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SYNTHESIS ON THE ASSESSMENT OF CHIPS CONTRACTION COEFFICIENT C_D

Milea Nicolae Marius[1]

[1] *Gheorghe Asachi* Technical University, Iaşi, milea_marius@yahoo.com

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Abstract: The assessment of plastic deformation of chips can be done based on theoretical and experimental considerations. This paper presents the two ways of assessing the chips contraction coefficient, namely the theoretical and experimental methods. The results obtained from both methods will be used to develop a mathematical model for chips contraction coefficient**.**

1. INTRODUCTION

The chips contraction coefficient represents the capacity of plastic deformation of different metals during the cutting process. The assessment of plastic deformation is based on both theoretical and experimental considerations, which are used to develop a mathematical model for C_d.

Historically, the chip contraction coefficient was introduced in studies on metal cutting as a measure of plastic deformation. It was shown that although C_d is not a perfect measure of plastic deformation, it directly reflects the final plastic deformation that takes place in cutting. [Astakhov, 2003]

Most published papers take into consideration the individual influence of some cutting parameters; only few studies consider the influence of some pairs of parameters on the chips contraction coefficient (cutting speed, the nature of the cut material, feed, the angles of the cutting tool). The results of the studies undertaken by researchers in USA and Russia show that the individual influence of the cutting speed (v), the feed (s), the inclination angle (λ) and the rake angle (γ) depends on the values of other parameters. In the mathematical model shown in this paper, C_d is dependent on the parameters of the cutting process.

2. THE ASSESSMENT OF C_D

2.1 ANALYTICAL AND EXPERIMENTAL METHODS

Analytical methods consist in the mathematical calculus of the elements that characterize the plastic deformation of the cut metal in various conditions. In order for this method to be applied it is necessary to know the yield curves, the structural characteristics of the materials and the distribution of the efforts in the deformation zone. The Ernst and Merchant approach introduces the concept of the single shear plane and the angle it makes with the surface generated referred to as the shear angle. It has become a classic approach in metal cutting and has been applied in analyzing the cutting of different materials even when shearing cannot occur at all. Zorev suggests a model for the cutting of ductile materials in agreement with the theory of plasticity. [Astakhov, 2003]

Summarizing the analytical models, it can be said that each cutting approach or model reflects a particular aspect of metal cutting practice. No model can cover all various cutting conditions that can be found during the real process.

Experimental methods directly measure the elements of plastic deformation. V. Astakhov suggests two experimental methods for the determination of the chip contraction coefficient. The simplest method is to measure the chip thickness and calculate C_d as

$$C_d = t_2 / t_1 \tag{1}$$

where t_2 is the chip thickness and t_1 is the uncut chip thickness. This method cannot be always used because of the chip's saw-toothed free surface or its smallness. The second method is the weighing of the chips. After determining the length L, the width d_w and the weight G_{ch} , the chip thickness is calculated as

$$t_2 = \frac{G_{ch}}{d_{w1} L \rho_W g} \tag{2}$$

where ρ_w is the density of the work material and $g=9,81 m/s^2$ is the gravity constant.

These methods, either theoretical or experimental, can lead to errors in assessing the chips contraction coefficient. To eliminate these errors, a theoretical-experimental model of assessing C_d is suggested, based on both theoretical considerations, but mostly on experimental results.

2.2 THE DEVELOPMENT OF A NEW MODEL FOR THE ASSESSMENT OF C_D

As we know, theoretical equations for the chips contraction coefficient do not include all the parameters with significant influence, reason why we suggest a new model which takes into consideration the sense and the level of influence of each parameter, that is *HB , v, s, K, γ and λ.*

A series of authors suggested the model below for the assessment of C_d, which includes the six parameters mentioned above.

$$C_d = C \frac{\delta^{n_5} \times \omega^{n_6}}{HB^{n_1} \times v^{n_2} \times s^{n_3} \times K^{n_4}} \tag{3}$$

The influence levels $n_1 \ldots n_6$ will be determined experimentally. The complementary angles δ=90-γ and ω=90-λ are used in order to avoid the negative and null values of γ, λ angles. The authors of this model also suggested the use of experimental diagrams in double-logarithmic coordinates to assess the influence levels $n_1 \ldots n_6$.

After determining the influence levels, a second step is necessary, namely the determination of the *C* constant with Eq. (4), where v_0, s_0, K_0, δ_0, ω_0 and HB_0 are the values for the independent variables that provide the same value for C_{do} (experimental data tabels or diagrams in double-logarithmic coordinates can be used).

$$C = \frac{C_{d0} \times HB_0^{n_1} \times v_0^{n_2} \times \delta_0^{n_3} \times K_0^{n_4}}{\delta_0^{n_5} \times \omega_0^{n_6}} \tag{4}$$

After determining both the influence levels and the *C* constant, other experimental data are necessary to take into consideration the interdependencies and the values obtained so far may need correction. Thus, after assessing the interdependencies, Eq. (3) may become Eq. (5).

$$C_d = C_m \frac{\delta^{n_{5m}} \times \omega^{n_{6m}}}{HB^{n_{1m}} \times v^{n_{2m}} \times s^{n_{3m}} \times K^{n_{4m}}} \quad (5)$$

The experimental data, the corrected values of C constant and of the influence levels will be used to verify Eq. (5). The values obtained with Eq. (5) will be compared with experimental data. Depending on the similarity between the two sets of values, a new model for assessing C_d can be obtained by correcting Eq. (5) and introducing an intermediary parameter with Eq. (6).

$$C_m = C_{dexp.} \frac{HB^{n_{1m}} \times v^{n_{2m}} \times s^{n_{3m}} \times K^{n_{4m}}}{\delta^{n_{5m}} \times \omega^{n_{6m}}} \quad (6)$$

In Eq. (6), the parameters HB, v, s, K, ω, δ have the values for which C_{dexp}. has been obtained experimentally. Finally, Eq. (7) is obtained, in which n_m, n_v, n_s, n_K, n_λ, n_γ represent the influence levels of the cut material, the cutting speed, the feed and the constructive angles of the tool, γ, λ, K.

$$C_d = C_m \frac{\delta^{n_\gamma} \omega^{n_\lambda}}{HB^{n_m} v^{n_v} s^{n_s} K^{n_K}} \quad (7)$$

The calculus model (7) suggested for the assessment of C_d must be adjusted according to the specific parameters of each cutting process and cut material (ductile or less ductile-fragile).

3. CONCLUSIONS

1. The new suggested model is useful for the development of a new model for the assessment of the cutting forces depending on the chips contraction coefficient and is complementary to other existing models.

2. This model includes six parameters of paramount significance, namely, the cut material hardness, the cutting speed, the cutting feed and the constructive angles of the tool.

3. In the future, the values obtained with this new model of assessing C_d could be used for classifying the metallic materials from the point of view of their cutting workability.

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