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Basic principles of technological object's touch registration during machining materials

Abstract. *Production of high-precision parts of devices requires high precision This is especially true for parts, manufactured on 6D-machines. Such technological movements require high accuracy using the appropriate software and measurement system. Lackck of feedback detail - cutting tool - the program leads to uncertainty of the location of the working space of the machine tool elements of the technological process. Therefore, the problem is to determine the coordinates of touching objects of the technological process in the working space of equipment.*

Streszczenie*. Produkcja precyzyjnych części urządzeń wymaga dużej precyzji. Dotyczy to zwłaszcza części produkowanych na maszynach 6D. Taki proces wymaga wysokiej dokładności co możliwe jest dzięki odpowiedniemu oprogramowaniu i systemowi pomiarowemu. Brak informacji zwrotnej narzędzie tnące-program prowadzi do niepewności lokalizacji w przestrzeni roboczej elementów obrabiarki. Dlatego problem polega na określeniu współrzędnych dotykających obiektów procesu technologicznego w przestrzeni roboczej sprzętu. (****Podstawowe zasady rejestrowania technologicznego kontaktu obiektu podczas obróbki materiałów****).*

Keywords: technological objects, electromagnetic field, Pandan zone, manufacturing process.
Słowa kluczowe: obiekty technologiczne, pole elektromagnetyczne, strefa Pandana, proces produkcji.

Introduction

The problem of increasing the efficiency of processing processes and improving the quality of products can be solved successfully by the creation and implementation of methods and systems for controlling the quality of production processes. The implementation of such methods is especially important for instrument making, where in many cases the requirements for improving the accuracy of processing are of paramount importance.

Analyzing the factors influencing the quality of the final product of mechanical processing [1, 2, 3], it should be noted that this is a set of indicators produced by the consumer market of products, formulated by quality standards.The rather superficial view of these indicators is to see the impact of equipment wear on their variations over time. The fluidity of the machine's parameters is especially felt on the exact parameters of the parts manufactured.

Hence, the quality parameter most exposed is the size of individual fragments of the part. The more precisely it is necessary to perform this or that part size, the greater the requirements for the accuracy of the machine. But due to the rapid wear and tear of the machine tool there are possibilities of violation of the above indicators. The main factor affecting this indicator is obvious hysteresis in the movement of the forward and reverse coordinates (duality - clearance). Analyzing the work of modern CNC-machines [4, 5, 6], it is necessary to notice the fact that despite the high precision of the motion of the working surface and the tool, the machine as a forming device is technologically unlocked in its circle. The movement of the working surfaces of the machine tool and the cutting tool can occur even without the presence of a detail on the workdesktop.

Such a lack of feedback leaves the technological information system in relation to the accuracy of the size be performed, the wear of the tool, the fidelity of the chosen mode of operation, the possibility of introducing the necessary corrections regarding the location of the part and its presence on the desktop in general. The currently existing control systems currently have a fairly management (crash) or are used strictly under the supervision of the operator, which greatly complicates the application of these systems in mass production. Consequently, the general conclusion is that in order to maintain the high quality of the size of the parts, it is necessary to close the technological circle and, consequently, to extend the life of the machine and the precision of production.

The precision of machining parts of the device depends on precise determination of the coordinate of the object's surface. In this case, it is necessary to determine the moment of contact of technological objects (parts and cutting tools), which allows to improve the accuracy of their positioning in the working space of the machine. At present, quite many researches [2, 3, 4] relate to the problems of measuring the coordinates of the location of the object, its current state and the effect on the accuracy of the part's surface [5, 6]. However, known methods do not have generalized principles of touching objectes registration of the technological process.

Therefore, the creation of new sensors for measuring the spatial-temporal parameters of technological process objects is associated with problems of improving the quality of manufacturing precision parts, which requires the definition of the basic principles of registration, in particular the touching of surfaces of objects, which is the main purpose of this research.

Model of registration and determination of surface coordinates

When machining materials on automated machines it is necessary to determine the flow coordinate position of the technological object, its speed, and also to record the time for which it moves in the working space of the machine. As a result, we need to determine the speed of its movement, which is not just the absolute speed, but the velocity of movement of the measuring element of the control of the position of the surface relative to the actual surface of the object [1, 5, 6].

Thus, in order to solve the problem of determining the coordinates of the object's surface, we need to make certain simplifications in order to obtain an abstract picture of the process.

First, it is necessary to determine the system of coordinates of space, that is to say, that there exists an imaginary and real system, in which we determine the surface's coordinate. Consequently, imaginary space is a space with ideal parameters, where each physical quantity or process has a well-defined mathematical description.

This space has no errors in any of its coordinates, mistakes in the imaginary system are catastrophic to the real.

For the most part, this fact can only be explained by the fact that we do not have a criterion for the correctness of what we are seeing. This is the primary technological phantom (TF I) that we store in our brain. For now, if we want to display it on paper, it will be a transition to real space, that is, any drawing is a technological phantom of the second kind (TF II), coupled with a real function [7, 8]. Of course, the linearity on paper is quite imaginative and it is easy to prove.

This is the way we move to the real system (space) of coordinates. Unlike the imaginary in this system, we have continuous errors and errors at any point of arbitrarily chosen coordinates. In addition to static, these coordinates have dynamic errors of various orders. That is, as a consequence, any parameter that enters the imaginary space to the real receives a whole range of various errors. Without consideration of all kinds errors, which are of secondary importance, we consider the uncertainty associated with the coordinate location of the abstract object (AO). The most difficult case in this case is the situation with the compatibility of imaginary and real coordinates.

The main issue of compatibility is the attempt to arrange real coordinate systems in such a way that the difference between imagination and reality is zero. In order to obtain it, it is necessary to move one coordinate system to a meeting, that is, there is a speed of approximation and, consequently, a dynamic compatibility error. We can't reduce it to zero, since "zero", as a physical quantity, is the prerogative of the imaginary system [9]. That is, at any point of the real space we get the coordinate error [$\mathbf{S}$]. Consequently, this leads to such a phenomenon as the imaginary stretching of the object we observe. As a result, we are not seeing a point, but a line depending on the value of the relative velocity. If we consider this situation on the basis of classical physics, then the simulation that is used in the theory of relativity when reflecting the relative motion of one reference system of coordinates in relation to the second is more suitable. In our case, this is an imaginary and real coordinate system. In this case, the real coordinates have some uncertainty about the imaginary. So, in this way, we got an idea of the coordinate system in which the process of determining the coordinates takes place.

The next step is to determine the speed of relative object's surface motion from the coordinate system. The process is necessary for any object without exception. This process occurs in the presence of a device measuring the length and time measuring device. The paradox of measuring the coordinates is that when we cross a certain coordinate (surface) that is desirable to determine, we do not immediately stop.

The movement continues for a while and it is not known where we (sensor) are on a relatively sought after surface. To do this, sensor need to go back and touch the surface again. At the same time, we have some speed V_p and touch analysis time to determine the coordinate (t_T) of the surface. So, we get the dynamic error [$\mathbf{S}$]. That is sensor need to go back and fix the surface coordinate again.

Consequently, there is some barrier that distributes processes to those that it registers and to those that do not register. Such an artificial barrier is the time (t_T) of the touch analysis. This is a purely natural solution, when for the sake of the existence of AO secondary informational flows are shifted. As a consequence, by rejecting all the secondary features, it can be argued that parameters t_T and V_p derive from the first level. If speed V_p is an external parameter for determining the coordinate of AO position, then t_T there is a function of the properties of the AO, produced during its lifetime.

That is, an imaginary model is create on a real object, but not conversely. So, we have a problem of measuring the coordinates with a certain sensor. In this situation, the sensor parameters have main influence effect on the accuracy of measuring the length, for example. Therefore, in further consideration, we will focus on the parameters of the sensor of the registration of coordinates.

Specifics of the sensors for registration of the surface coordinates

If we leave the secondary signs of processes in determining the coordinates of the AO surface, we are guided by the change of some physical parameter in time. It is desirable that this process of change takes place at the maximum speed, which enables us to obtain high accuracy of the determination of the surface coordinate. In addition to such a high-speed process, we need to have as fast as possible a sensor and information disassembly. It is clear that the resultant process will completely depend on the sensor parameters.

Thus, when processing information coming to the sensor of a particular class or subclass, there is a requirement for the high-speed transmission of the form of the signal to the processing devices, which in turn, according to its parameters of signal, work out the appropriate decision regarding further actions. It is practically impossible for us to obtain a non-distorted signal; we can only have a degree of approximation to the prototype.

If the information source works with sinusoidal oscillations, then the input of the processing device is the same oscillation, regardless of the type and specific data of the technological circuit linear circuit. Its effect consists only in changing the voltage and in the shift of its phase.

However, in the initial phase of signaling at touch, the signals can be torn in time, which leads to a situation where very fast processing of information is required. The main problem here lies in distinguishing a useful signal from a noise. In order to find out what influence the sensor gives its design on a controlled signal, it is necessary to consider how the types on the physical principle affect the distortion of a typical pulse waveform of a rectangular shape [8].

A continuous process, which is different from the initial touching process, is preceded by a transitional process, in which there is a sharp change in the mechanical, electrical and other physical parameters in the AO mass. The transition from one process to another can be caused by a change in the mechanical parameters or circuits of the electrical circuit, which in the general case is a switching or transient process.

Of course, it is possible theoretically to assume that switching is instantaneous, that is, switching off or switching electromechanical chains does not take time. However, the transition from the input mode to the next installed process is not immediately, but for some time.

This is explained by the fact that for each state of the electromechanical chain a certain reserve of energy of mechanical and electromagnetic fields corresponds. The transition to a new mode is associated with an increase or decrease in the energy of these fields. The kinetic or potential energy, which is concentrated in the mechanical parts of the AO, is not able to immediately (jump-free) change. If we take that AO sometimes have a high energy content of mass and shape, it is clear that their interaction causes a chain reaction between separate parts.

The consequence of such a reaction is the emergence of appropriate electrical leaks, which change the entire electrophysical structure of the AO. For the most part, this is a change in the energy connections between the inductive, capacitive and resistive parameters of the mechanical systems. These values although small enough, but they do not equal zero and have a very significant impact on the control systems.

The energy $W_L = Li_L^2/2$ accumulated in the magnetic field of inductance L, and the energy $W_C = Lu_C^2/2$ accumulated in the electric field of the capacity C, can not change immediately: the energy may vary continuously, without jumping, because otherwise the power equal to the derivative energy over time would reach infinite values that are physically impossible. That is why, for example, in the circuit with an inductive coil at the place of breakage inevitably there is a spark, in the bearing which consumes the energy accumulated in the magnetic field of the inductive coil. Similarly, if the short-circuit clamps of a condenser, which was charged in advance, are closed, then the electric energy accumulated in it dissipates in the support of the connected wire and between the contacts.

If you do not focus on secondary factors, then the transition process is the main determinant of the determination of the coordinates of any process.

Emergence factors of the of transient processes in technological equipment

If we exclude cases of looping inductance and short-circuiting the capacitance and consider the circles, in which the energy accumulated in the magnetic and electric field can dissipate in the form of heat in the support, then assuming that the switching is instantaneously, sparking can be ignored. It should be noted that transient processes with electromagnetic leakages are accompanied by all physical objects without exception.

For end the transition and the onset of a stable process, theoretically necessary is an infinitely long time. However, in practice, the time of the transition process is determined by a small interval, after which the current and voltage are so close to the constant values that the difference is practically not felt. The more intense the energy dissipates in the supports, the faster the transition process takes place. Here it should be noted that the further we move away from the moment of contact (transition process), the greater the loss of information about the coordinate of the surface until its complete loss.

Similar processes occur in the mechanics of devices and machines. This is especially true of its blocks and parts that are in motion during the metalwork. In this case, a large number of mechanical contacts leads to the appearance of local mechanical stresses and, as a consequence, the appearance of electric local currents.

If the electromechanical system consisted only of resistances and did not contain masses, inductances and capacities, then the transition from one stable state to another would occur instantaneously, without loss of time. In real electromechanical devices, thermal losses due to current, magnetic and electric fields to each other are related. As a result, using a special scheme and selecting the appropriate design parameters can accelerate or slow down the transient process.

In some cases, transient processes in electric circuits are undesirable and dangerous (for example, in case of cutting tool destruction and short circuits in power systems). Such processes need to be foreseen, because they are preceded by small size (powerful forces) transitional process-leaders, on the basis of which it is possible to predict with a fairly high accuracy the moment of destruction of the entire system [10, 11, 14].

In other cases, the process is a natural, normal mode of electromechanic's operation, as for example, it occurs in radio transmitting and receiving devices, automatic control systems in CNC machines [12, 15].

As you know, there are two models of the transition process: this is a unit function and δ-function. For example, in its physical nature, the process of metalworking causes phenomena, similar to the first, and the second. In addition, because of its specificity, the metalwork process initially forms short pulses, which are possible to simulate as δ-function, and then as a unit. In reverse motion of the cutting tool (from the part), the model of a single function must be replaced by δ-function.

For example, when the instrument is brought closer to the part, there are always short-pulsed bursts, the frequency of which is gradually increasing. The reaction of the sensor in this case can be described through δ-function. Due to the approach of the tool to the component, the magnitude of the electromagnetic field (EMF) is increasing, which leads to the formation of a signal of presence. This process has a description through a single function. In the future, when the tool enters the Pandan zone (PZ) of the part [13], the touch system generates short pulses in the math description the δ-function. When passing the PZ, the touch system generates a tapping signal again after the description of the single function. If the process takes place in the opposite direction, for example, leaving the cutting tool, then all processes take place in the opposite direction.

Since the basis of the simulation of transitions is a unit and δ-function, we pay attention to their properties. These functions relate to the elementary deterministic influence on the manifestation of the characteristics of dynamic systems, or the description of the idealized behavior of a dynamic object. For such a description, depending on the purpose, the ideal single function is used. Since there are at least five variants of its description in the technical literature, we give only one of them [14]:

(1) $$1(t-\varepsilon) = \begin{cases} 1 \text{ at } t > \varepsilon \\ 0 \text{ at } t < \varepsilon \end{cases}$$

and single impulse (Dirac function or δ-function),

(2) $$\delta(t-\varepsilon) = \begin{cases} 0 \text{ at } t \neq \varepsilon \\ \infty \text{ at } t \neq \varepsilon \end{cases}$$

also

(3) $$\int_a^b f_a(t)\delta(t-\varepsilon)dt = f_a(\varepsilon)$$

where a and b – free real numbers, $f_a(t)$ – sinusoidal oscillations or a complex of such oscillations.

The idealization of the real situation is that the impulse is considered to be an ideal rectangular with zero elongation and infinite amplitude. At the same time, the area of the unit pulse is finite and is equal to unity, since at $f_a(t) = 1$, $a = 0$, $b = 1$

(4) $$\int_0^t \delta(t-\varepsilon)dt = 1$$

Since it is assumed, that the impulse operates at the moment $t = \varepsilon$, the value of the integral is nonzero for $t = \varepsilon$, this will be recorded as $1(t-\varepsilon)$

Then formula (4) takes the form

(5) $$\int_0^t \delta(t-\varepsilon)dt = 1(t-\varepsilon)$$

where $1(t-\varepsilon)$ – single function. Therefore, we get the following

(6) $$\delta(t-\varepsilon) = \frac{d}{dt} 1(t-\varepsilon)$$

Both functions have the opportunity to obtain a more stringent mathematical result when considering the limit of convergent sequences of continuous functions. So, for example, a sequence of functions

(7) $$f_k(t) = \frac{1}{1+e^{-kt}}, \qquad k = 0,\ 1,\ 2,\ ...$$

has limits: 0 at $t < 0$, 1 at $t > 0$ and 0.5 at $t = 0$ (Fig. 1a). Sequence of functions

(8) $$g_k(t) = a^{\exp(-kt)}, \qquad 0 < a < 1,\ k = 0,\ 1,\ 2,\ ...$$

has limits: 0 at $t < 0$, 1 at $t > 0$ (Fig. 1b).

Obviously, the limits of these sequences determine the unit function, i.e.

(9) $$\delta(t) \equiv 1(t) = \begin{cases} 0 & \text{for } e < 0 \\ 1 & \text{for } e > 0 \end{cases}$$

The value of the unit function at $t = 0$ remains unclear, since defining its sequences at this point are directed to different limits.

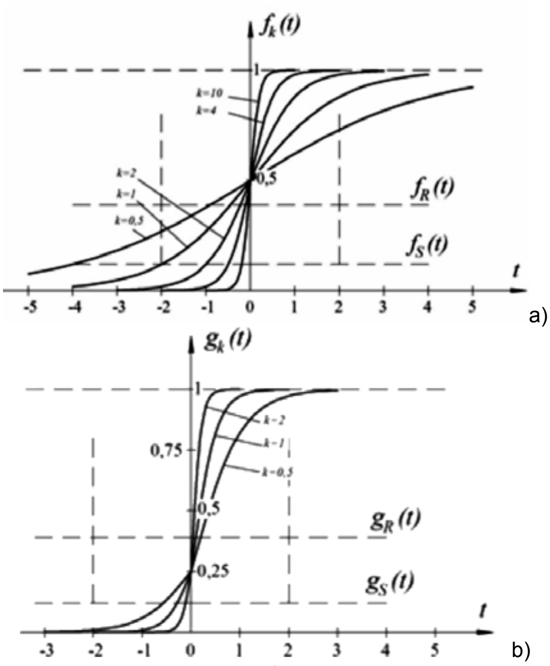


Fig. 1. The general nature of the transition process: a) by dependence (7), b) by dependence (8)

What we have reviewed is the theoretical basis, which provides a description of the front edge of the transition process when determining the surface coordinate. The determination of the coordinates takes place using the level of registration of the moment of touch $f_R(t)$ or $g_R(t)$. In addition, the registration process interferes with the noise component $f_R(t)$ or $g_R(t)$, which is accompanied by a series of short-term impulses [16-18].

The noise level problem is that we can't reduce the level of registration ($f_R(t)$, $g_R(t)$), to the level of noise in order to increase the speed. The level of noise has some instability, the worst of which is the presence of short pulses. These impulses are characterized in their nature and the fronts are very similar to the previous review. So, we are only able to approach the level of noise.

Let's consider, what happens when registering a coordinate in two simple cases that occur in nature and technology. Currently, this relates to the rotational and linear motion associated with coordinate control.

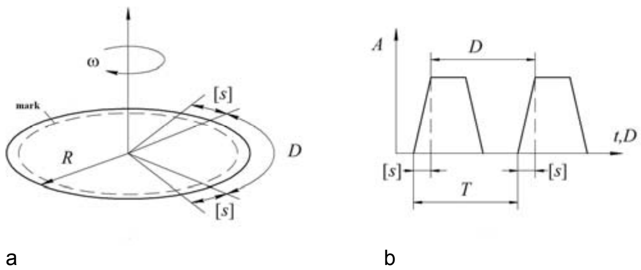


Fig. 2. Coordinate cases: a) rotational motion; b) linear motion

This dual simulation gives us a number of possibilities to evaluate the magnitude of the coordinate and its error from two perspectives. The best technical example of this case may be the movement of the tape under the action of the rotation of the shaft. In this case, the coordinates of each mark of the shaft must coincide with its linear representation. The coordinate of each mark on the Fig. 2,a but should coincide with the coordinate of the mark on Fig. 2,b. If we discard all secondary features, then we have the opportunity to perceive the registration of each mark, which is deterministic in space with the corresponding deterministic time line, but relative to absolute time. This will enable us to combine a single distance and time through the speed [19, 20].

Therefore, this addiction can be defined as:

(10) $$D + [\mathbf{S}] = tV_L = t\omega R\ ,$$

where D - duality (uncertainty) coordinates in distance (time) between intervals of coordinate control, $[\mathbf{S}]$ - coordinate control interval (elemental error) […]; V_L - linear velocity; R – radius of rotation; t – flow time for a cycle of measurement, which per rotation is equal to the period.

In order to control the coordinate, we need a mark of size not less than $[\mathbf{S}]$. You can get the maximum coordinate control density only for the maximum number of marks within a single revolving object. Within this circle, this number will be determined as

(11) $$k_P^{\max} = \frac{2\pi R}{[\mathbf{S}]}\ ,$$

since the length of the circle is irrational, it is necessary to apply the entire function [ ], i.e.

(12) $$k_P^{\max} = E\left(\frac{2\pi R}{[\mathbf{S}]}\right),$$

Consequently, the number of marks is inversely proportional to the magnitude $[\mathbf{S}]$. The value $[\mathbf{S}]$ is dependent on the structural features of the control system. Its value may vary within a wide ranges (Fig. 3), but making a mark of significant size for controlling speed at high speeds makes no sense. The minimum size limit can't be less than the atom's diameter, but this is in the case of speed approaching zero. Then the number of labels can reach significant values, but there is a purely structural constraint.

The essence of this limitation is that the sensor, however qualitative we did not, would still have some inertia, as mentioned above. The essence of this inertia is that after reacting to the registration of the coordinates, it does not react to the input signal, that is, it is in a state of insensitivity. This feature is typical for all sensors without exception. At the moment, the best-performing designs have this interval in size $[\mathbf{S}]$ and only then react to another signal. The best option is when the length of the mark is 4$[\mathbf{S}]$, which will be substantiated further. In this expression (12) takes the form

$$k_P^{\max} = E\left(\frac{\pi R}{2[\mathbf{S}]}\right), \tag{13}$$

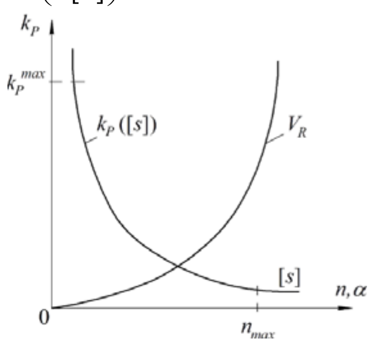


Fig. 3. Dependence of the number of marks and speed V_L on the structural features of the control system

We will now consider the inertia of the entire registration system as a whole. This parameter has a dual character, namely mechanical or electrical, or electromechanical character. That is, the resulting process is a summary, for this we consider the case of a simple combined case: imagine that the mark is a triangular figure on a moving object (Fig. 4).

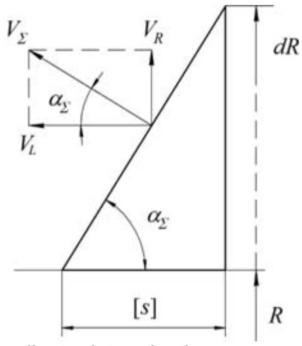


Fig. 4. Control of coordinate determination

The determination of the coordinates takes place within the interval $[\mathbf{S}]$. At the same time, the sensor reacts to the growth rate of the signal V_R. This speed has a direct influence on the overall system performance and accuracy of the coordinate determination. In this case we obtain:

$$V_R = V_L \operatorname{tg} \alpha_\Sigma , \tag{14}$$

Using expression (13), we have the opportunity to determine the magnitude $[\mathbf{S}]$, that is, after a series of transformations we obtain the following result

$$[\mathbf{S}] = E\left(\frac{\pi V_R}{2\omega k_m^{\max} \cdot \operatorname{tg} \alpha_\Sigma}\right), \tag{15}$$

where $\operatorname{tg} \alpha_\Sigma = \operatorname{tg}(\alpha_M + \alpha_e)$

At the same time, the angle α_M is equivalent to the mechanical parameters of the system, and the angle is the equivalent of the electrical part of the system. With respect to these angles it is necessary to make a certain remark. For example, a mechanical angle may approach $\pi/2$, but never reach it, because it is neither theoretical nor practically impossible. The maximum value of this angle $\pi/2 - \operatorname{arctg}[\mathbf{S}]$. In this case, the system will have maximum qualitative indicators. At small angles α_M, the system gradually loses the ability to register coordinates, and at a angle less $\operatorname{arctg}[\mathbf{S}]$ than the general loses the ability to fix the coordinate. The electric angle α_e also works the same way, but without the angle α_M one cannot get the right result.

Consequently, having such a number of parameters, it makes sense to formulate the main problem of determining the coordinates, namely: the more often, the better. The solution to this problem is based (limited) by the properties of the sensor, that is, the magnitude $[\mathbf{S}]$. For the general properties of the sensor, the value $[\mathbf{S}]$ is the limited, that points to its physical capabilities. The reason lies in the fact that any sensitive element has the property of restoring its functions. Consequently, as a result, we have zones of sensitivity to the controlled process. Make it smaller than the speed of the reaction to the input process can, but it will have significant hardware costs. Therefore, one should be guided by the value $[\mathbf{S}]$ as the final one. In this case, based on this value, we have the opportunity to construct a diagram of the maximum time control of the surface (Fig. 5).

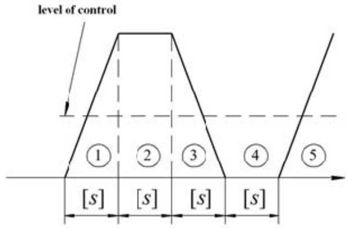


Fig. 5. Optimization of the coordinate cycle determination

According to this principle, in the first quarter-period (Fig. 5,1), we register the coordinate according to the same principle as in the case of a normal transient process (Fig. 4). The next quarter-period (Fig. 5) is a zone of insensitivity to the input signal, ie the tangent is outside the control of the surface.

During the next quarter-period (Fig. 5), the tangent leaves the surface and, as a result, forms a signal of the output coordinate, which is inverse to the functions depicted in Fig. 1, a, b in the fourth quarter-period (Figs. 5) we get the static insensitivity necessary to restore the surface coordinate control system. So, the real number of labels can be defined from expression (12), like

$$k_P^{\max} = E\left(\frac{\pi R}{2[\mathbf{S}]}\right), \tag{16}$$

Analyzing pre-determined signs of determining the object's coordinates, we can state that from the point of view at optimality, the dependence is reflected in Fig. 5, must have the form of a sinusoid with a period of 4 [4]. In this case, we get the maximum quality of coordinate control.

So, analyzing the transients, we must note that the feature δ-function is that it can be represented as an idealized sequence of impulses with a period T_0. If the amplitude is constant, then (Fig. 6,a)

$$f_a(t) = \sum_{i=1}^{N} a\delta(t - iT_0), \tag{17}$$

If a variable rate is provided, then (Fig. 6, b),

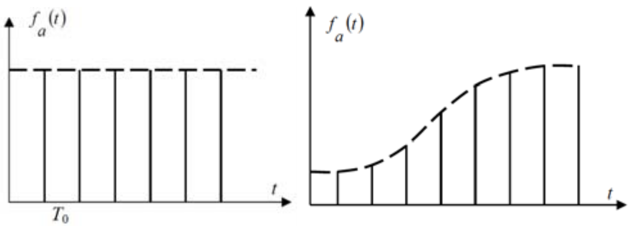
$$f_a(t) = \sum_{i=1}^{N} f_a(iT_0)\delta(t - iT_0). \tag{18}$$

Such tasks usually require a prior approximation of the process and characteristics of the system.

In the same way as in [14], we deal with the interaction of two deterministic dynamic objects, or the study of the effect of one another, that is very similar to the situations we are considering in a particular case.

Currently, dependence (18) is the basis of the work of the control board of the cutting tool state [13].

Consequently, as previously discussed, the interaction of the cutting tool and the detail is an integral part of the elementary processes. Therefore, in the end it should be noted that the mathematical model on the basis of a single function, impulse, etc., most reflects the real processes when touching technological objects.



a) b)

Fig. 6. Dependence of the idealized δ-function: a) by dependence (10) and constant amplitude; b) by dependence (11) and variable amplitude

Quite often, these models use Fourier transforms and integral type functions [20]

$$f(\lambda)=\int_a^b W(\lambda,\rho)f(\rho)dp \quad (19)$$

is the partial case of which is the Fourier integral.

For metalworking, the most typical are pulses of a triangular appearance or those that are close to their shape. This case has a description in the author's works [7, 14] and therefore is not given here except for its consequences, which is extremely important when constructing systems of control touch.

Conclusions

The situation discussed in this paper, is closely related to the transients that occur when the cutting tool contacts the detail's surface when the noise component of the interference is practically the same as the touch signal. Therefore, it is necessary to consider exactly what these differences make, that will allow to identify the touch signal.

Determining the coordinates of the surface and time coordinates of the contact point of the component and the instrument with high accuracy will allow the measurement of microhardness and roughness of the surface of the parts in automatic mode on CNC-machines, which does not require a change in the positioning of the part, and thus increases the accuracy of the manufacture of the part.

The research has shown that there are currently no automated devices and systems for controlling the fluidity of the surface coordinates of a component or tool that provide superfine precision in the performance of the surface shape of the component, and, moreover, there are no means for controlling the location of the working surfaces in the working space of technological instrumentation equipment. Therefore, the proposed technical solutions have fundamentally new principles of action that increase the accuracy of manufacturing parts of devices.

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