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EQUATIONS FOR CUTTING-TOOL PERFORMANCES MARKING IN THE FUNCTION OF CUTTING CONDITIONS

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Abstract

Existing relation between tool life and cutting conditions represent a deterministic approach. As the cutting process is a tipical stohastic one, recent literature contain an approach from the probability aspect. The determined number relationsips for tool life of cutting tools, with needed coments, in the papaer are given. In order to, estabilish specific connections and relations and to analyse of cutting-tool failures and cutting conditions based on probability approach duble-parameter Weigull distribution function, in this papaer, was used.

Key words: *Tool live, Cutting condition elements, Reliability, Time to tool failure*

1. INTRODUCTION

In up to date production conditions optiml cutting condition selection is signify for selection optimal variant of machining. Developed mathematical models for they calculation request to have reliable dates of cutting-tool performances. How is known thay we can get by: 1. laboratory investigations, in very strict conditions, which related on work piece and cutting tool material and other following influences and 2. escort of behavior of cutting tool in production conditions.

Investigation of tool life in laboratory conditions indicate tht for equal condions by cutting, we have signify tool life dispersions as consequence unequability tribological conditions by cutting. From this reason alredi we have preliminary investigations with numerious cutting tools by them eliminating that which extremal values of tool life, and with remainder the systematical investigation we performinvestigations. If we observe such method representative cutting tool selection for investigations of tool life functions, ith probability positions we can conclude that he have not basis and justify.

Data colection of cuttig-tool failures of all kinds, in production conditions, we can see very large dispersions. which is consequence smoler controled conditions, conected, before everyting for work piece and cutting tool, and other conditions which follow the process.By that in real condions of machining, to failure cams not only in consequence tribological phenomenous in cutting zone and alredy as cosequences other coicidental perturbances.

On the basis of before presented need ful differ conception of tool life and time to failure of cutting tools, and for both conceptions give correct definitions considering the cutting process as a tipical stohasic one. Thus for tool life we can say that present mean time effective cutting to appearance unsharp defined by corresponding wear crterion, while time to failure, in production condditions, present mean time of effective cutting till appearance of failure. On the basis of before presented we can conclude that the mean time to failure is smoler then tool life. Difference between that two conceptions is very significate cosidering the first corresponding on tribological caracteristics of work and cutting-tool materials by another equal conditions, and second on another coicidence perturbancesd which follow real production conditions.

In production conditions, dependent of buch large, which them selves machining, number of registrated failures can be differ. If the numer registrated values $N > 50$ that present representative samples, and if is $N \le 50$ thay is not. For both before presented coincidence, need applicate corresponding data processing methodologies which possibly distribution function determination of distribution function of the cutting tool failure, reliability, frequence and iodensity and meann time to cutting-tool failures[1,2,3].

2. REVIEW OF RELATIONSHIPS FOR MARKING OF CUTTING-TOOL PERFORMANCES

For someting smoller the hundret years we cn, in literature, find large number relationships which conect tool life with cutting condition elements. Thay cn be with one, two thre or four cutting-tool condition parameters**.**

Aplication of probabilistic aoproach which related on determination mean time to failure, for determined cutting condition (A = δ.s = const. i v = const.). In this coincidence, by data processing, which which distribution function normal, log-normal, exponential and, ogftennes, Weibull's distribution was used. The number works, in this manner, is very large [9-13]. Number of work which related on prognosis of mean time to failure in function of cuttinh condition elements is very small.

2.1 Relationships for determination cutting tool life

Without pretensions on complete presentation, in continue, hronological, the inportantly relatonships, are given (1-16)

Taylor(1907) $vT^m=C_T$; $T=C_v v^k$ *(1)*

Kronenberg (1927) $v_{60} = C_v \; A^{-1/\varepsilon v}$ *(2)*

Walichs (1930) $v_{60} = C_v/(\delta^x s^y)$; $T = 60\ min$ *(3)*

Woxen (1932) $(T'/T)^n = c(q+q_n)$ *(4)*

Shvach (1948) $v\,T = \pi/\{(\delta/s)\,[\,c_1 s_1\ ((\delta/s) + c_2)^{1/2}]\ \}^{1/2}$ *by milling* *(5)*

Gilbert (1950) $v\ T^n = c\ /(\delta^x\ s^y)$ *(6)*

Kronenberg (1954) $v = (T'/T)\ c\ (\delta/s)^k/(\delta s)^{-1}$

$v_{60} = C_v\ g^\alpha\ A^{-f}$ $v_{60} = C_{vs}\ (g/5)^\alpha\ A^{-f}$ $g = \delta/s$ *(7)*

Weber (1954) $b = K\ t^\beta$; $K = f(v)$; $\beta = const.$ $A = \delta.s = const.$ *(8)*

Colding(1958) $k+ax+cy–z+kxz=0$

$$k+ax+bx^2+cy+dy^2-z+ez^2=0$$

$$x = ln\ q\ ; \quad y = ln\ v\ ; \quad z = ln\ I$$ *(9)*

Colding(1960) $k+ax+bx^2+cy+dy^2-z+ez^2+fxy+gyz+hxy=0$

$$x = ln\ q\ ; \quad y = ln\ v\ ; \quad z = ln\ I$$ *(10)*

Matthijensen (1965) $v(e + T)^m = c$ *(11)*

Sekuli} (1967) $b = C\ \delta^x\ s^y\ v^r\ t^{P(v)}$

$P(v) = a_0 + a_1 v + a_2 v^2 + a_3 v^3 + \quad + a_n v^n$ *(12)*

$T = (C\ \delta^x\ s^y\ v^r\ B^{-1})^{-1/P(v)}$ *for* $b = B$ *is* $t = T$ *(12')*

Kronengerg (1968) $(v + k)\ T^n\ c$ *(13)*

N.N. (1968) $T = T_0\ \ exp\ \{k_1\ [1 - (1 - k_2\ ln\ (v/v_0))^{1/2}\ ]\}$ *(14)*

Hasch (1969) $v\ T^n = \delta^x\ s^y\ b^z\ c$ *(15)*

Koenig-Dipiereux (1969) $T = exp[-(k_v/m)v^m - (i_s/n)^n + c]$

(16)

2.2 Relationships for prognosis mean time of cutting-tool failures

How in the begining of this chapter remarked, for technical systems, Weibull's distribution function of failures, are oftener used [9-13]

$$F(t) = 1 - exp(t/\eta)^{\beta} \quad (17)$$

and another here are not in consideration. eibull's distribution parameters, how is knowing, can be determined with analytical, graphoanalitucal or graphical procedures pa se ostale ovde ne}e ni analizirati [9-11].

When the distribution function parameters are known, shape [illegible] and pozition η, mean time to failure $T_{m,,}$ for determined cuttin conditions, cab be determined via gamma Γ funkcions

$$T_m = \eta\Gamma(1/\text{[illegible]}$$

Relationships for mean time to failure of cutting tool T_m in function of feed s and cutting speed v, by equal depth of cut (δ = const.), are [11-13]

$$T_m = a\ s^p\ v^{b + c\,s} \quad (19)$$

and

$$T_m = d\ v^q\ s^{e + f\,v} \quad (20)$$

3. COMENT

3.1 Relationships for tool life of cutting tools

All 16 presented relationships for cutting-tool tool life can be sorted depedent of number of the cutting condition parameters which contain, on: :

- one parametric *($T = f_1(v)$)* and
- multhy parametric, with
  - two, *($T = f_2(s,v)$*
  - three *($T = f_3(\delta,s,v)$ and*
  - four *($T = f_4(\delta,s,v,b)$* parmeters.

One parameter contain relationships (1), (2), (4), (8), (11), (13), (14), two (3), (7), (9), (10), (16), three (5) i (6), four parameters contin relationships (12) and (15).

Comparation between particular relationships poited that from newly, with more parameters, floing, also, early with smaller number parameters

Thus from relation (12) and (13) for $b = B = const,\ \delta = const.$ i $s = const.$ *(i $P_{(v)} = P_{(0)}$)* follow relations (1) and (3) for $b = B = const.$ i $T = 60\ min,$ while relation (6) follow for $b = B = const.$ Relationship (7) idnetical with (3) thaking in respect that are $\delta = (A\ g)^{1/2}$ i $s = (A/g)^{1/2}$ (introdusing slenderness coeficient of chip $g = \delta/s = 5$ we can directly determining coeficient C_{vs} for chip cross sectional area $A = 1\ mm^2$ corresponding $\delta = 2{,}24$ mm and $s = 0{,}44\ mm$). Weber's equation (8) follow from (12) and (15) for $b = B = const.,\ \delta = const.$ i $v = const.$ and $K_v = c\ v^q$ follow $T = k_v\, v^q$ i.e.. $Tv^{-q} = k_v = const.$, that present relationship (1).

Reltions (11), (13) i (14) are paraboles or hiperboles. Relations (9), (10) and (16) Colding's and Koenig-Dipiereux are equations higher orders.

Partisular relationships in coordinatas log T-log v presents strainght lines (1), sheaf strainght lines for s = const. (15), curve(13) and curve family lines for s = const. (16).

3.2 Mean time to failure of cutting tools

The mean time to failure T_m (18), for adopted cuting condition (*$A = \delta.s = const.$* and *$v = const.$*), can be determined on the basis of Weibull's distribution function parameters (17).

Mean time to failure in function of cutting conditions elements can be determined on laboratory or production conditions by follow of cutting-tool failures. For sufficient reliability results, for determined depth of cut δ = const., indispaseble is variation 25 different cutting conditions (5 different cutting speeds v and 5 different feeds s, in combinations every by every). For every particular combination of cutting condition need sufficient number repestsfollows to cutting-tools failures (minimum 5, but the reliability is higheer if the sample is larger or if the sample is representative $N \geq 50$).and on the basis of theirs can determine eibull's distribution parameters β and η and mean time to failure T_m.

Data processinf conslude on determintion followinf dependeens

$$T_m = f_1(v) \quad ; \quad s = const. \quad (21)$$

and

$$T_m = f_2(s) \quad ; \quad v = const. \quad (22)$$

Previously dependens for mean time to falureT_m in exponentional form are searched

$$T_m = C\ v^x \quad ; \quad s = const \quad (21')$$

and

$$T_m = D\ s^y \quad ; \quad v = const. \quad (22')$$

Coeficients C i D in exponential and exponents in linear form are searched

$$C = a\,s^p \qquad a = const\,; \quad p = const$$
$$x = b + c\,s \qquad b = const \quad c = const$$

$$D = d\,v^q \qquad d = const\,; \quad q = const$$
$$y = e + f\,v \qquad e = const \quad f = const$$

After substitutions on the end, we have two relationships for mean time to cutting tool

$$\boldsymbol{T_m = a\,s^p v^{b + c\,s}} \quad (23)$$

and

$$\boldsymbol{T_m = d\ v^q\ s^{e + f\,v}} \quad (24)$$

Last two equations we can solve, first for cutting speed

$$v = (T_m\ a^{-1}\ s^{-p})^{1/(b + c\,s)} \quad (25)$$

and second for feed

$$s = (T_m\ d^{-1}\ v^{-q})^{1/(e + f\,v)} \quad (26)$$

4. CONCLUSIONS

On the basis of previously presented we can conclude:

- on the bais of analysis of the derivate relationships founded on probablistic base, with previously presented reltionships, we can conclude that thay pointed on complexity and delicasy dates usge by determination respponsive cutting conditions, and bring in reliability insure biger sequrity,
- in exponetil relationships for tool life of cutting tools exponents is not constants and are function of cutting conditions elements,
- for prognozis mean time to failure of cutting tool to failure the probbility approach have full justication,
- for mean time to failure T_m two different reltionships, both in exponential form, which can be benefit, by solve different problems conested for optimization of cutting processes.

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