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Technical Resource of Single Flute End Mill Cutters - Prediction and Analysis

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Abstract

Main quantitative indicators characterizing the reliability of cutting tools and in particular of single flute mill for high-speed milling processing are: fastness, infallibility, storage capability, maintainability [1,3,4]. In this relation, technical resource category includes the operational period of time for which the tooling system reaches the wear criterion. Technical resource (mean time between failures) is assessment of the fastness of the tools. His research is related to the optimization of predicting the maximum levels of the defining parameters in this case are the elements of the cutting conditions in correlation with technological criteria low cost, high performance and high quality machined surfaces.

Keywords: Technical resource (mean time between failures), single flute mill cutters, high-speed milling.

1. Introduction

An object for approval in this article is a statistical method of analysis of the technical resource in the technical state using prediction of change of the basic parameters. Through the results of these tests will depend on the time for resharpening of tools, high speed steel (with or without inflicted multilayer coating) or replacement of the cutting tip in carbide tools.

To determine the guaranteed fastness of single flute end mill cutters are employed regression and stochastic methods [2,5,6]. Moreover, it is often necessary to solve differential equations pulse, reflecting operational environment [7,12].

Regression methods require the study of process models wear. Each of the functional parameters of *X(t)* of a tool is characterized by its mathematical expectation m_{x0}, which is sufficient close enough to the nominal value m_{xH}, and a root mean square deviation of its σ_{x0} [8, 10].

The purpose of this work is to analyze the possibility to determine the technical resources of single flute end mill cutters – fig.1 with high-speed machining of aluminum sheets, composite panels and HPL panels.

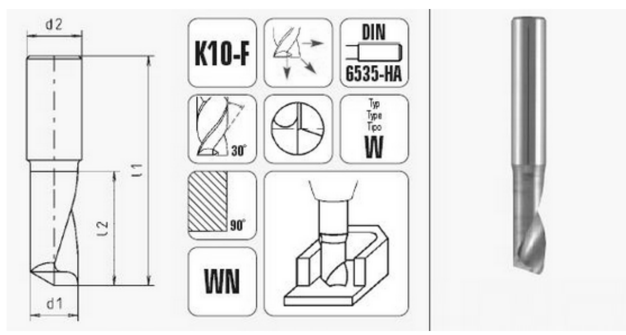

Fig. 1 Single flute end mill cutters - technical parameters [13]

2. Calculation of technical resources of single flute end mill cutters

Dynamic change in the levels of the parameters of cutting conditions $m_x(t)$ and $\sigma_x(t)$ can be expressed by the regression model first, second and higher order [9,11].

Nearest adequate models of the process of wear are regression models of first and second order.

The regression linear model of the first order is stored in the following contrivance:

$$m_X(t) = a_m.T + b_m$$
$$\sigma_X(t) = a_\sigma.T + b_\sigma \quad (1)$$

where:

- a_m, a_σ are the velocity of change of the mathematical expectation,
- $b_m \approx m_{x0}$, $b_\sigma \approx \sigma_{x0}$ - mean square deviation of the parameters.

While the regression model of the second order is expressed as:

$$m_X(t) = c_m.t^2 + d_m.t + e_m$$
$$\sigma_X(t) = c_\sigma.t^2 + d_\sigma.t + e_\sigma \qquad (2)$$

where:

- c_m, c_σ - are acceleration of climate mathematical expectation,
- $e_m \approx m_{x0}$, $e_\sigma \approx \sigma_{x0}$ - mean square deviation of the parameters,
- d_m - the velocity of change of the mathematical expectation,
- d_σ - mean square deviation of the parameters.

For deterministic interval t parameter X with probability P = 0.954, characteristic of the normal distribution, is expressed as:

$$X(t) = m_X(t) \pm 2\sigma_X(t) \qquad (3)$$

Examining the change of any parameter $X(t)$ allows to determine the technical resource – T_H *(MTBF)*.

State of normal functioning is determined by the inequality:

$$m_{xH} - \Delta \le X(t) \le m_{xH} + \Delta \qquad (4)$$

After transformation and substituting (4) into (3) we obtain:

$$m_{xH} \pm \Delta = m_x(t) \pm 2\sigma_x(t) \qquad (5)$$

Mean time between failures T_H to reach criterion of wear $X(t)$, located infinitely close but outside the tolerance band Δ is expressed by:

$$T_H(MTBF) = \frac{(m_{xH} \pm \Delta) - (b_m \pm 2b_\sigma)}{(a_m \pm 2a_\sigma)} \qquad (6)$$

In a regression model of the second order, the definition of technical resource T_H, for any parameter $X(t)$, located outside the tolerance band Δ of optimal values, following an analogous sequence:

$$T_H = \frac{-(d_m \pm 2d_\sigma) \pm \sqrt{(d_m \pm 2d_\sigma) - B}}{2(c_m \pm 2c_\sigma)} \qquad (7)$$

$$B = 4(c_m \pm 2c_\sigma).[(e_m \pm 2e_\sigma) - (m_{xH} \pm \Delta)] \qquad (8)$$

where:

- B - summarizing parameter.

Determination of technical resource TF of of single flute end mill cutters to their resharpening or replacement of the carbide tip requires determination and time correlation [5, 8-11]. For this purpose use polynomial approximation in deterministic interval and threshold levels of variation of observed parameters $X(t)$ (the cutting conditions).

$$\tau_k = \alpha - \ln 0{,}1 \qquad (9)$$

where:

- α - smoothing parameter.

Essentially the model of functioning of instrument – part in high-speed machining with single flute end mill cutters described as risk technical system taking into account the recovery period [4]. It follows that the correct description of the processes is necessary to analyze and recovery times, either by sharpening or a change of carbide cutting tip. In fact, they are far smaller than those in other risk systems as here upon reaching wear criterion tool refundable and replaced with another. In the case of interest is the time to reset the system, taking into account the correction coefficient's of new tools.

We introduce the coefficient of availability $K_r(t)$. It forms an important probability characteristic of reliability, defining opportunity tooling system to satisfy both system characterized by two parameters - storage capability and maintainability. To access of Mean time between failures MBTF, i.e while tools is efficient, taking into account the periods in which the risk system is not used as intended, namely the moments in which any adjustment - T_{Hkr}. Coefficient is given by the relationship [4]:

$$K_r(t) = 1 - F_0(t) + \int_0^{T_{Hkr}} [1 - F_0(t-\tau).g_B(\tau)]dt \qquad (9)$$

where:

- F_0 - the law of distribution of failures,
- g_B - density of the probability of recovery.

Stationary process of readjustment in deterministic interval Δt= *480 minutes* (one active day). Coefficient is expressed as $\hat{K}_r(\Delta t)$ and production types [4]:

$$\hat{K}_r(\Delta t) = \frac{\hat{T}_H(\Delta t)}{\hat{T}_H(\Delta t) + \hat{T}_B(\Delta t)} \qquad (10)$$

where:

- $\hat{T}_H$ - mean time between failures at reset,
- $\hat{T}_B$ - the average recovering time.

On the whole range of technical use, statistical appraisal indicator $\hat{K}_r$ is dependent on the cumulative period in which the tooling system is at reset, entrained to product of the number carried details and flawless work efficiency rating to technical resources.

$$\hat{K}_r = \frac{\sum_{i=1}^{P} \tau_{p_i}}{P.T_{Hkr}} \qquad (11)$$

where:

- τ_{pi}- residence time of the tooling system is in a period of readjustment,
- P - number of details (parts).

Depending (11) could also be seen in the form:

$$\widehat{K}_r = F\left[\overline{\varpi}(\Delta t) \pm \overline{\mu}(\Delta t)\right] \quad (12)$$

where:

- $\overline{\varpi}$ - conditional probability density of the failure,
- $\overline{\mu}$ - conditional probability density of the recapping.

Therefore, at high-speed milling processing with a single flute end mill cutters, proper functioning to mean time between failures of tools, taking into account time for readjustment is correlated with the conditional probability density of the failure and conditional probability density of the recapping, in boards of the term technical servicing of tools.

3. Conclusions

1. Prediction of technical resource TF for single flute end mill cutters through regression model is effective for deterministic span less time correlation.
2. In mill cutters for high speed machining, in view of the intensive cutting conditions, the value of the time correlation with a discharge greater than their technical resource for the corresponding parameter.

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