EXPERIMENTAL TEST FOR TOOL-LIFE PREDICTION IN TURNING

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ABSTRACT. A comparison between two different experimental methods for predicting the cutting-edge tool life in turning is presented: the Standard ISO 3685 and the here proposed one, that make free the variation of cutting parameters, in particular the cutting speed. The methodology here presented take into account the cumulative damage or the residual life of the cutting edge. On the contrary to the Standard, the cutting speed is not constant up to the complete wear of the edge, but different cutting speeds are to be employed. This brings to perform a test with a minimum use of two cutting edges and to evaluate the Taylor exponents analytically. The comparison is based on experimental tests for both methods and the results in this previous work are encouraging.

1 INTRODUCTION

In chip removal, the cutting parameters are well correlated by the Taylor equation, which actually remain the most convenient despite the approach by more complicated models with not appreciable improvements [1]. For determining the unknowns of the Taylor expression, the exponents and the constant, an experimental test is mandatory because of the influence of uncontrolled factors which leads high uncertainty in computation if model is adopted [2]. Experimental tests are produced and often offered by manufacturers of cutting tool inserts, but data must be carefully used because of different tool machines and materials employed. Hence in factory it is significant to run tests proving the best behaviour of the cutting tool, therefore tests must be rapid and give as many information as possible. Several techniques have been proposed like RMS [3] and Factorial design [4] for choosing the number of tests to perform and to cover an assigned range of values, whereby a linear regression for Taylor relation would be determined.

The method presented in this paper relates to the cumulative damage or the residual life of the cutting edge and the base hypothesis is first posed, followed by the analytical exposition which leads to the formulation of the Taylor equation.

2 THE RESIDUAL TOOL LIFE

In considering valid the empirical Taylor equation $vT^n=C$ at the cutting conditions expressed by $C$, one can asks which amount of residual life $L_1$ should have the cutting edge after a cutting time $t_0 < T_1$ at cutting speed $v_1$. With $t_0$ the working time from the initial state 0 to 1 at the cutting condition expressed by 1: the residual life is $L_1 = T_1 - t_0$ and the rate of consumed life is $d_1 = t_0 / T_1$, remaining the residual rate $l_1 = (T_1 - t_0) / T_1 = 1 - d_1$.
Under the hypothesis that the residual tool life rate $l_i$ is constant varying the operating conditions, for example the cutting speed $v_i$, it is defined:

$L_{ij}$: residual life at time $t_i$, with cutting speed $v_j$;

$L_{ii}$: residual life at time $t_i$, after processing at cutting speed $v_i$;

$$d_i = (T_i - L_{ii}) / T_i = 1 - L_{ii} / T_i .$$

Can be generalised as follows:

$$L_{ii} = T_i (1 - d_i) - l_i$$

$$L_{(i-1)i} = T_i (1 - d_{(i-1)})$$

$$d_i = \sum_{j=1}^{i} \frac{t(j-1)_j}{T_j}; \quad d_0 = 0 .$$

Using the Taylor equation, as logarithmic transformation:

$$Y = a + bX, \quad X = \ln v, \quad Y = \ln T, \quad c = \ln C \quad \text{and} \quad a = c/n, \quad b = -1/n ,$$

in fig. 1 the progression of the tool life is represented.

![Graphic representation of the progression of the tool life.](image)

By eliminating the unknown $T_i$ with the Taylor equation, the above three equations can be expressed with the unknowns $n$ and $C$.

If the cutting speed $v_j$, $j=1,2,\ldots,i$, will only vary during the test, other cutting parameters remaining constant in $C$, the cutting edge will be completely worn at time $t_i = \sum_{j=1}^{i} t_{(i-1)i}$ which correspond to $L_{ii}=0$ or $d_i=1$ :

$$d_i = \sum_{j=1}^{i} \frac{t(j-1)_j}{T_j} = \sum_{j=1}^{i} t(j-1)_j \cdot C^{-\frac{1}{n}} \cdot v_j^{\frac{1}{n}} = 1 $$