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AUTOMATIC OF COMPONENT PRODUCTION AND MINIMALIZATION OF PRODUCTION COSTS

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ABSTRACT: The notion of „machinability of materials“ is a complex of characteristics of the machined material which is monitored in the view of its fitness for the production in a certain way of machining. The machinability of materials is considered to be a parameter which characterizes the machined material in the process of cutting and expresses the degree of machining effectivity in terms of material of a product. When optimizing cutting conditions, under certain conditions it is possible to determine optimal serviceability of a machine according to a certain optimizing criterion independently on cutting condition optimization. When cutting conditions and tool durability optimizing, it is necessary to apply certain optimizing criterion within certain restraining conditions. The restrictions are given by technical parameters of a machine, tool, machined material, required quality of machined surface etc. The essential economic criterion is the amount of production cost.
KEYWORDS: machine serviceability, production cost, economic reasons, optimizing

INTRODUCTION

The machinability of materials is considered to be a parameter which characterizes the machined material in the process of cutting and expresses the degree of machining effectivity in terms of material of a product. Cutting speed when considering certain cutting edge durability, surface roughness, degree of splinter deformation and resultant splinter shape and its proportions are utilized as evaluation of machinability indexes. Confrontation with the reference material enables to determine the rated machinability as one of the basic characteristics of machined material used when cutting conditions are optimized.[7]

ECONOMIC REASONS FOR AUTOMATION OF COMPONENT PRODUCTION

When considering machining process from the point of efficiency (productivity) production costs are oblivious. Yet, it is applicable exceptionally.

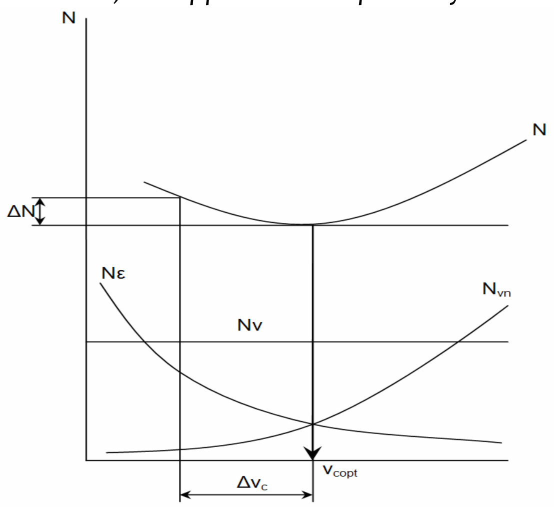

Fig. 1.a. Dependence of N production costs and their components on cutting speed. Conventional machining

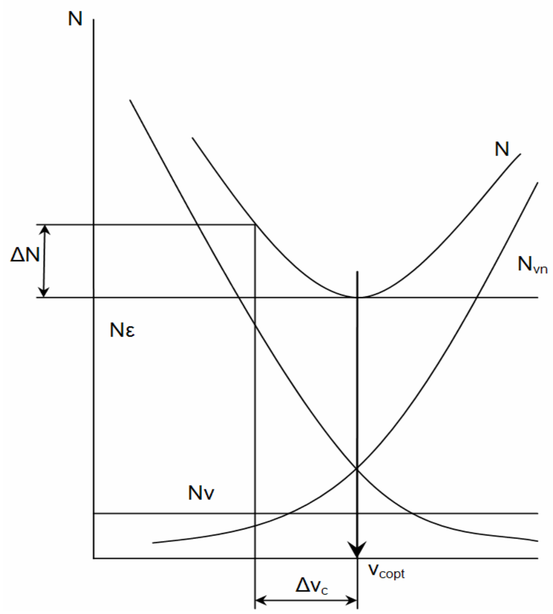

Fig. 1.b. Dependence of N production costs and their components on cutting speed. CNC machining

$v_c \cdot N_c$ – costs on machine work,

N_v – secondary work costs,

N_{vn} – costs to device exchange.

In market mechanism it is required to produce a product in such economic conditions so that its sale price is acceptable and attractive. To start thinking about a production process it is necessary to get an idea about its cost structure.

Using more expensive production installation the costs raise more rapidly. They reach minimum at higher cutting speed than when utilizing usual machines. Disobedience to this relation leads to sharp rise of production costs when machining using the CNC machines. The basic cost development scheme is in the fig. 1.

MATHEMATICAL MODEL MINIMALIZATION OF COSTS

In present, the cutting conditions are mainly chosen from norms that are not optimal.

The nature of cutting conditions optimization is to determine optimal values of given conditions (cutting depth – a_p, underthrust depth – f, cutting speed – v_c) and the optimization of a machine durability.

For a machine with replaceable cutting plates that are re-sharpened is valid:

$$N_{nT} = \frac{C_p.z_p.z_o}{z_h.s_p(z_o+1)} + (1+k_{ut}).\frac{C_{tn}}{z_u} + \tau_{as}.k_c\frac{M_{as}}{60}(1+\frac{RNO_{pl}}{100}).\frac{z_o}{z_o+1} \quad (1)$$

where:

z_o is the number of possible re-sharpening of a plate.

Costs to exchange of a device can be given by:

$$N_{vn} = \tau_{vn}\; k_c\frac{M_n}{60}.(1+\frac{RNS_{pl}}{100}) + \frac{O_s}{60} = \tau_{vn}N_{vmn}z_v \quad (2)$$

where:

N_{vmn} are costs to exchange of a device per, [min],

M_n – wages of a setup man including social and health insurance, [€ [1]],

τ_{vn} – time to exchange a device,[min],

The criterion for minimal production costs can be given (production costs to operational department shall be minimum) by the relation:

$$N_c = N_s + N_n + N_m \quad (3)$$

where:

N – production costs to calculate an operational section,[€],

N_s - costs to machine labor per an operational section, [€],

N_n – costs to machines related to the operational section, [€],

N_{vn} – costs to exchange or offset of a worn-out device related to the operational section, [€].

Having substituted the above-mentioned relations into this criterion the optimization criterion to be reached from the point of view of production costs as follows:

$$N = \tau_{As}N_{sm} + \frac{\tau_{As}}{T}k_rN_{nT} + \tau_{vn}N_{vmn}\frac{\tau_{As}}{T}.k_r \rightarrow min \quad (4)$$

or :

$$N = \tau_{As}N_{sm} + \frac{\tau_{As}}{T}k_r(N_{nT} + \tau_{vn}N_{vmn}) \rightarrow min \quad (5)$$

The machine time can be given by:

$$\tau_{As} = \frac{L_{ch}}{n.f} \quad (6)$$

where:

L_{ch} is the length of machine automatic operation run, [mm],

n- rotational frequency,

f – displacement,[mm]

Substitution (4) in (5) results in the criterion equation:

$$N = \frac{L_{ch}}{n.f}N_{ns} + \frac{L_{ch}k_r}{n.f.T}(N_{nT} + \tau_{vn}N_{vmn}) \rightarrow min \quad (7)$$

Having modified:

$$\frac{K_1}{n.f} + \frac{K_2}{n.f.T} \rightarrow min \quad (8)$$

where:

$$K_1 = L_{ch}.N_{sm} \quad (9)$$

$$K_2 = L_{ch}k_T(N_{nT} + \tau_{vn}N_{vmn}) \quad (10)$$

When milling operation, proportional parameter of displacement per rotation f and displacement per tooth fz are considered. Total production costs per a work-piece can be given by the relation:

$$N_c = \sum_{1}^{nu}N_i + N_v + \frac{N_d}{n} + \frac{N_{šz}}{n} \quad (11)$$

where:

N_c are total production costs per a work-piece, [€],

N_i – production costs to i- operational section, [€],

$N_{šz}$ - costs to a special device necessary for production of a given work-piece, [€],

n – number of produced pieces,

n_u – number of operational sections within one work-piece,

Costs to secondary work:

$$N_v = \tau_{Av}\; k_c\frac{M_o}{60}(1+\frac{RNS_{pl}}{100}) + \frac{O_s}{60} = \tau_{As}N_{vn} \quad (12)$$

Where:

N_{vm} – costs to secondary work, [€],

τ_{Av} – unit secondary time,[min.],

Rate costs:

$$N_B = k_c\frac{M_s}{60}(1+\frac{RNS_{pl}}{100}) + \frac{O_s}{60} = \tau_{BC}N_{Bm} \quad (13)$$

where:

N_{Bm} are rate costs, [€ [1]],

τ_{BC} – rate time with shift time over plus,[min]

Criterion of minimum production costs can be also given by the method of hourly operational costs.

Fixed costs whose share in total costs continually raises are just those unwelcome costs that burden production. This is one reason why it is success to produce with optimal capacity employment.

For practical utilization it is appropriate to express the capacity utilization in time units (hours, norm hours).

When formulating the cost model of a production workplace (of a machine) other advantageous properties of this method can be used.

1. Possibility of division (decomposition) hourly overhead lump sum into two individual units as follows:
    - Into hourly overhead lump sum of joint expenses (HRP_{sp})
    - Into hourly overhead lump sum of a production workplace (a machine) (HRP_{pra})
2. Possibility to decompose each hourly overhead lump sum as the sole number into more partial generic cost items that enables to separately observe individual impacts on hourly overhead lump sum.

The first property enables to present overhead costs to particular activities within the production process with the help of hourly overhead lump sum as the total of two separable components.

Total value of hourly overhead lump sum is consequently given by the total of both components.

While HRP_{sp} will be the same for all workplaces within a single organizational unit (center, operational department, etc.) to which joint expenses are related, the HRP_{pra} value will be unique for each workplace (machine, set of machines).[3,7,8]

The second property allows the distinction of general expenses from the point of generic e.g. for example to components of write-offs, rent (leasing), wages, energy costs, overhead material etc. It is crucial to choose such a classification in concrete application that would respond to the situation given. It is necessary to focus on main items sensible that the less important ones can possibly be joint together. It means for example that while the significant part of a production device will not be true but rented (leased) than that item has to appear in the HRP decomposition. While the production device is true it is useless to mention the item.

The simple solution is not to divide general expenses into two parts i.e. joint expenses of a department and costs of a workplace but leave it as the average value of hourly overhead lump sum designed on the basis of share of total of all overhead costs within a department and total department capacity. It is a simple solution that can be appropriate as the first stage of transition from a calculation through an extra charge to a calculation with the usage of the hourly overhead lump sum method.

By this simplification the influence of individual factors is covered and their impact is not clear in the total calculation.

Essential matters for the working process optimization are a solid analysis of on what the value of expense units depends. It is determining just because the information enables to manage the working process effectively.

From the point of preceding ideas, there is an alternative coming out to determine minute costs to machine work:

$$N_{sm} = k_c \frac{M_o}{60} + \frac{HRP_{sp}}{60} + \frac{HRP_{pra}}{60} \qquad (14)$$

where:

HRP_{sp} hourly absorbed lump sum of joint expenses, [€h⁻¹],

HRP_{pra} – hourly overhead lump sum of a production department (a machine), [€h⁻¹].

By analogy for minute expenses to exchange of a machine (relation 2):

$$N_{vmn} = k_c \frac{M_s}{60} + \frac{HRP_{sp}}{60} + \frac{HRP_{pra}}{60} \qquad (15)$$

The mentioned way of how to express cost items presents the model that comes out of the dynamic calculation principle and uses the method of hourly annual lump sums. It requires a solid analysis mainly of overhead expenses in the relation to a calculation unit. It is a model applicably open e.i. it accepts the costs units that are defined and able to find out in the application given. It relates the lowest organizational levels; it means workplaces (a machine) and a department.

It concerns the open model also from the point of the possibility to enhance it by more-detailed specification of dependence of costs on cutting conditions. [6,7,8]

CONCLUSIONS

When optimizing cutting conditions, under certain conditions it is possible to determine optimal serviceability of a machine according to a certain optimizing criterion independently on cutting condition optimization.

When coming out from optimal serviceability intended from the point of minimum production costs at cutting conditions optimizing, the criterion of maximum reduction is identical with the criterion of minimum production costs.

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