model: A Review

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Abstract— A metal cutting is one of the most widely used manufacturing processes in an industry and there are great deal of studies to investigate the metal cutting process in both academia and industrial work. The objective of analyzing the metal cutting process is to tooling cost. Prediction of important process parameter using experimental investigation such as forces, stress distribution, temperature, etc. plays significant role for designing tool geometry and optimizing cutting conditions to improve productivity.We cannot find out the forces with analytical model experimentally measured cutting forces Here our aim of these researches is to choose the analytical model which will give optimum result for particular kind of material.By using 1) Ernst and merchant. 2) Lee and Schaffer and 3) duotones berg model theoretically and comparing with each other and also with practical. Experiments are to be carried out using various tools. The mathematical models are developed and tested for adequacy using analysis of variance and other adequacy measures using the developed models. Which indicate that the developed models can be effectively used to predict the responses in the turning of selected material.

Key words: Ernst and merchant, Lee and Schaffer and duotones berg, Cutting force

I. INTRODUCTION

Machining is used as one of the most important processes in industry to obtain the final shapes of the products [1]. A wide variety of machining operations are applied in industries that include material removal during cutting. Understanding the material constitutive behaviour in machining is becoming increasingly important for better understanding the parameters of machining such as, cutting force, plastic strain distribution and chip morphology. Machining processes involve high deformations, high strain rates, high local temperature, high transient phenomena and it has been known for a long time that a size effect exists in metal cutting, where the specific energy increases with decreasing in deformation size which have not been considered in conventional mechanics of materials [2]. The angle at which the chip will separate from the work material during metal cutting is called the shear angle and determines many fundamental aspects of the cutting mechanics such as the magnitude of the cutting force, the efficiency of the metal removal process and the surface roughness. A large shear angle is associated with continuous and thin chip formation, good surface finish and low cutting force. The value of the shear angle is measured either by measuring the deformed and unreformed chip thickness or by metallographic inspection of the machining zone of samples obtained by quick stop devices. There has been extensive research on close-form analytical modelling of the shear angle equation as specified by Ernest and Merchant [3-5].

II. CUTTING FORCE MODEL

Within the machining, the purpose of developing mathematical models is to understand the effects of the parameters involved in the machining process on different machinability aspects. In general, the cutting force model is a function of the tool geometry, cutting parameters and workpiece material, respectively. A traditional approach was considered, i.e. exponential model, in order to predict the cutting force during the machining of PTFE composites [6]. According to this model, the machining response in terms of the cutting force may be expressed as a function of cutting parameters and insert radius in the following form

$$F = C_F d^k f^l r^m v^n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where d is the depth of cut, f is the feed rate, r is the insert radius, v is the cutting speed, and C_F, k, l, m, and n are the model parameters to be determined. This model provides practical functions to predict the cutting force incorporating the effect of cutting parameters.

The varying trends in the machining may be obtained from the sign of the exponents in the above equation. A positive value of the coefficients suggests that the cutting force increases with the increase of the associated parameter, while a negative value indicates that the cutting force will decrease with the increase of the associate parameter. The magnitude of the variables indicates the weightage of each of these factors. In order to facilitate the determination of the model parameters, Eq. (4) may be represented in a linear form by performing logarithm transformation.

$$\ln F = \ln C_F + k \ln d + l \ln f + m \ln r + n \ln v$$

The model parameters may be determined either by using the method of least squares or graphically by plotting the experimental data against each cutting parameter on a log–log scale. Since the cutting speed and tool insert radius were found not to be significant for the prediction of the cutting force, these parameters were not included in the model. The values of the coefficients were calculated from the plot of the main cutting force versus cutting parameters in log–log scale. The models obtained for the cutting force are given as follows:

$F=43.63\, d^{0.82}\; f^{0:61}$ for PTFE GR 15.

$F =57.59\, d^{0:73} f^{\,0:72}$ for PTFE CG 32-3:

Based on the models above, it can be seen that the cutting force increases with the increase of the feed rate and depth of cut.

III. MODIFICATION OF MERCHANT MODEL

Most of orthogonal cutting models assume the existence of a primary shear zone which has the aspect of a thin band where the chip is formed by intense shearing of the work material, see for instance, Refs. [7-9]. These models are extensions of the seminal work of Merchant [10,11] who assumed that the primary shear zone was infinitely thin. Representing the primary shear zone as a narrow band seems to be a realistic schematization in many cases, such as high-speed machining and cutting operations of materials with negligible strain hardening [6]. For the working of cutting models, the shear angle f, characterizing the inclination of the primary shear band with respect to the cutting velocity, must be accurately defined. This requirement is essential to obtain realistic predictions of cutting variables such as cutting forces and temperature distribution within the cutting zone [3,7]. In the Merchant's model, plastic shearing is localized along the shear line AB (Fig. 1). Across this line the tangential component of the particle velocity is discontinuous. The material is assumed to be perfectly plastic (no strain hardening, no thermal and no rate dependence). Friction at the tool–chip interface is governed by a Coulomb law, with friction coefficient m. The Merchant's shear angle is obtained by minimization of the cutting energy:

$$\phi M = \pi/4 + \frac{\alpha - \lambda}{2} \quad (1)$$

where α is the rake angle and λ is the friction angle defined by μ= t g(λ).However, some discrepancy is generally found between the value of the shear angle measured in experiments and the theoretical prediction (1), Indeed, experimental data are generally better described by the empirical Zvorykin's law [14]:

$$\phi = A_1 + A_2 \phi (\Box - \lambda) \quad (2)$$

where the constants A1 and A2 are determined from orthogonal cutting experiments. Using Zvorykin's law (2) in the cutting model [3], provided a good agreement with experimental results for cutting forces and temperature distributions. To explain the discrepancy between the value of the shear angle predicted by Eq. (1) and experimental data, the hypothesis of perfect plasticity made in the Merchant's

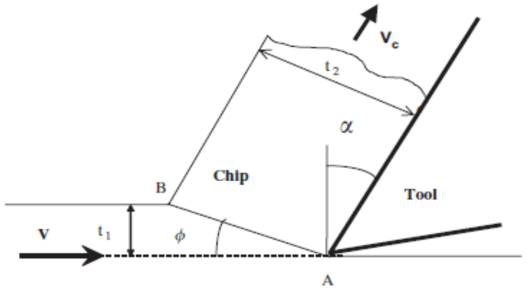

Fig. 1: Schematic view of the orthogonal cutting process

Modelling could be incriminated. Indeed, the workpiece material behaviour is in general not perfectly plastic. However, strain hardening, strain rate sensitivity and thermal softening of the work material can be accounted for in the thermo mechanical model of Moufki et al. [9]. Then, if the hypothesis of minimization of the cutting energy is used, the value of the shear angle is found to be close to Merchant's result (1). Thus, the nature of the plastic response cannot be viewed as the main cause of disagreement between experiments and modelling. Moreover, finite element simulations of orthogonal cutting predict that the shear angle may be quite different from the value given by cutting models based on cutting energy minimization (for the same constitutive law of the work material). This was clearly demonstrated by Barker [12] who considered a perfectly plastic material as in the Merchant's approach. This was also shown by Miguelez et al. [12] by considering a viscoelastic thermal-sensitive material. Bak¨er [12] concluded that the minimization of the cutting energy is not an adequate criterion to estimate the shear angle .Note that this conclusion was also made by Hill [12] who attributed the failure of the theory when compared to experiments to ''almost certainly the inadequacy of the minimum work hypothesis''.

IV. SCOPE OF THE WORK

There are numbers of material are newly found out now a days for different application in industry.Validation these models with these newly found material and evaluation of this forces with that material and

V. METHODOLOGY

After selecting Material for work piece and tool,Tool design and fabrication is carried out.Then theoretical calculation of the force for each three material is carried out. After this graph are plotted for three different materials for same cutting condition. Then graph is plotted for other cutting condition. Then experiment are carried out andComparison of experimental result with theoretical one is done. By this Conclude the best method which can give optimum value in practice for specific kind of material and finding reason behind it.

VI. CONCLUTION

There are number of analytical models are available to for predicting the cutting forcer like feed force, radial force, thrust force etc. based on different theories and with lots of assumptions. Because of these assumptions we cannot find out the forces with analytical model near to experimental cutting forces or experimentally measured cutting forces. We can use any one of these model to calculate cutting force. But Which Model will give us result to real optimum value of cutting force is question Which analytical model is good for which material Is also an question .Which are the factor responsible for deviation of force value by analytical model to experimental value. So for answering this question we have find out optimum analytical model for particular material.

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