International Journal of Research
Available at https://journals.pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 04
April 2019

# Deformation of Threads In The Course Of Spinning

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*As show researches of force of inertia rotating and it is longitudinal a moving thread, and also aerodynamic forces influence size of tension of a thread. If the tension reaches the size equal to explosive effort of thread, it breaks. Therefore with the thread having weakened sections, it is necessary to limit sizes of kinematic parameters of the mechanism so that the dynamic component of tension depending on sizes of angular speed and speed of longitudinal movement did not overbalance certain size.*

*For maintenance of normal technological process of winding of a thread it is necessary to reel up a thread tense, and the size of this tension influences density of winding of a thread in packing. Depending on it kinematic parameters of let-off, outlet and intermediate moving of a thread should be set.*

*As a whole, for the analysis strength properties of threads in the course of spinning, it is necessary to consider thread movement in twisting and builder mechanisms in parts where kinematic and power influences on a thread are various therefore the complete dynamic picture of mechanical system with a thread turns out.*

## 1. Dynamic models of spinning process

At fibre spinning, settling down approximately on screw lines, under the influence of forces of elasticity it is condensed, increasing forces of friction between fibres in which results durability of product raises.

Spinning process is carried out for formation from rather short fibres of the product possessing the roundish form of cross-section section, corresponding durability, extensibility and elasticity. In particular, on the basis of the dynamic equations of thread received above [1], we will receive the equation of process of spinning in as

$$T\frac{dK}{dt} + K = n(t)/V \quad , \qquad (1)$$

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Wherein n (t)-intensity of spinning; dt-elementary time of spinning; V-speed of spinning; the K-law of spinning of the T-tension. The equation (1) describes process of single-mess spinning.

Where $K_1$ -twist in zones; $T_1 = L_1 / V_1$; At reception of the equation (1) following assumptions are accepted:

- Deformations are purely elastic;
- Speed of distribution of twisting is much more speed of longitudinal movement of a product;
- The product is uniform on a thickness and rigidity;
- Speed of movement of a product does not depend on twist size;
- the twiner works without slippage.

The equations (1,2) we will numerically solve, at entry conditions:

At t = 0 $K_1 = K_{10}$, $K = K_0$, wherein $K_{10}$, $K_0$ - initial twisting. In particular n=const. V=0,43m/c; $L_1$=L = 1. Numerical results are resulted on rice 1.

From these schedules it is visible, that the increase in intensity number of twisting leads to reduction twisting.

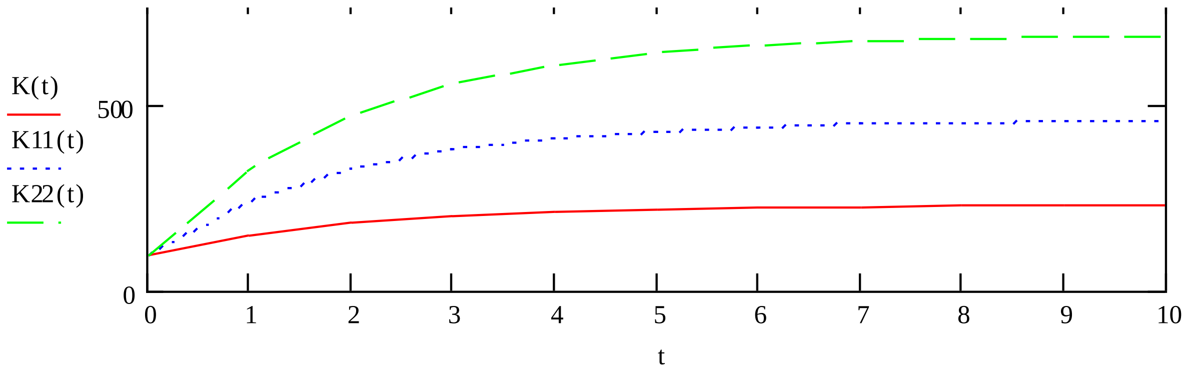


**Fig. 1. Change of twisting depending on time.**

Varying parameters of refueling L and V it is possible to define leveling actions of twiner, and also influence of these parameters on strength properties of a thread. As

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shows numerical results, the most rational from the point of view of durability is values $L_1 = L = 1$m and V=0,419m/c.

2. Examples of the decision of problems about definition of tension of thread

Let's consider the private problems illustrating influence of separate factors on tension of thread.

Problem 1. Stationary rotary movement of thread round vertical axis on an ideal surface of funnel. A thread tension are defined under formulas from work [1]. In particular we will receive

$$P = 0.5\omega^2 r_k^2 T(1-(r/r_k)^2 + P_{\sigma}). \quad (2)$$

For force of normal pressure it is had.

$$N = P/\rho + \omega^2 rT \sin\varphi \quad (3)$$

On fig. 2 the schedule of change of a tension of a thread depending on r is resulted. Change of normal pressure depending on r for various values curvature radius are resulted on fig. 3

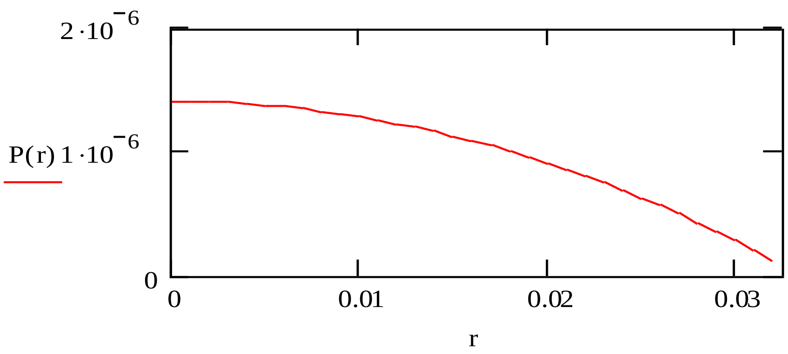


**Fig. 8. Change of tension of thread depending on r.**

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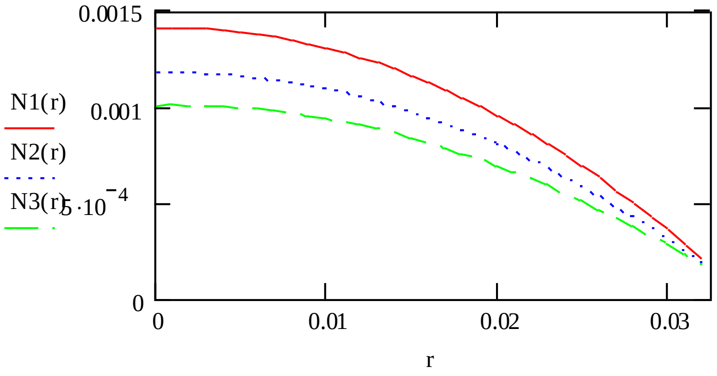


**Fig. 3. Changes of normal pressure of thread depending on r for various values of radius of curvature.**

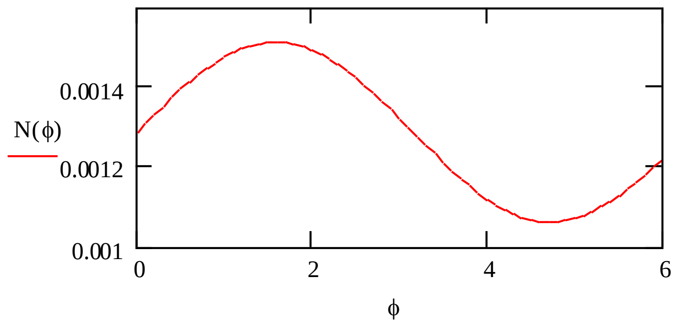


**Fig. 4. Change of normal pressure depending on a corner.**

Problem 2. Stationary contour movement of thread on a surface of a funnel taking into account forces of a friction and without rotary movement. In this case the tension of a thread and force of normal pressure are defined under formulas:

$$P = V^2 T + (P_1 - V^2 T) e^{k\varphi} signV,$$
$$N = (P - V^2 T) / \rho. \qquad (4)$$

Numerical results are resulted in the form of schedules (fig. 5)

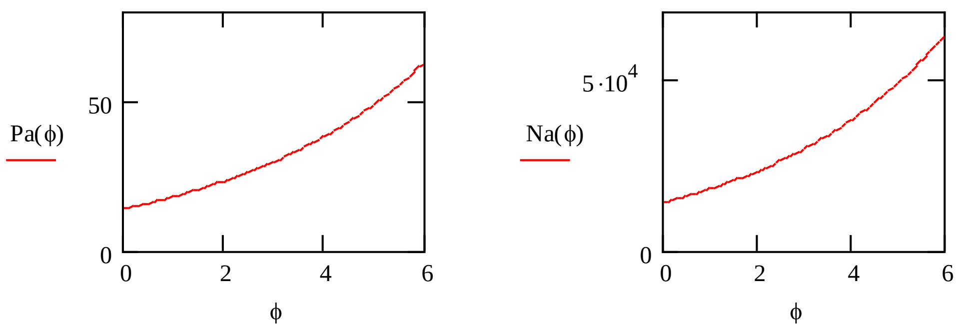

**Fig. 5 Change of tension and normal pressure**.

Depending on a corner $\varphi$.

Problem 3. The generalized problem. Generally it is possible to write down following expression for a tension and force of normal pressure of a thread:

$$P = V^2T + [P_k + 0.5\omega^2 T(r_k^2 - r^2) - V^2T]e^{k(\varphi+\ddot{\varphi}}\,)signV,$$
$$N = (P - V^2T)/\rho + \hat{e}\omega^2 T\sin\varphi. \qquad (5)$$

Let's calculate value of a tension and normal pressure under the formula (5) at following data: $n_k$ =30000 rpm., V=0.5m/c, $P_k$=0.94 cH, $r_k$ =3.25.$10^{-2}$ m, $r_2$ =$10^{-3}$ m, k=0.18, j=0.5p-$j_1$, $j_p$=0.25, $k_p$=0.25. Results of calculations are presented in the form of schedules (fig. 6).

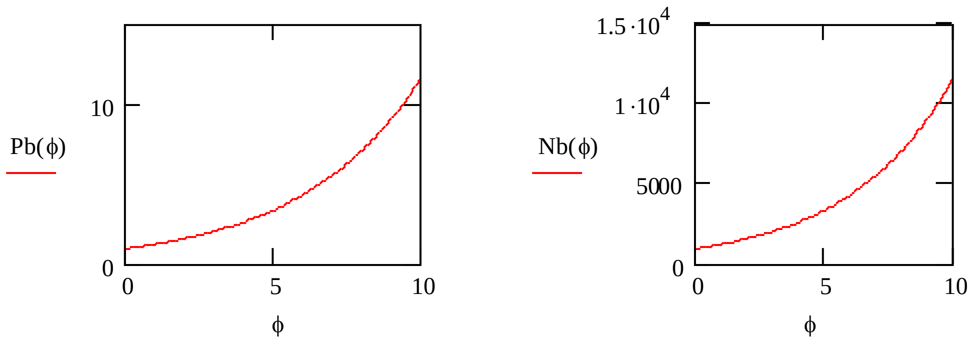


**Fig. 6 Change of a tension and normal pressure**.

Depending on $\varphi$.

3. Deformation of fibres in the course of torsion and its stretching

The full relative lengthening of a fibre arising at a stretching of a yarn, taking into account its deformation during torsion is defined under the formula [2]:

$$x = (1+e_k)(1+e)-1,$$

Where

$$e_k = K_y/\cos b - 1 = e = \{[(e_0+1)^2 + tg^2 b\,(1-e_q)^2] / [1+tg^2 b]\}^{0,} \quad (6)$$

The full tension of a fibre arising at a stretching of a yarn, taking into account its tension during torsion it is possible to define under the formula

$$p = \frac{E_B T_B \xi}{1000\ \gamma_B} \qquad (7)$$

At formation of a yarn and at its rupture of a fibre slip from each other and thus test resistance which are defined under the formula [2].

$$p_0 = (2b\rho + h\rho/\mu)(\exp(\mu\varphi) - 1), \qquad (8)$$

Where-pressure $b$ external fibres on unit of length of an internal fibre; $b = 10Etg^2\beta_R(1 - r/R)^2\delta, E = E_B(\gamma/\gamma_B).E_B$ the-module of a stretching of a fibre; $\gamma, \gamma_B$ -Accordingly yarn and fibre density; $\delta$ -width of a ribbon of a fibre; $\rho$ curvature-radius; $\rho = r[1 + (1/2\pi rK)^2], r$ layer-radius in which the fibre is located; $h$ -tenacity of fibres; $\mu$ friction-factor; $\varphi$ a coverage-corner; $\varphi = l_{ck}/\rho;\ l_{ck}$ -length of sliding. Tenacity of fibres $h$ define from a parity: $h = 4T_B F_l / lT_l,$ (9)

Where $F_l$ -explosive loading of a tape; $l$ -length of sliding of fibres; $T_l$ -linear density of a tape; $T$ -linear density of fibres. We will consider a numerical example. Let $T_l$ =0.0012; $T_B$ =0.002; $F_l$ =0.2. On fig. 7 the schedule of change of tenacity of fibres depending on length of sliding is resulted

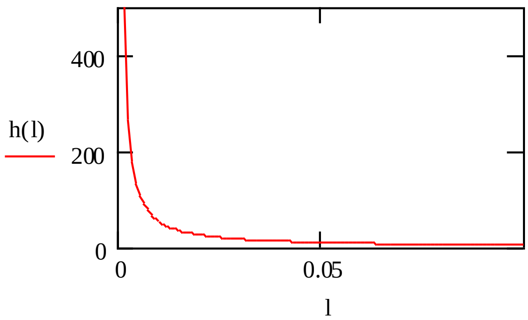


**Fig. 7. The schedule of change of tenacity of fibres depending on its length.**

Further we will consider a problem about definition of a tension of a thread moving threads on a rough cylindrical surface. Thus the problem is reduced to the decision of the differential equation in the vector form [1].

$$\frac{d}{ds}(\overline{T}\frac{d}{ds}\overline{R})+\overline{F}_s\frac{\partial}{\partial s}\overline{R}+\overline{N}e_r=0, \qquad (10)$$

Where under a vector $\overline{F}_s$ it is understood value $cF_s/mV^2$ as a vector $\overline{N}$ we accept size $cN/mV^2$. We will enter variables $\theta, z$. After simple mathematical transformations we will receive system of the differential equations concerning unknown persons $\theta, z, T$

$$\overline{T}\theta'^2=\overline{N},\quad \frac{d}{d\overline{s}}\overline{T}\theta'+\overline{T}\theta''=-\mu_s\overline{N}\theta'',\quad \frac{d}{d\overline{s}}\overline{T}\overline{z}'+\overline{T}\overline{z}''=-\mu_s\overline{N}\overline{z}'. \qquad (11)$$

In a case when $\theta''=z''=0$ (11) it will be transformed to a kind $\frac{d}{d\overline{s}}\overline{T}=-\mu_s\overline{N}$ (12)

Between co-ordinates $\theta, z, s$ it is possible to present communication under formulas

$$dz/ds=\sin\varphi,\quad d\theta/ds=\cos\varphi. \qquad (13)$$

Having solved the equation (12) taking into account (13) we will receive expression for definition of a tension of a thread, driving on a rough surface

$$\overline{T}(\overline{s})=\overline{T}_u\exp\left(\frac{\mu(\cos\varphi)^2}{s_s-s_u}(0.5(s^2-s_u^2)-s_ss+s_ss_u)\right) \qquad (14)$$

The received results are presented in the form of schedules (fig. 8 and 9).

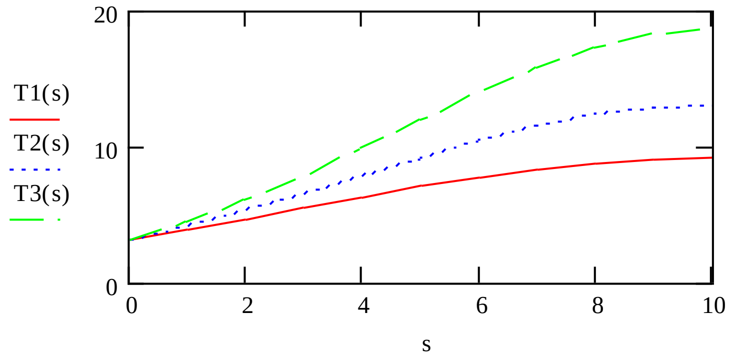

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**Fig. of 8 Schedules of change of a tension depending on s for various values of factor $\mu$ (the top curve for $\mu$ =0.3, average for $\mu$ =0.4., bottom for $\mu$ =0.5)**

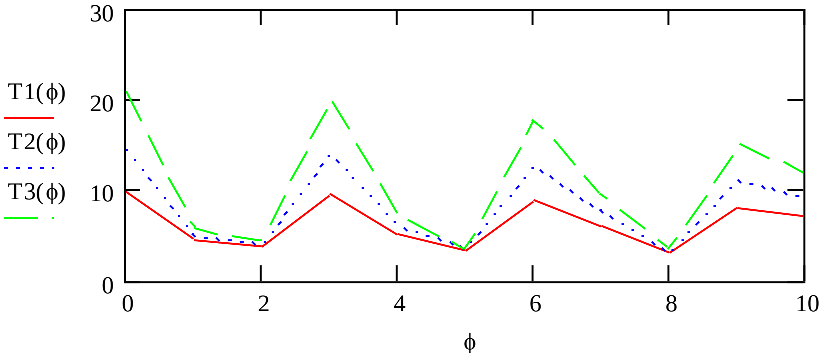


**Fig. 9. Schedules of change of a tension depending on $\phi$ for various values of factor $\mu$ (the top curve for $\mu$ =0.3, average for $\mu$ =0.4., bottom for $\mu$ =0.5)**

4. Experimental methods of definition of a tension of a thread

In experiment following problems were put: to Develop mechanic-mathematical models of threads which would reflect the basic properties of a material of real threads; to develop a technique of definition of the physic-mechanical parameters entering into mathematical model of considered threads. Some results of experiment are resulted on fig. 10-12. From these schedules it is defined explosive loadings and deformations. Further we will spend experiences on creep. Various threads have undergone to test. The spent series of experimental researches with various threads have shown, that for threads are characteristic relaxation the processes proceeding in time. The received curves of creep can be approximated on the basis of Maxwell's model the equation

$$\frac{\partial^2 \varepsilon}{\partial t^2} = \frac{1}{E}\frac{\partial^2 \sigma}{\partial t^2} + \frac{1}{\eta}\frac{\partial \sigma}{\partial t} \qquad (15)$$

Let's complicate Maxwell's model with addition of an additional spring characterizing nonlinear properties of a material of a thread. The decision of a task in view taking into account set forth above is reduced to a kind

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$$\sigma = A(1 - \exp(-E\varepsilon / \eta u) + D\varepsilon^{n} \qquad (16)$$

Entering into (16) parameters it is defined by a method of the least squares. In particular expression (16) it is possible to lead to a kind

$$\sigma = 0.5 + 1.28\,(1 - \exp\,(-B\varepsilon) + D\varepsilon^{2/3} \qquad (17)$$

Where A=1.28; B=52.6; D=47.69

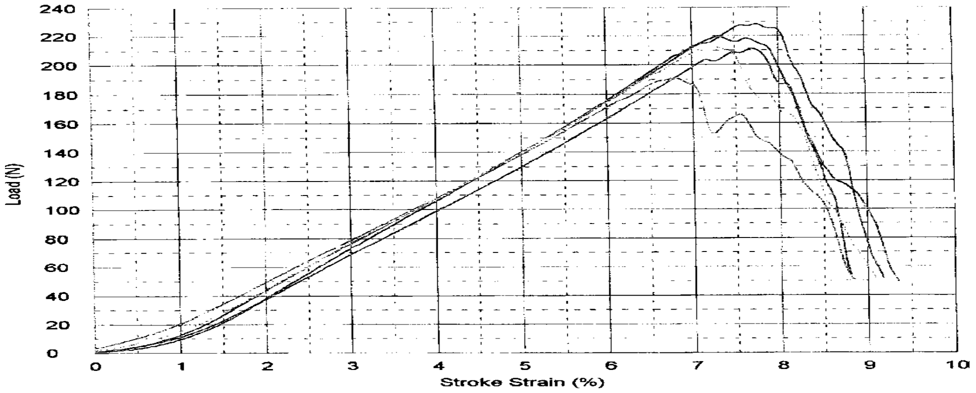


**Fig. 10. Explosive characteristics of cotton threads with linear density 29.4 tex.**

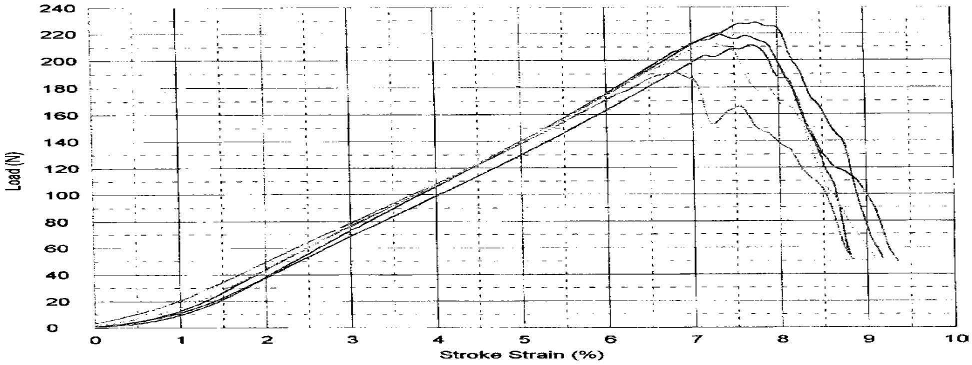


**Fig. 11. Explosive characteristics of cotton threads with linear density 29.4 tex.**

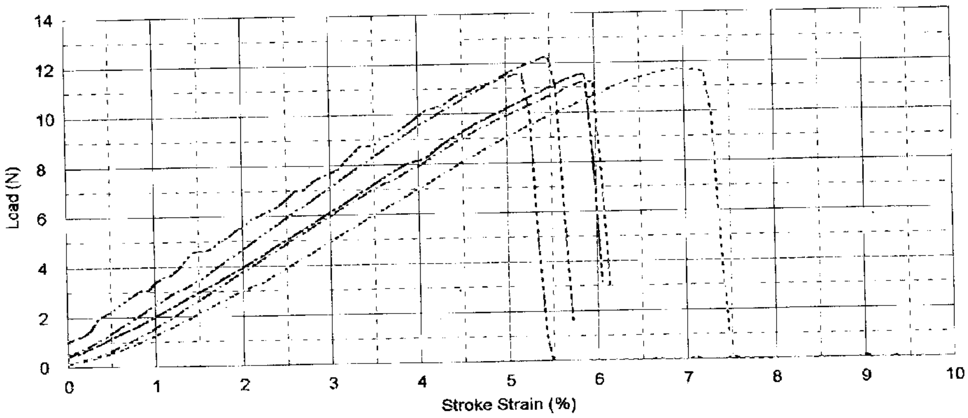

**Fig. 12. Explosive characteristics of cotton threads**
**With linear density 29.4 tex.**

Results of calculations fig. 13 is presented in the form of the schedule.

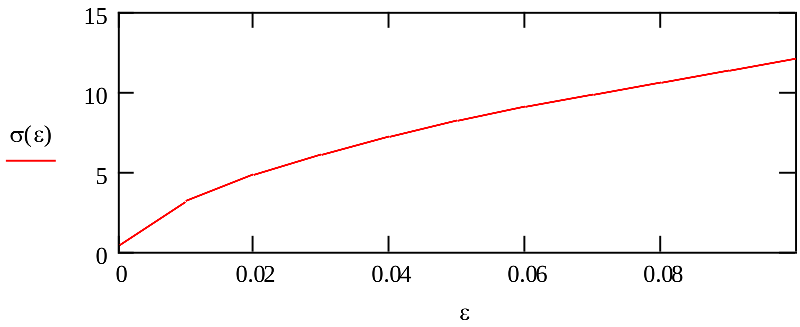


**Fig. 13. Change of pressure $\sigma$ depending on deformations $\varepsilon$.**

On the basis of the received results it is possible to draw a conclusion that communication between pressure and deformations has nonlinear character and for the description of this communication it is necessary to use modified Maxwell's model which analytical kind is described by the equation (17)

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