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MATHEMATICAL MODEL OF A PV SIGNAL POLYMERIZATION OF DENTAL MATERIAL IN THE FORM OF PULSED PERIODIC CORRELATED STOCHASTIC PROCESS

Stochastic energy signals theory is used to the choice of a photoelectric signal polymerization of dental materials mathematical model in the pulse periodically correlated random process form.

Key words: dental material, polymerization, photoelectric signal, mathematical model, pulsed periodically correlated random process.

Introduction

In modern dentistry widespread composite (dental) materials which are used for the removal of defects of enamel of the tooth, polymerization process which is carried out under the action of ultraviolet (UV) radiation. The dominant operational characteristics of these materials is a strength, because of this indicator depends on the reliability and durability of the material.

To determine the strength of dental materials used methods according to GOST R-98 «dental restorative Materials polymer. Technical requirements. Test methods» [1] (bend, diametrical gap, and others) (table. 1), which negatively affect the structure of composite materials (destruction), which makes it possible to further use them in dentistry.

Table 1 - Methods of evaluation of physical and mechanical properties of dental material according to GOST R-98

№	Estimation method	Invasiveness
1	Fold	+
2	Diametrical gap	+
3	Curing	+
4	Water dissolving	+
5	Rentgenocontrast	+

Therefore, an important scientific task is to develop a new method of determination of strength dental material (non-invasive) PV signal polymerization of dental material on the basis of adequate adequate mathematical model.

The mechanism of formation of PV signal polymerization of dental materials.

For the selection of PV signal polymerization of material in this experiment, block diagram is shown in Fig. 1.

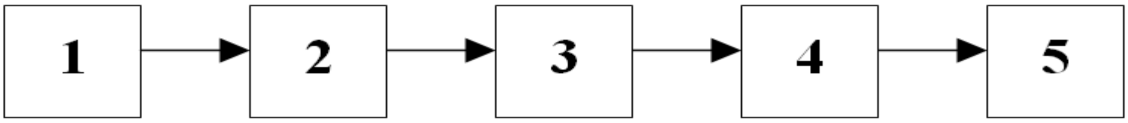

Fig.1. The structural scheme of the experiment for the selection of PV signal:
1 - source of UV radiation; 2 - a sample of material;
3 - measuring transducer, 4 - digital oscilloscope; 5 - computer

According to rice. 1, the sample is irradiated by UV radiation, reflected light becomes a transmitter in an electric signal (PV signal), which is recorded and digitized digital oscilloscope. The digitized signal is fed to the computer, where processing occurs.

On Fig.2. shows the view of one pulse PV signal polymerization of material that is registered with the assistance of the structural scheme (Fig.1).

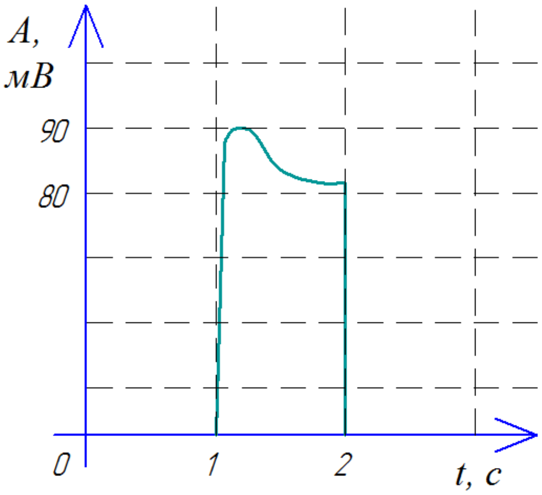

Fig. 2. Implementation of one pulse PV signal polymerization material

Maximum peak value PV signal is of the order of 90 mW. The signal is constant component caused part of luminous flux reflected from the surface of a material, with intensity I1. Pulse contains three main half - a, b, and C. let's Consider them in the physical sense. On Fig. 3. shows the impulse with dedicated halves of the waves.

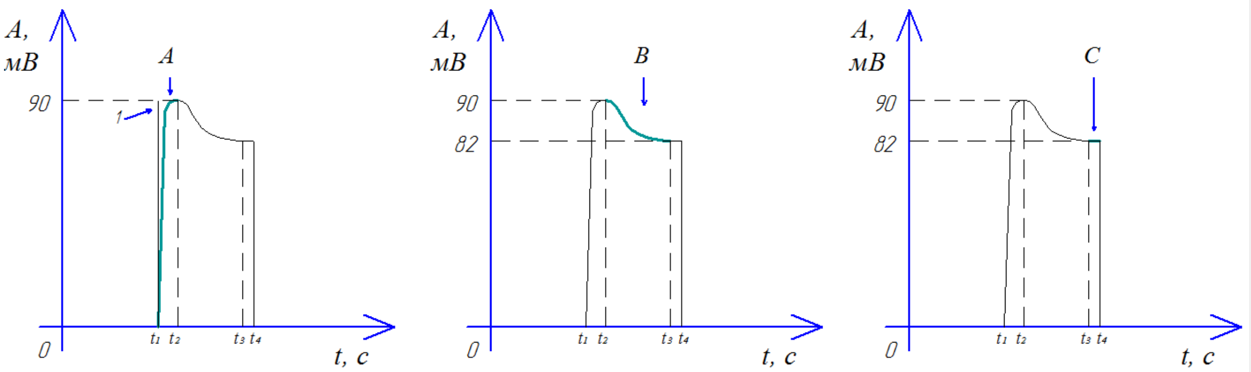

Fig.3. The structure of the pulse PV signal:
a) half wave A, b) - half wave B, in) - half wave C

Fig.3,a) figure 1 the arrow shows the vertical line, that is, the wavefront start lamp photopolymerization. Bold line shows the half-wave And that is the leading edge of the pulse PV signal. He is slightly inclined and characterizes the transition process exit lamp on steady-state operation. The time period t_1-t_2 characterizes the transition process ignition of a lamp photopolymerization.

Fig.3,b) shows the half Century after contact nepalimovisong material layer of light from photopolymerization process is initiated polymerization of this layer. However, this process is slow and passes through a logarithmic law. Half-wave B displaying just the transition process of polymerization process, however, given the fact that the intensity of light S_2 is inversely proportional to the polymerization process, kind of half-wave B is also the inverse of the mean logarithmic law. The time interval t_2-t_3 characterizes the transition process.

On Fig.3) shows a view half-waveC. After the completion of the transition process begins the process of polymerization, which displays half-wave C duration indicates the time interval t_3-t_4.

According to the method of signal registration, photovoltaic signal is the result of reflection from the dental material series of UV outbreaks, so these pulses (Fig. 1) depicted on one axis of time in the form of the ensemble as a periodic its sequel (Fig. 4)that gives the opportunity to see the dependence of the change in the time signal reflection from flash to flash.

In Fig.4. depicts the implementation of pulses PV signal polymerization at one time axis provisional frequency of outbreaks duration of 1 C.

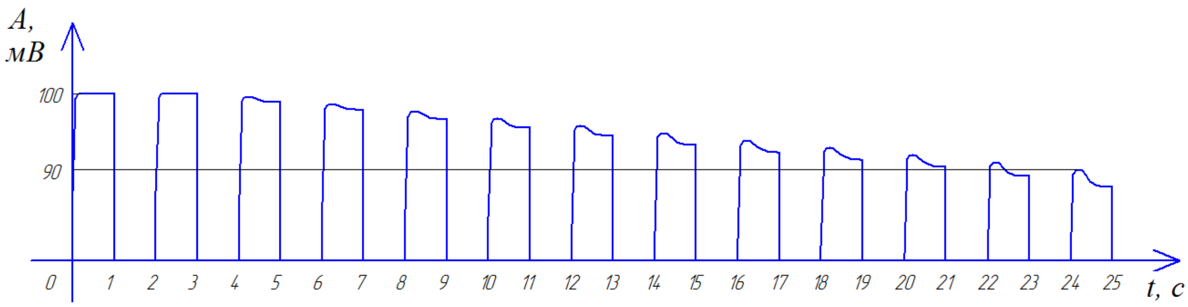

Fig. 4. Implementation of pulses PV signal polymerization at one time axis provisional frequency of outbreaks with duration of 1c [2]

PV signal, as a set of impulses, takes into account the frequency of outbreaks, which ensures uniformity of the phases of the process of generation of the signal in the interval of time equal to a fixed period of UV flash.

Because when registering studies, UV flash periodically served with the specified interval $T_{СПАЛ}$ and duration, so the signal reflections from dental material will also contain the periodicity of properties with the same period.

Considering the mechanism of formation, photovoltaic signal as many impulses shifted in time relative to each other on a sustained period $T = T_{СПАЛ}$ in the form of:

$$\xi(t) = \sum_{k \in Z} \chi_{D_k}(t) \cdot \xi_{імпульс_k}(t - kT), \quad t \in R, \tag{1}$$

where $\chi_{D_k}(t) = \begin{cases} 1, \text{if } t \in D_k \\ 0, \text{if } t \notin D_k \end{cases}$ - the indicator function of a set D_k;

$D_k = [kT, (k+1)T)$ - time range duration of k-th feedback $\xi_{імпульс_k}(t), t \in [0, T)$;

T - the duration of one pulse PV signal.

The image of the ensemble PV signal in the form of its periodic continuing into its structure a combination of the properties of periodicity with stochasticity, and thus gives the possibility to take into account statistical correlations between different pulses reflected from dental material of the same series of observations, which is impossible in case of the traditional view of same series of reactions in the form of an ensemble of realizations.

The analysis of the structure of PV signal polymerization (Fig.4) and raising the nature of the individual pulses (Fig 3) it is established that adequate mathematical model of such kind of signal must be taken into account in its structure periodicity property (specified intervals UV outbreaks) and stochastic (the influence of external (outdoor lighting, temperature, humidity) and internal (quality of the material, its composition, thickness and other) factors.

In terms of energy theory of stochastic signals such properties takes into account the mathematical model in the form of periodically korenoveho random process (ABVP), which has the means of expression as the connectivity of the harmonic components, and the change of the probability characteristics [3].

In this theory also runs periodically correlated stochastic process class π^T that is, by definition, is a process, correlation function which satisfies the conditions $r_\xi(t+T,s+T)=r_\xi(t,s)$, $T>0$ для всіх $t,\ s\in\mathbf{R}$ та $M_t(r(t,t))<\infty$ [3].

Looking at the reflection from the dental material each flash as the implementation of the ABVP, at time intervals $[kT,(k+1)T)$, can a set of (set) of them be interpreted as the implementation of view ABVP through translational components:

$$\xi(t)=\sum_{p\in Z}\sum_{k\in N}\alpha_k(p)\Phi_k(t-pT), \tag{2}$$

where $\alpha(p)=[\alpha_k(p)]_{k\in N},\ p\in Z$ – vector stationary sequence;

$\{\Phi_p(t),\ p\in N, t\in[pT,(p+1)T)\}$ – translational basis in functional space $L^2(0,T)$;

$\{\alpha(n), n\in\mathbf{Z}\}$ – the sequence translational stationary component.

The image (2) adequate pulse signal formats and effective when modeling PV signal polymerization of dental materials as pulse ABVP.

Conclusion

Considering the results of the analysis and the mechanism of formation of PV signal polymerization of dental materials (view ensemble as periodic continuation) substantiated his choice of the mathematical model in the form of pulsed periodically korenoveho random process.

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