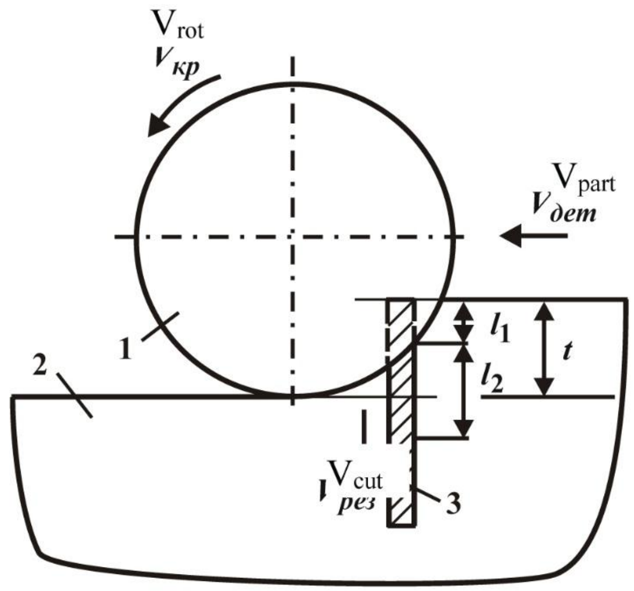

Figure 3: Thermal process parameters in flat grinding: 1: wheel; 2: part; 3: adiabatic rod (l_1: removed section of adiabatic rod; l_2: heat penetration depth into adiabatic rod; *t*: grinding depth)

According to equation (10), the parameter l_2 is determined only by one variable τ : the larger it is, the larger the parameter l_2 is, i.e. the more heat transfers to the adiabatic rod, the larger the parameter l_2 is and the rod heats up more.

This behavior is valid when the heat flow q affects the fixed end surface of the adiabatic rod. However, if one considers the motion of the heat flow q along the adiabatic rod with a fixed speed V_{cut} determined by the cutting speed of the rod with the grinding wheel, then the behavior of l_2 and the cutting temperature will change. Heating time of the adiabatic rod during its cutting (τ), which is used in equation (10), will be shorter than the time of contact of the grinding wheel with the adiabatic rod τ (cutting time with the grinding wheel of the adiabatic rod). Naturally, a decrease in the heating time of the adiabatic rod will lead to a decrease in the parameter l_2 and, correspondingly, the cutting temperature. Therefore, knowledge of the behavior of this time has a great theoretical and practical significance in the assessment of heat stress for the cutting process. For the convenience of analysis, continuous steady motion with the speed V_{cut} of a heat source along an adiabatic rod can be considered periodically with a step $V_{cut}\times d\tau$, where $d\tau$ is an infinitesimal time step[s]. Then, during the time $d\tau$, the depth of heat penetration into the adiabatic rod can be determined as follows:

$$l_{2_0}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times d\tau} \qquad (11)$$

Due to the cutting of a section from the adiabatic rod with a length equal to $V_{cut}\times d\tau$ the depth of heat penetration into the adiabatic rod decreases by a value equal to $V_{cut}\times d\tau$ and becomes equal to:

$$l_{2_1}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times d\tau}-V_{cut}\times d\tau \qquad (12)$$

Taking into account that the parameter l_2, based on equation (10), is determined only by one variable τ, equation (12) can be represented as follows:

$$l_{2_1}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_1} \qquad (13)$$

where τ_1: is a heating time of the adiabatic rod when its cut for the time period $V_{cut}\times d\tau$ [s].

Comparing equations (12) and (13), the following equation is obtained:

$$\tau_1=\frac{c\times\rho}{2\times\lambda}\cdot\left(\sqrt{\frac{2\times\lambda}{c\times\rho}\times d\tau}-V_{cut}\times d\tau\right)^2=d\tau\times(1-\alpha)^2 \qquad (14)$$

where $\alpha=\frac{V_{cut}\times d\tau}{l_{2_0}}<1$.

As can be seen, the condition $V_{рез}\cdot d\tau$ is required due to cutting of a section of the adiabatic rod in length $V_{cut}\times d\tau$, the heating time of the rod decreases, that in accordance with equation (13) leads to a decrease in the parameter l_{2_1}:

$$l_{2_1}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times d\tau\times(1-\alpha)^2}=l_{2_0}\times(1-\alpha) \qquad (15)$$

In this case the depth of heat penetration into the adiabatic rod l_{2_1} is measured from the point of the heat source effect, which moves along the adiabatic rod at a speed of V_{cut}. Similar to parameter l_{2_1}, the parameter l_{2_2} (at $V_{cut}\times d\tau$) can be determined as follows:

$$l_{2_2}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times(d\tau+\tau_1)}-V_{cut}\times d\tau \qquad (16)$$

On the other hand:

$$l_{2_2}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_2} \qquad (17)$$

where τ_2: is a heating time of the adiabatic rod when its cut for the time period $2\times V_{cut}\times d\tau$ [s].

Comparing equations (16) and (17), the following equation is obtained:

$$\sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_2}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times(d\tau+\tau_1)}-V_{cut}\times d\tau \qquad (18)$$

From which

$$\tau_2=\frac{c\times\rho}{2\times\lambda}\times\left(\sqrt{\frac{2\times\lambda}{c\times\upsilon}\times(d\tau+\tau_1)}-V_{cut}\times d\tau\right)^2 \qquad (19)$$

or

$$\tau_2=d\tau\times\left(\sqrt{1+\frac{\tau_1}{d\tau}}-\alpha\right)^2 \qquad (20)$$

Then, taking into account equation (14) the following equation can be found:

$$\tau_2=d\tau\times\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]^2 \qquad (21)$$

Obviously, the condition $\tau_2>\tau_1$ is correct, i.e. as the length of the removed section of the adiabatic rod increases, the time of its heating decreases:

$$l_{2_2}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times d\tau}\times\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]=$$

$$l_{2_0} \times \left[\sqrt{1+(1-\alpha)^2} - \alpha \right] \quad (22)$$

Next, the parameter l_{2_3} (at $V_{cut} \times d\tau$) similar to parameters l_{2_1} and l_{2_2} can be determined as follows:

$$l_{2_3} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times(d\tau+\tau_2)} - V_{cut}\times d\tau \quad (23)$$

$$l_{2_3} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_3} \quad (24)$$

where τ_3: is a heating time of the adiabatic rod when its cut for the time period $3\times V_{cut}\times d\tau$ [s].

Comparing equations (23) and (24), the following equation is obtained:

$$\tau_3 = \frac{c\times\rho}{2\times\lambda}\times\left(\sqrt{\frac{2\times\lambda}{c\times\rho}\cdot(d\tau+\tau_2)} - V_{cut}\times d\tau\right)^2 = d\tau\times\left(\sqrt{1+\frac{\tau_2}{d\tau}} - \alpha\right)^2 \quad (25)$$

Taking into account equation (21) the following equation can be found:

$$\tau_3 = d\tau\times\left\{\sqrt{1+\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]^2} - \alpha\right\}^2 \quad (26)$$

As can be seen, the condition $\tau_3 > \tau_2 > \tau_1$ is met. Accordingly, the parameter l_{2_3} can be determined as follows:

$$l_{2_3} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times d\tau}\times\left\{\sqrt{1+\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]^2} - \alpha\right\} =$$

$$l_{2_0}\times\left\{\sqrt{1+\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]^2} - \alpha\right\} \quad (27)$$

Comparing equations (27), (22) and (15), it is seen that the condition $l_{2_3} > l_{2_2} > l_{2_1}$ is correct. Consequently, with an increase in the number of steps equal to $V_{cut}\times d\tau$ the depth of heat penetration into the adiabatic rod increases.

Next, the parameter l_{2_4} (at $V_{cut}\times d\tau$) can be determined as follows:

$$l_{2_4} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times(d\tau+\tau_3)} - V_{cut}\times d\tau \quad (28)$$

$$l_{2_4} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_4} \quad (29)$$

where τ_4: is a heating time of the adiabatic rod when its cut for the time period $4\times V_{cut}\times d\tau$ [s].

By comparing equations (28) and (29), the following is found:

$$\tau_4 = \frac{c\times\rho}{2\times\lambda}\times\left(\sqrt{\frac{2\times\lambda}{c\times\rho}\times(d\tau+\tau_3)} - V_{cut}\times d\tau\right)^2 = d\tau\times\left(\sqrt{1+\frac{\tau_3}{d\tau}} - \alpha\right)^2 \quad (30)$$

Substituting equation (26) into equation (30), we obtain the following:

$$\tau_4 = d\tau\times\left\{\sqrt{1+\left[\sqrt{1+\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]^2}-\alpha\right]^2} - \alpha\right\}^2 \quad (31)$$

Based on equations (31), (26), (21) and (15) and following that: $\tau_4 > \tau_3 > \tau_2 > \tau_1$.

Substituting equation (31) in equation (29), we obtain the following:

$$l_{2_4} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times d\tau}\times\left\{\sqrt{1+\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]^2} - \alpha\right\} =$$

$$l_{2_0}\times\left\{\sqrt{1+\left[\sqrt{1+\left[\sqrt{1+(1-\alpha)^2}-\alpha\right]^2}-\alpha\right]^2} - \alpha\right\} \quad (32)$$

Similarly, it is possible to determine the value:

$$l_{2_n} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_n} = \sqrt{\frac{2\times\lambda}{c\times\rho}\times(d\tau+\tau_{n-1})} - V_{cut}\times d\tau \quad (33)$$

It has been found by calculations, that with an increase in the number of steps n the ratio l_{2_n}/l_{2_0} increases (Table 1). However, as it can be seen, the pattern of change of parameter l_{2_n} with an increase in the number of steps n is rather complicated and it is difficult to express it by a simple analytic equation. Therefore, it is much easier to determine the parameter l_{2_n} using numerical calculations in equation (20), considering step n instead of step 2, and step $(n-1)$ instead of step 1:

$$\frac{\tau_n}{d\tau} = \left(\sqrt{1+\frac{\tau_{n-1}}{d\tau}} - \alpha\right)^2 \quad (34)$$

where τ_n, τ_{n-1}: is the heating times of the adiabatic rod when cut for the durations of $n\times V_{cut}\times d\tau$ and $(n-1)\times V_{cut}\times d\tau$ [s], respectively.

Table 1: Calculated values for the ratio l_{2_n}/l_{2_0}

n	1	2	3	4	5	6	7
l_{2_n}/l_{2_0}	0.800	1.080	1.270	1.417	1.534	1.631	1.713

From the physical standpoint, equation (34) corresponds to equation (33):

$$l_{2_n} = l_{2_{(n-1)}} + V_{cut}\times d\tau \quad (35)$$

Taking into account that:

$$\sqrt{\frac{2\times\lambda}{c\times\rho}\times(d\tau+\tau_{n-1})} - \sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_n} = V_{cut}\times d\tau \quad (36)$$

After rearrangement, equation (36) takes the form of equation (34). The dimensionless value can vary from 0 ... 1. For the case α = 0.2, the calculated equation (34) will be as follows:

$$\frac{\tau_n}{d\tau} = \left(\sqrt{1+\frac{\tau_{n-1}}{d\tau}} - 0.2\right)^2 \quad (37)$$

The initial value $\tau_1/d\tau$ is determined from equation (14) and is equal to 0.64. From equation (37) we obtain $\tau_2/d\tau$ = 1.1677. Substituting this value in equation (37), the following is obtained: $\tau_3/d\tau =$ 1.6187, and so on. Figure 4 shows the calculated values $\tau_n/d\tau$ for the cases, when

$\alpha =$ 0.1 and $\alpha =$ 0.2, which with increasing number of steps n increase steadily, asymptotically approaching steady-state (maximum) values.

To determine the value τ_n, it is necessary to know the value $d\tau$, this can be determined from the equation $\alpha = \frac{V_{cut} \times d\tau}{l_{2_0}}$:

$$d\tau = \frac{2 \times \lambda}{c \times \rho} \times \left(\frac{\alpha}{V_{cut}} \right)^2 \qquad (38)$$

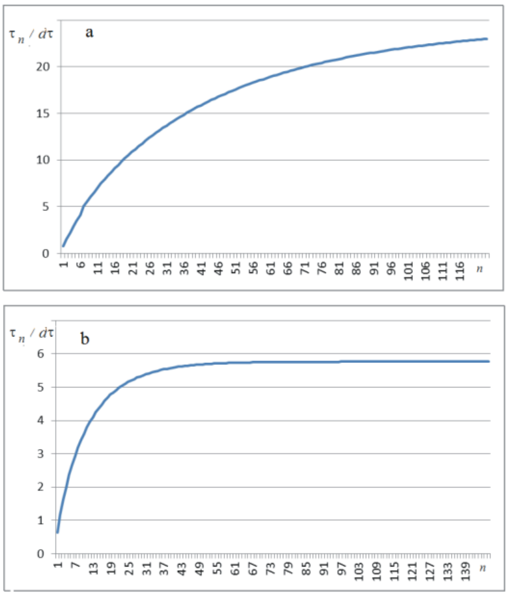

Figure 4: Relation between $\tau_n / d\tau$ and *n* for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

Taking the initial data for machining of steel ШХ15 (similar steel grades are 52100; or 1.3505): temperature conductivity coefficient $a = \lambda / c \times \rho =$ 8.4·10-6 m2/s; V_{cut} =3.33 mm/s; $\alpha =$ 0.2, there is: $d\tau =$ 0.0605 s. Correspondingly, for the case if $\alpha =$ 0.1 we obtain: $d\tau =$ 0.0151 s. Figure. 5 shows the calculated values τ_n for the cases when $\alpha =$ 0.1 and $\alpha =$ 0.2, obtained by multiplying the values $\tau_n / d\tau$ (given in Figure 4) by the values 0.0605 s and 0.0151 s, respectively, using Compass 3D software.

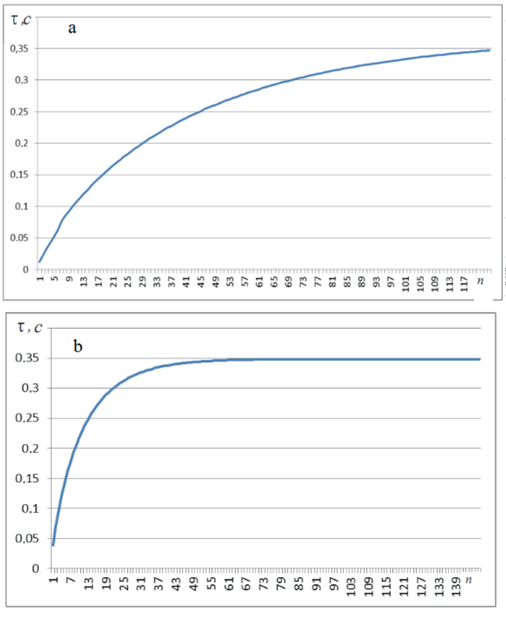

Figure 5: τ_n and n for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

As it can be seen, calculated τ_n values behaves similar to $\tau_n / d\tau$ values, i.e. with increasing the number of steps (n)it steadily increase asymptotically reaching a steady-state (maximum) values.

Figure 6 shows the nature of change in the heating time of the adiabatic rod during its cutting τ_n as a function of the contact time of a grinding wheel with the adiabatic rod $\tau = n \times d\tau$ (of the time of cutting of the adiabatic rod with a wheel). In this case, with an increase of time τ the time τ_n changes similar to Figure 5.

Figure 7 shows the calculated values of the ratio τ_n / τ and time τ : the larger τ is, the smaller the ratios τ_n / τ are. Moreover, for the case when $\alpha =$ 0.2 the ratio τ_n / τ takes smaller values than for the case when $\alpha =$ 0.1. Since a decrease in the value $d\tau$ makes it possible to obtain more accurate τ_n and τ_n / τ values, it is obvious that the case with $\alpha =$ 0.1 more accurately reflects the patterns of change of these values. Therefore, the ratio τ_n / τ should decrease to a value 0.2 (Figure 7a), and not to 0.02, as follows from Figure 7b. The obtained result shows that the heating time of the adiabatic rod can be much shorter (up to 10 times) than the time of its contact with the grinding wheel during grinding. Therefore, the proposed theoretical approach, by accounting the cutting of the adiabatic rods with the grinding wheel during grinding, makes it possible to refine the known solutions, and to make the calculated grinding diagram closer to the real machining conditions [9].

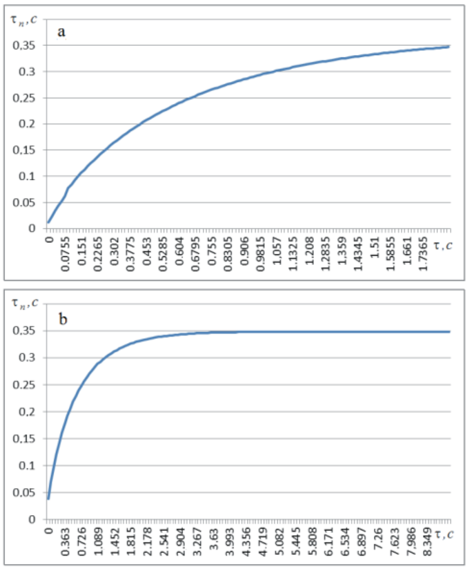

Figure 6: τ_n vs n τ for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

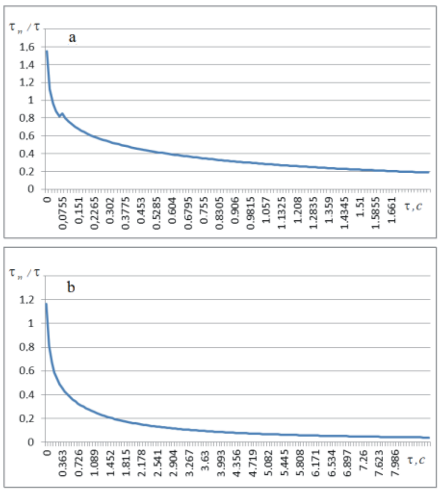

Figure 7: τ_n / τ vs. n τ for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

On the basis of the equation for determining cutting operation $A = N \cdot \tau$ (where N is a grinding power [W]), the ratio τ_n / τ is equal to the ratio of the amount of heat leaving into the adiabatic rod to the total amount of heat released during the cutting process. Consequently, as the time τ increases, the amount of heat leaving into the adiabatic rod (into the surface layer of the workpiece) decreases, and the amount of heat leaving into the formed chips increases. Then, based on Figure 7, the fraction of heat leaving into the adiabatic rod can be very small, i.e. low percent.

Using the calculated values τ_n, Figure 8 shows the calculated values of heat penetration depth into the adiabatic rod $l_{2_n} = \sqrt{\frac{2 \times \lambda}{c \times \rho} \times \tau_n} = \sqrt{2a \times \tau_n}$ when machining steel ШХ15 (similar steel grades are52100, or 1.3505) (temperature conductivity coefficient $a = \frac{\lambda}{c \times \rho} =$ 8.4×10-6 m2s). As it can be seen, as the contact time between tool and adiabatic rod τ increases to a certain value, the parameter l_{2n} reaches a limit value corresponding to the state of thermal saturation of the surface layer of the work piece, and remains constant.

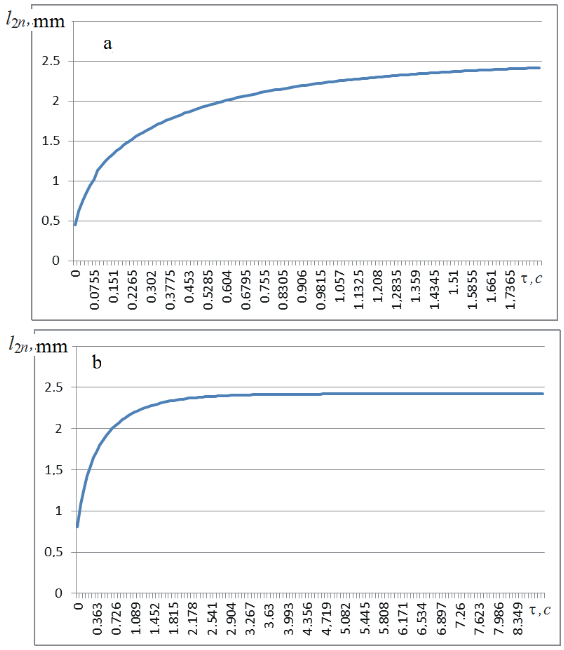

Figure 8: l_{2n} vs. τ for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

For the final decision on the selection of the optimal ratio τ_n / τ, it is necessary to know the nature of change in the cutting temperature θ vs. time τ. Therefore, using the calculated values l_{2n}, Figure 9 shows calculated values of the cutting temperature $\theta = \frac{q \times l_{2_n}}{\lambda}$, obtained by considering the equations for determining heat-flux density $q = \sigma \times V_{cut}$ (W/m2) and conventional cutting stress $\sigma = 2\sigma_{comp.} / K_{cut}$ (N/m2), where $\sigma_{comp.}$: is a ultimate compression strength of the work material (for steel ШХ15: $\sigma_{comp.}$ = 2000 N/mm2), $K_{cut} =$ 0.4: is a cutting factor [6]. Then $\sigma =$ 10 000 [N/mm2]=1010 [N/m2], $V_{cut} =$ 3.33 [mm/s], and $\lambda =$ 42 [W/ (m.degree)].

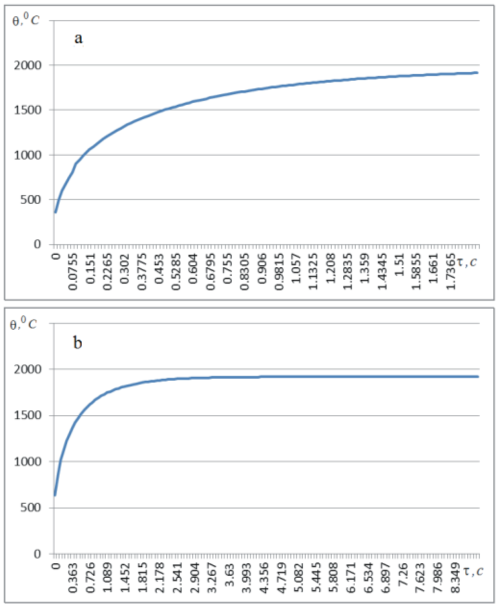

Figure 9: θ vs. τ for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

As the contact time between the wheel and the adiabatic rod τ increases, the cutting temperature θ initially increases to a certain value, and then it actually stabilizes and remains constant at approximately 2000 oC. Figure 9 shows that the cutting temperature θ for the case when $\alpha =$ 0.1 is stabilized at lower values of the time τ, than for the case when $\alpha =$ 0.2. However, the maximum value of the cutting temperature θ remains the same for both cases. This indicates that there is no connection between the parameter α and the maximum value of the cutting temperature θ.

For comparison, Figures 10 and 11 show the calculated values of the parameters l_2 and θ obtained using equation (10) and the relation $\theta = q \times l_2 / \lambda$, which do not take into account the motion of the heat source along the adiabatic rod, i.e. for the condition V_{cut} = 0. Equation (10) contains the contact time of the wheel with the adiabatic rod τ, while the equations, taking into account the motion of the heat source along the adiabatic rod with a speed V_{cut}, contain the heating time of the adiabatic rod during its cutting τ_n. As shown above, the condition $\tau_n < \tau$ is correct (Figure 7). Thus, as the time τ increases, the time τ_n initially increases, and then it stabilizes and remains constant. This predetermines the nature of the change in the parameters l_{2n} and θ (Figures 8 and 9): they increase initially with increasing time τ, and then they assume constant values.

Based on the figures depicting the change in the parameters l_2 and θ (Figures 10 and 11), obtained without taking into account the motion of the heat source along the adiabatic rod, their continuous increase takes place with increasing time τ. This is due to the fact that all the heat generated during the cutting process transfers to the adiabatic rod, i.e. into the surface layer of the workpiece. Therefore, the longer the contact time between the grinding wheel and the adiabatic rod τ, the more heat transfers into the workpiece and, accordingly, the greater parameters l_2 and θ well be.
Obviously, at relatively small values of time τ, the difference between the parameters l_2 and θ obtained without taking into account and with taking into account the motion of the heat source along the adiabatic rod is insignificant. However, as the time τ approaches the value at which the parameters l_{2n} and θ stabilize (Figures 8 and 9), this difference increases, which introduces a fundamental changes in the patterns of the

formation of the parameters of the thermal process during cutting.

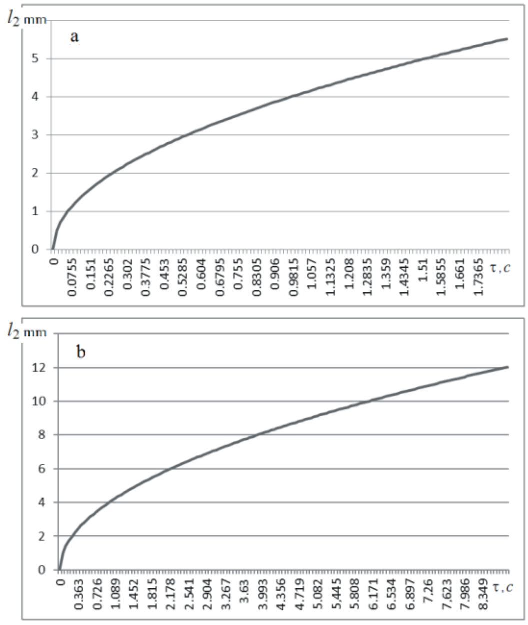

Figure 10: l_2 vs. τ for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

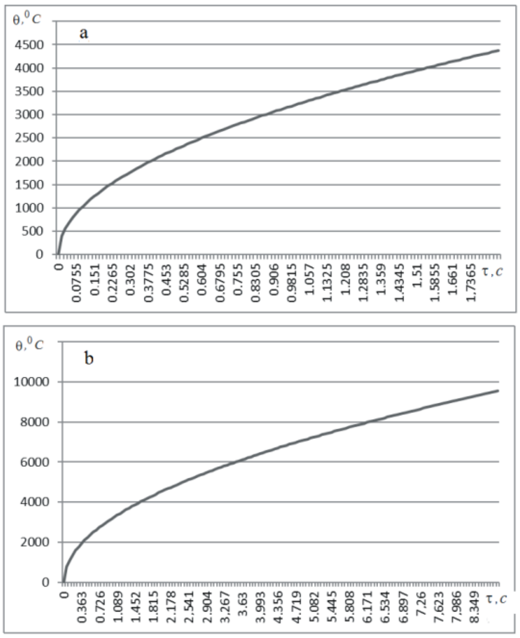

Figure 11: θ vs. τ for $\alpha =$ 0.1 (a) and $\alpha =$ 0.2 (b)

To determine the maximum values $\tau_n / d\tau$ and τ_n it is necessary to use the condition $\tau_n \approx \tau_{n-1}$. Then equation (37) takes the following form:

$$\frac{\tau_n}{d\tau}-\sqrt{1+\frac{\tau_n}{d\tau}}=-\alpha \tag{39}$$

After multiplying and dividing the left-hand side of equation (39) by the conjugate value $\frac{\tau_n}{d\tau}-\sqrt{1+\frac{\tau_n}{d\tau}}$:

$$\frac{1}{\left(\sqrt{\frac{\tau_n}{d\tau}}+\sqrt{1+\frac{\tau_n}{d\tau}}\right)}=\alpha \tag{40}$$

Considering $\frac{\tau_n}{d\tau}>1$ and $\sqrt{\frac{\tau_n}{d\tau}}\approx\sqrt{1+\frac{\tau_n}{d\tau}}$, the maximum value of the variable will be as follows:

$$\frac{\tau_n}{d\tau}=\left(\frac{1}{2\times\alpha}\right)^2=\frac{\lambda}{c\times\rho}\times\frac{1}{2\times V_{cut}^2\times d\tau} \tag{41}$$

Taking into account that $q=\sigma\times V_{cut}$ [6]:

$$\tau_n=\frac{\lambda}{c\times\rho}\times\frac{1}{2\times V_{cut}^2}=\frac{a}{2\times V_{cut}^2} \tag{42}$$

$$l_{2_n}=\sqrt{\frac{2\times\lambda}{c\times\rho}\times\tau_n}=\frac{\lambda}{c\times\rho}\times\frac{1}{V_{cut}}=\frac{a}{V_{cut}} \tag{43}$$

$$\theta_{\max}=\frac{q\times l_{2_n}}{\lambda}=\frac{\sigma}{c\times\rho} \tag{44}$$

where σ: is the conventional cutting stress (machining efficiency [N/m2].

Thus, it is theoretically established that the maximum cutting temperature at grinding is determined only by the conventional cutting stress σ and does not depend on the parameters of the grinding mode and the characteristics of the grinding wheel. Therefore, the main condition for reducing the cutting temperature during grinding is the reduction of the conventional cutting stress σ due to the reduction of friction in the cutting zone and the increase in the cutting ability of the grinding wheel [10].

On the basis of equations (42) and (43), with an increase of V_{cut} the parameters τ_n and l_{2n} significantly decrease in the steady-state thermal process when grinding and the time τ_n decreases more than the depth of the heat penetration into the surface layer of the work piece l_{2n}. For the cases when $\alpha =$ 0.1 and $\alpha =$ 0.2, according to equation (41), the ratio $\tau_n / d\tau$ will take the following values:

$$\frac{\tau_n}{d\tau}=25 \text{ and } \frac{\tau_n}{d\tau}=6.25 \tag{45}$$

Taking into account the obtained values $d\tau =$ 0.0151 s (for $\alpha =$ 0.1) and 0.0605 s (for $\alpha =$ 0.2), the parameter τ_n in the steady-state thermal process at cutting, based on equation (45), should take approximately the same value equal to $\tau_n =$ 0.3781 s (Figure12). Consequently, the parameter $d\tau$ does not actually affect the value of the parameter τ_n in the steady-state thermal process during cutting.

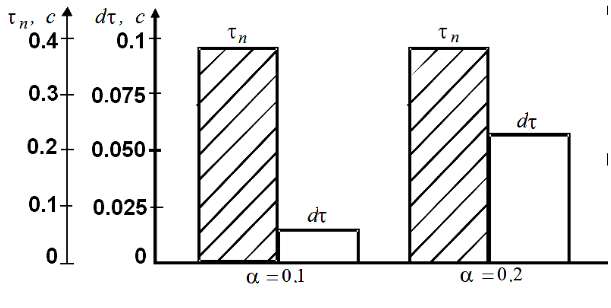

Figure 12: Calculated values of parameters τ_n and $d\tau$

Using equation (41), Table 2 shows the calculated values of the variable $\tau_n / d\tau$ at different values of the dimensionless variable α. As it shown, when α increase the variable $\tau_n / d\tau$ decreases, taking greater or less than 1. Obviously, the size of changing $\alpha =$ 0 ... 0.5 is correct, because the variable $\tau_n / d\tau$ cannot be less than 1.

Table 2: Calculated values of variable $\tau_n / d\tau$

α	0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0
$\tau_n / d\tau$	∞	25	6.25	2.78	1.56	1.0	0.7	0.39	0.31	0.25

Based on equation (38) with increasing the dimensionless variable α along the quadratic dependence the variable $d\tau$ increases. Therefore, multiplying the values $\tau_n / d\tau$ and $d\tau$, as a result, a value τ_n is obtained that does not depend on the dimensionless variable α, but rather on the variable $d\tau$, as follows from equations (41) and (42).

Thus, taking into account the motion of the heat source along the adiabatic rod during the cutting process makes it possible to refine the known solution about the nature of change of parameters l_2 and θ with increase of time τ, and to reveal new patterns of their formation related to the achievement of the state of temperature saturation in the surface layer of the work-piece and stabilization in time of the parameters l_2 and θ. This provides new technological opportunities for the enhancement in cutting process, while ensuring the high quality of the surfaces being machined at the same time.

4. CONCLUSIONS

This research showed the numerical calculations to evaluate the heating time of adiabatic rods, which conditionally represent the removable allowance and which are cut by a wheel during the grinding process. It has been established that the heating time of an adiabatic rod can be up to 10 times shorter than the time of its contact with the grinding wheel at grinding. This is due to the fact that the heating time of the adiabatic rod increases with the course of machining time, asymptotically approaching a maximum value determined by the condition of thermal saturation of the surface layer of the work piece. Calculations have established that cutting temperature and the depth of heat penetration (thickness of the defective layer) change under the same law. This implies that a large fraction of heat generated during grinding is transferred to the formed chips, and a smaller heat fraction is transferred to the workpiece.

Based on this, the formulated equations for determining the maximum values for the adiabatic rod heating time, the depth of heat penetration into the surface layer of the work piece, and the cutting temperature during grinding are obtained. It is found that the maximum cutting temperature during grinding is determined only by the conventional cutting stress and does not depend on the grinding mode parameters and grinding wheel characteristics. It is shown that accounting for the adiabatic rod cutting with the grinding wheel reduces the cutting temperature by more than two times, which brings together the theory and practice of grinding. This makes it possible to provide a new approach for the selection of the abrasive wheel contact time and, accordingly, the grinding mode parameters and grinding wheel characteristics, based on the cutting temperature limits. It is also found that the length of the cut section of the adiabatic rod (equal to the grinding depth) is always greater than the depth heat penetration into the work piece, and the cutting temperature is determined by the length of the adiabatic rod subjected to heat, including its cut-off part.

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