THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICAL ENGINEERING, ISSN 1224 – 5615
2003

THE WEAR INFLUENCE ON THE WORKING CONDITION

Conf.dr.ing.Cristian-Silviu SIMIONESCU,
Conf.dr.ing. Niculai HAUK
Universitatea "Dunarea de Jos" din Galati

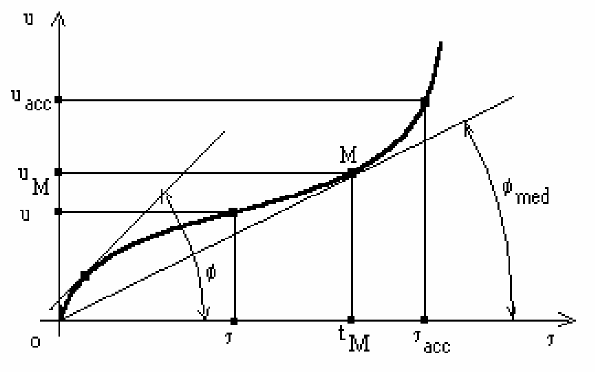
ABSTRACT

During the operation, any machine, equipment, machine parts, or piece, is submitted to a wear. The evolution in time of the wear size, or, in other words, a real form for the characteristic of the wear depends on working parameters values. The present paper analyses the working conditions improvement taking into consideration the wear.

1. General presentation

During the operation, any machine, equipment, machine parts, or piece, called from now on "object", is submitted to a wear which evolution in time presents the same form in all the cases, diagram in fig.1. The wear evolution in time is known as "characteristic of the wear".

The evolution in time of the wear size, or, in other words, a real form for the characteristic of the wear depends on working parameters values p1; p2;...pn (speed, pressure, temperature).



τ= time; u=wear; u_{acc}=accepted wear; τ_{acc}=u_{acc} appearence time; for the other notations see the text

Diagram 1. Characteristic of the wear representation

The intensity of the wear is estimated either local, with the characteristic of the wear slape, I, I=tg ϕ or global, with a wear medium intensity, Imed, Imed=tgϕ_{med} corresponding to the M point.

As a measurement unity it's used time measurement unities (like hour or minute) for τ, and lenght unities (like milimeters) for u.

According to diagram 1 and the considerations mentioned above, it can be said that the wear, by an analitic point of view, is a function presented below:

$$u = f(\tau, p1, p2,...pn) \qquad (1)$$

The object submitted to the wear is put back in normal working conditions by partial usage of the reserve that is specially provided and that reserve is called from now on "Rez".

Goods are being produced during the object operation (all kinds ot pieses or services) which will be called "producte" from now on.

The working parameters, p1; p2;...;pn, influence both the object productivity (the products quantity realised in the whole working period) and the cost that is transferred to the product.

An economic operation of the object is in place to find the parameters values p1, p2,...,pn or, in other words, certain working conditions, that finally leads, by case, to a maximum productivity or to a minimum cost.

It will be shown in succesion that the consideration of the wear goes at the astonishing working conditions and economic effects in comparison with the general procession used in order to get a more efficient economic process.

2. The economic criterions used in order to determine the best working conditions

In the following relations they use the notations presented below:

C - object supply cost, which is expressed in currency measurement units/one object.

Cr - the cost of the normal working conditions restored by using the wear reserve, without the changing of the object, including however the spare parts, which is expressed in currenly measurement units/repair.

N - the products quantity realized in the whale working period by the object, which expresses itself in conventional measurement units (pieces, currency measure units...).

Tb - the time neccessary to produce one piece of product, which expresses itself in the same measurement units as in the τ expression.

S - the cost of the manpower (labour) that serves the object, which expresses itself in currency measurement units/time units (the same as in the τ or Tb expression).

K - the cost transferred to the realised product being in investigation, which expresses itself in currency measurement units/product measurement units.

The cost K, not to be mixed with the cost piece, which determines it, can be written according to the notations above, like below.

$$K = (C + \frac{Rez}{u} Cr)/N + Tb \cdot S \qquad (2)$$

where, if N is written with relation (3):,

$$N = \frac{\tau \cdot Re z}{Tb \cdot u} \qquad (3)$$

it can be obtain:

$$K = \frac{Tb}{\tau} \cdot \frac{u}{Rez} \cdot (C + \frac{Rez}{u} \cdot Cr) + Tb \cdot S \qquad (4)$$

The following specification is necessary: in expression (4) the wear -u- is a function described by expression (1) and the time -Tb- is also a function that depends on the working parameters p1, p2,…,pn described by the expression (5);

$$Tb = g(p1, p2,...pn) \qquad (5)$$

It is considered to be the object using time (time t from expressions (3) and (4)) until the normal working conditions restoring intervention, at time τ appears also the wear -u-

Other costs may also exist in expression (4) such as the energy cost, different charges, fees; but these costs are small enough that they may be ignored.

The rational operation of the object presumes the determination of these working conditions (parameters values p1, p2,…,pn) and the wear size which may give the wanted economic effect.

It should be underlined (stressed) that the methods previously used to determine economic working conditions didn't take into consideration the effects involving the wear.

From now on, it will be consider like economic criterions the products quantity N, and the cost K.

3. The determination of the object rational operation conditions

By its construction and working characteristics, the object may operate in two different ways: at the constant parameters or at the variable parameters respectively.

Both situations will be analysed on turn.

3.1. The object is operated at constant parameters

In the present case, the wear depends only on the operation time,τ, and the time Tb has a constant value.

Expression (3) shows that N depends only on τ

Obtaining the producte maximum quantity or in other words the N maximum in expression (3), it follows:

$$\frac{dN}{d\tau} = \frac{Rez}{Tb} \cdot \left(\frac{u - \tau \frac{du}{d\tau}}{u^2} \right) = 0$$

respectively

$$\frac{u}{\tau} = \frac{du}{d\tau} \qquad (6)$$

The solution of expression (6) is the best value for τ, but it is also the best value for u, in expression (1).

Expression (6) describes the condition according to which a straight line, that goes through the origin (u/τ), has to be tangent at the characteristic of the wear (du/dτ).

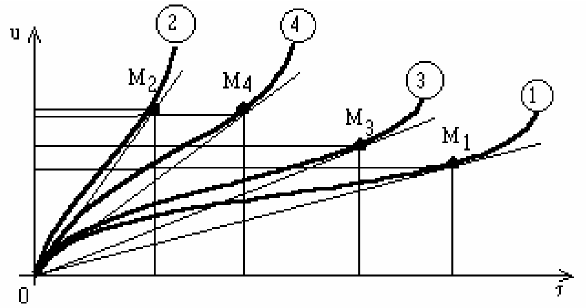
Consequently, the best wear, that assures a maximum production, corresponds to M point (diagram 1).
Because u accepted may be bigger or smaller thau u_M, the best wear, generally, will be determined from the following condition:

$$ubest = MIN(uacc,uM) \quad (7)$$

They may similary proceed in order to get the best operation time τ.
To obtain the minimum cost or the minimum of K respectively, from expression (4) see the following functions:

$$(\frac{du}{d\tau}\cdot\tau - u)\cdot C - Rez\cdot Cr = 0 \quad (8)$$

The solution of expression (8) is the best value for τ but it is also the best value for u, in expression (1).



1=minimum values for the working parameters
2=maximum values for the working parameters
3,4=some values for working parameters

Diagram 2. Characteristic of the wear familly.

It is necessary to underline the influence that both the wear reserve and the costs C, Cr have on the best wear.
Let u be the solution of the expression (8), there the best wear be determined with condition (7), in which u_M become u_c.
If the costs of the normal working conditions restoring Cr can be ignored, that expression (8) because a good enough approximation, identical with expression (6).
Accordingly, in these very conditions, the best wear may be determined for the minimum costs with the help of the wear u_M, too.

3.2. The object is operated at variable parameters

In this case, the wear depends on all the parameters (expression (11)) and the diagram cover a field in u - τ - space, like in diagram 2.

Obtaining the products maximum quantity N maximum in expression (3), goes to resolve the equations system as a result of the N partial derivative zero equalization depending on and parameters p1, p2, ...pn.

$$\begin{aligned} & u - \tau\cdot\frac{du}{d\tau} = 0 \\ & Tb\cdot u - \tau\cdot(\frac{\partial\ Tb}{\partial\ pi}\cdot u + Tb\frac{\partial\ u}{\partial\ pi}) = 0 \\ & i = 1,2,....n \end{aligned} \quad (9)$$

Because of the first equation from the sistem (9), that is identical with expression (6), the solution of the sistem (9) will be represented by an M point situated on the characteristic of the wear coresponding to the parameters values (p_1, p_2,...p_n that satisfy (9)) in that very place where a straight line going through the origin in a tangent at the characteristic.
The following system is used to obtain a minimum cost:

$$\begin{aligned} & (\frac{\partial\ u}{\partial\ \tau}\cdot\tau - u)\cdot C - Rez\cdot Cr = 0 \\ & Rez(\frac{\partial\ Tb}{\partial\ pi}u + Tb\frac{\partial\ u}{\partial\ pi})Cr + \frac{\partial\ Tb}{\partial\ pi} + \tau\cdot\frac{\partial\ Tb}{\partial\ pi}S = 0 \\ & i = 1,2,...n \end{aligned} \quad (10)$$

Again, if the Cr cost may be ignored, the equation from (10) shows that the solution of the system will be represented by a point on a certain characteristic of wear described with the solutions p_1, p_2,...,p_n.
A tangent goes through this point and it also goes through the origin.

4. Possibilities of using of the suggested improvement method

As a rule, for the object being investigated, it is necessary to know the expression (1) of the characteristic of wear familly, deduced from the experimental data processing.
Taking notice of the fact that in many situations the Cr cost is ignored in comparision with C, it concerns just the M point situated on each characteristic of the familly.
Experimental research in order to get the characteristics ploting u = f(τ;p1,p2---pn) is inevitable. However instead of searching some equations more or less precise or complicated for the wear characteristic familly,u, only those values u*i*,ti,p1i,p2i,---pni that satisfy the M point are kept.

With the help of these values it is easier to determine the functions:

$$u = f1(p1, p2,....pn) \qquad (11)$$

$$\tau = f2(p1, p2,....pn) \qquad (12)$$

which replace in expression (3) or (4) go by extreme conditions (N→ maximum or K → minimum), to determine the working parameters p1÷pn, from a equations system.
The research made by the authors has shown that the functions (11) or (12) are described wellenough by pollytropic expressions, such as:

$$u = ao \cdot p1^{a1} \cdot p2^{a2} ....pn^{an} \qquad (13)$$

$$\tau = b0 \cdot p1^{b1} \cdot p2^{b2} ....pn^{bn} \qquad (14)$$

The coefficients and the exponents $a_0,a_1,a_2 \div a_n$ and $b_0,b_1,b_2 \div b_n$ may be obtained easy euongh and expressions (13) and (14) may easily be reduced to a simple equation by logarithmation.
Another way may be through the determination of the functions from the values corresponding to the M points, with pollytropic expressions.

$$u = a \cdot \tau^{b}$$
$$pi = ai \cdot \tau^{bi} \qquad (15)$$
$$i = 1,2...n$$

These functions introduced in (3) or (4) will directly obtain the best τ value and, with the help of (15) they determine the wear and working parameters values.
The last method presents the advantage of a considerable reduction of the calculations.

5. Results

Making several tests on resharpening cutting tools, respectively on lathe cutters and on twist drills (in which just one parameter was used, p_n = cutting speed, v) cost reductions were found in the improvement considering the wear, the more considerable so as S are bigger in value.
Furthermore, it is necessary the elimination of the wrong values that appear at the classic method using, especially at the drilling, deviations produced by the bad correlation offered by a Taylorian classic expression applied at very different working conditions[2]

References

[1] **Gheorghe Oproescu**:(1991) *Optimizarea regimului de aschiere*. Uz intern, Facultatea de Inginerie din Braila.
[2] **Gheorghe Oproescu**:(1994) *Wirtschaftliche Anwendung der spanabhebenden Werkzeuge*. Analele Universitatii "Dunarea de Jos" din Galati.
[3] **Iulian Popescu:** (1987) *Optimizarea procesului de aschiere*, Craiova