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THE QUANTUM MODEL OF THE DEVELOPMENT OF INTELLIGENCE AS A THEORETICAL BASIS OF THE THEORY OF TECHNOLOGICAL DEVELOPMENT. CONSTRUCTION TECHNOLOGY LIFE CYCLES

The article outlines the main provisions and analyses the main models of intelligence development using a historical approach. A quantum model of intelligence development is proposed, which reveals the logical essence of intellectual processes occurring at the levels of individual and integral intelligence. Individual and integral intelligences can remain in stationary states for a long time, in which the intelligence and the system of intelligences have "volumes". Any change in the "volume" of intelligence occurs only with a complete transition from one state to another, the mechanism of intellectual transitions is a discrete process. It is shown that the pattern of growth of the "volume" of integral intelligence obeys the exponential law. The volume of integral intelligence increases like an intellectual flash; the process of development of integral intelligence is discrete, cyclical and has a constant parameter – the lag of integral intelligence, which belongs to the interval of 6–8 years. The relationship between the development cycles of integral intelligence (its outbursts) and "Kondratiev's big cycles" is established. For each lag of integral intelligence, its "volume" increases, relative to the initial level, by the value of the exponent, and each "great Kondratiev cycle" has from 6 to 8 lags of integral intelligence, which precede waves of technical inventions and their practical application in the form of innovations, that is, innovative products and technologies. The development of construction technologies is a continuous and irreversible process of increasing their effectiveness over time, and is generally described by s-shaped curves that are tangent to the contour curve characterizing the integral effectiveness of public labor in the construction industry. Technologies have their own life cycles, consisting of stages that differ in the level of relative effectiveness, namely: the stage of introduction and initial diffusion, the stage of maximum diffusion, the stage of rationalization, the stage of obsolescence. The existence of technologies at the stage of aging is impractical.

Keywords: construction technologies, technological progress, quantum model of intelligence development, life cycle of technologies.

Introduction. Construction, as a branch of material production, has a significant role in the development of society and determines the technical level of almost all branches of production, scientific and social spheres. In turn, the technological and technical level of construction is determined by the achieved level of development in the scientific and technical spheres (noosphere) of a certain society. In general, the process of development of production systems (technosphere) is characterized as non-equilibrium (gradual-spontaneous), irreversible and dependent on prehistory.

Many works of domestic and foreign authors [1–7], which reveal the relationship between the development of science and technology, are devoted to the problems of technological development and scientific and technical progress.

Indeed, the development of the technosphere is facilitated by the development of the noosphere and, first of all, the intelligence of creators, because the solution to any issue begins with the generation of an idea, and an idea is born by the intelligence.

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Formulation of the problem. The development of fundamental issues related to the development of the intelligence of creators is relevant for solving the problem of increasing the effectiveness of forecast estimates regarding the main directions of scientific and technological progress in the construction industry.

Certain issues of this problem are covered in the author's earlier works – [8–10].

Main part. Many models are known that describe the regularity of the growth of intelligence [1, 11–14]. We will list the most famous ones.

The Adams model (1907). The model is based on a comparison of the acceleration of progress with the effect created by the introduction of a new mass into a system of forces that was in equilibrium before. The new mass determines the acceleration of movement (with gravity).

If it is assumed that the accumulated information (J) – is an analogue of the distance (S) traveled by the new mass ($m_н$): $J \sim S$, then the rate of information growth will be equal to $\frac{dJ}{dt} \approx v(t)$, and the acceleration of information growth (second derivative) – $\frac{d^2J}{dt^2} \approx g = const$. So, it can be written that the speed of information growth is equal to $\frac{dJ}{dt} = g \cdot t$, from which the amount of accumulated information is $J = \int_0^t gtdt = \frac{1}{2}gt^2$.

Graphical interpretations of the Adams model are shown in fig. 1.

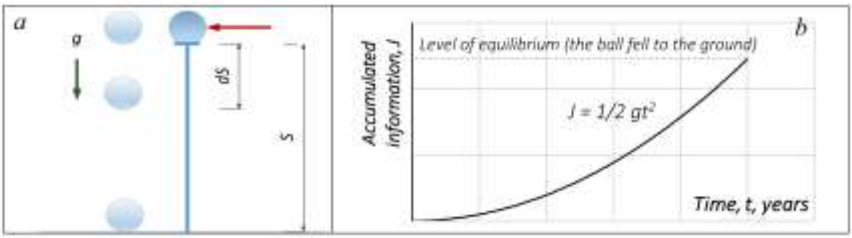


Fig. 1. Physical model (*a*) and pattern of development (*b*) of intelligence (*accumulation of information according to Adams*)

The model of Lenz (1962). The model is built on the basis of an analogy between the increase in information and the growth of a biological population, namely: the rate of increase in the number of drosophila in a dish; the rate of increase in the number of yeast cells in the environment, etc.

All these and other examples obey the same simple mathematical law, which, in relation to the generation of new information, has the form:

$$I = \frac{L}{1 + ae^{-bt}}, \qquad (1)$$

where I – is the state of knowledge at time t; L – is the upper limit of information; a – is a constant; b – is the proportionality factor (tgφ).

The graphic interpretation of Lenz's model is shown in fig. 2.

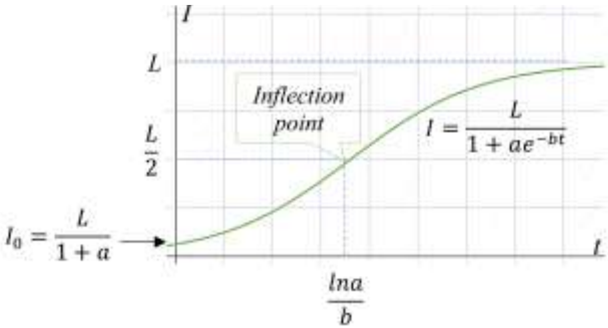


Fig. 2. Regularity of intelligence development
(*increase of information according to Lenz*)

The Eisenson model (1966). Information growth over time depends on factors: factor 1 – the number of researchers; factor 2 – recognized upper limit (next level); factor 3 – the level of communication between researchers.

Factor 1 – excluding factors 2 and 3. Information growth over time is carried out according to the exponential law:

$$\frac{dI}{dt} = qN(t) = qN_0 e^{ct}, \qquad (2)$$

where q – is the average productivity coefficient of one scientist per unit of time, article/year (according to S. Price, the average productivity of one scientist is $q_{\text{ср}} =$ 0,1 article/year); $N(t)$ – is the number of researchers at time t; N_0 – is the number of researchers at the initial moment of time t_0; c – proportionality coefficient, constant (the angular coefficient of the straight line on the logarithmic graph – tgφ.

Then, the volume of accumulated information at time t (Fig. 3, a):

$$I(t) = qN_0 \int_0^T e^{ct} dt = \frac{qN_0}{c}(e^{ct} - 1). \qquad (3)$$

Taking into account factor 2 – the recognized upper limit of L. Eisenson introduces a correction factor $(1 - {}^{I}/_{L})$, so ${}^{dI}/_{dt}$ becomes dependent on I:

$$\frac{dI}{dt} = qN_0 e^{ct} \frac{L - I}{L}. \qquad (4)$$

Therefore, I changes along an S-shaped curve (Fig. 3, b):

$$I(t) = L\left(1 - e^{-\frac{qN_0}{cL}e^{ct}}\right). \qquad (5)$$

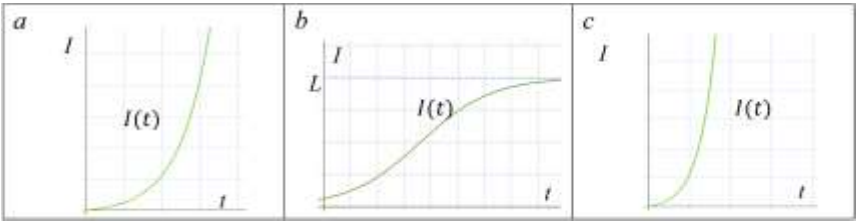


Fig. 3. Regularity of intelligence development:
(*growth of information according to Eisenson*)
a – growth of the volume of information in the initial period;
b – also, when approaching the upper limit of L;
c – growth of the volume of information in the initial period, taking into account the communication factor

Taking into account factor 3. Assuming that the communication link is also productive, as well as the contribution of the scientist.

Therefore, with the maximum number of connections between N scientists – $½N(N-1)$:

$$\frac{dI}{dt} = q[N + ½N(N-1)] = ½qN_0e^{ct}(N_0\, e^{ct} + 1) \qquad (6)$$

or at

$$N >> 1 \rightarrow [N + ½N(N-1)] = N + ½N^2 - ½N(N+1) \approx ½N^2,$$

as $N \rightarrow \infty$.

Therefore, information grows according to the exponential law, but with a double exponent e:

$$\frac{dI}{dt} = ½qN^2 = ½qN_0^2e^{2ct}. \qquad (7)$$

Therefore, the volume of accumulated information at time t (Fig. 3, c):

$$I(t) = \frac{1}{2}qN_0^2\int_0^T e^{2ct}dt = \frac{1}{2}\frac{qN_0^2}{2c}(e^{2ct} - 1). \qquad (8)$$

Hartman's model (1966) – is based on the analogy of the interactions of particles in gases: S – molecules-scientists – "non-moving"; I – information molecules – move at a constant speed v in random directions.

Graphical interpretation of the Hartman model is shown in fig. 4.

The generation of new information occurs when S have a “reaction cross section” δ (“target area”) with respect to I. Then, the information gain (generation of new information per unit volume) over time:

$$\frac{dI}{dt} = kvN\delta I(t), \qquad (9)$$

where k – is the proportionality factor;

N – is the number of scientists in this volume; $N = N_0e^{ct}$.

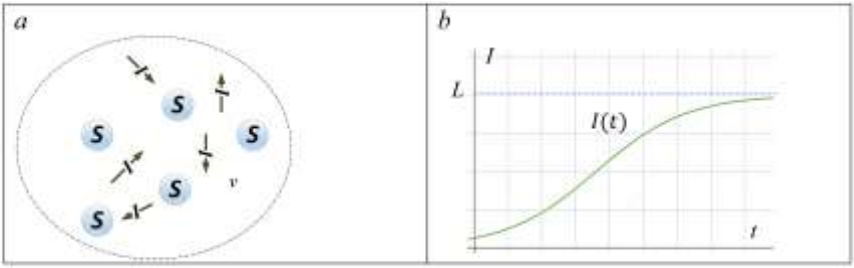


Fig. 4. Physical model (a) and pattern of development (b) of intelligence
(*growth of information according to Hartman*)

Then the expression (9) becomes:

$$\frac{dI}{dt} = kv\delta N_0 e^{ct} I(t). \tag{10}$$

Thus, the increase in information $\frac{dI}{dt}$ depends on the amount of already available information $I(t)$, which fundamentally distinguishes Hartman's model (10) from Eisenson's model (2).

For the case of approaching the upper limit of L, Hartmann introduces the same correction factor as Eisenson, so that expression (10) has the form:

$$\frac{dI}{dt} = kv\delta N_0 e^{ct} I(t) \left[\frac{L - I}{L}\right]. \tag{11}$$

The solution to the equation is the function:

$$I(t) = L\left[1 + \left(\frac{L}{I_0} - 1\right) e^{kv\delta N_0 (t - t_0)}\right]^{-1}, \tag{12}$$

where I_0 – is the amount of already available information at the initial moment of time t_0.

Information grows along an S-shaped curve, asymptotically approaching the upper limit of L.

The Eisenson and Hartman models are usually combined into the general *Eisenson-Hartman model*, which generally shows the importance of taking into account the effect of slowing down the growth of information (intelligence) when approaching the upper limit.

In general, the above and other models in their totality correctly describe the patterns of growth of intelligence, although indirectly – through the patterns of growth of information flows, volumes of knowledge, etc.

But the issues of highlighting and interpreting the internal processes and phenomena that occur during the development of intelligence remain open.

Taking into account the above, we will give our own model of the development of intelligence – *the quantum model of the development of intelligence*, which was first taught by the author during the course of lectures "Main directions of progress in construction" at the Kyiv National University of Construction and Architecture in 1998-2007.

We know that the volume of knowledge is characterized by certain states, this applies to both holistic and individual knowledge (intelligence).

So, let's give a convenient for us (in the conceptual apparatus of the state of intelligence) interpretation of Bohr's two postulates.

The first postulate. Individual and integral intelligences (the latter as a system of individual intelligences) can remain in certain states for a long time – stationary states in which the intelligence and the system of intelligences have "volumes", creating a discrete series:

$$\begin{cases} \vartheta_1, \vartheta_2, \vartheta_3, \dots\ \vartheta_n - \text{ volume individual intelligences,} \\ \theta_1, \theta_2, \theta_3, \dots\ \theta_m - \text{volume integral intelligence.} \end{cases} \quad (13)$$

The second postulate. Any change in the "volume" of intelligence occurs only with a complete transition (jump) from one state to another, due to the absorption (perception) of external information.

The act of absorption of external information $\mathcal{J}$ is almost always accompanied by the act, after some time τ, of generation (transformation) of new information $\mathcal{J}_r$.

A. Individual intelligence.

The mechanism of intellectual transitions for individual intelligence is a discrete process of changing its states ω' and "volumes" ϑ under the influence of perception (absorption) and generation of new information (Fig. 5):

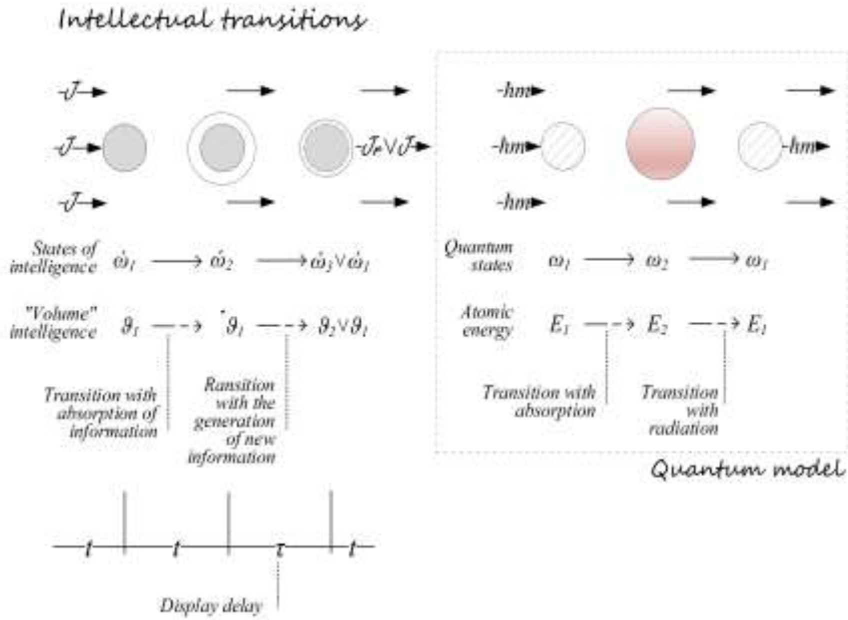


Fig. 5. Intellectual transitions of individual intelligence
(*by analogy with the quantum model*)

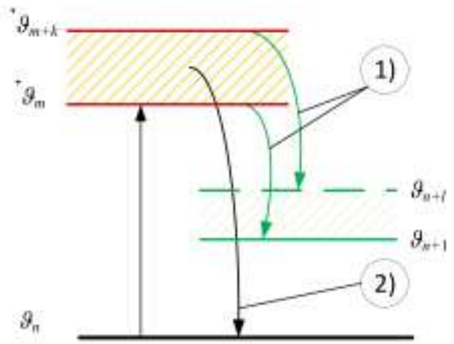
$$\begin{cases} \mathcal{J} \to \mathcal{J}_r \vee \mathcal{J} - \text{absorption and generation of information}, \\ \acute{\omega}_1 \to \acute{\omega}_2 \to \acute{\omega}_3 \vee \acute{\omega}_1 - \text{states of intelligence}, \\ \vartheta_1 \to \check{\vartheta}_1 \to \vartheta_2 \vee \vartheta_1 - \text{transitions of intelligence}, \end{cases} \quad (14)$$

which (the process) goes *ambiguously* – external information $\mathcal{J}$ is transformed by the intellect either with the generation of new information or without its generation ($\mathcal{J}_r \vee \mathcal{J}$), therefore the intellect either moves to its next state and "volume", or returns to the previous state and "volume" ($\acute{\omega}_3 \vee \acute{\omega}_1$ та $\vartheta_2 \vee \vartheta_1$). At the same time, the absorption of external information $\mathcal{J}$ by intelligence brings it into a *state of intellectual activity* (SIA) – $\acute{\omega}_2$ without increasing the "volume" of intelligence ϑ_1; intelligence recognizes, compares, analyzes, models and searches for solutions, using the available "volume" of intelligence – $\check{\vartheta}_1$.

In another form, the mechanism of intellectual transitions of individual intelligences can be represented by a formal graphoanalytic model of the form – (15).

That is, two options are possible, but, as a rule, the process follows option 1).

We will consider an individual intelligence in a stationary state as "normal", such that it is in a *state of intellectual passivity* (SIP) - its "volume" corresponds to the current paradigm.



1) solution found
$\vartheta_n \to \check{\vartheta}_m \to \vartheta_{n+l}$
(*new information generated*)
2) no solution found
$\vartheta_n \to \check{\vartheta}_m \to \vartheta_n$
(*new information could not be generated*)
(15)

B. Integral intelligence.

The mechanism of intellectual transitions for integral intelligence also represents a discrete process of changing its states Ω_i and "volumes" Θ_k, but already under the influence of internal processes in integral intelligence – the nature and intensity of intellectual transitions of individual intelligences, which are its components:

$$\begin{cases} \Omega_1 \to \Omega_2 \to \ldots \to \Omega_n \to \Omega_{n+1} \to \cdots, \\ \Theta_1 \to \Theta_2 \to \ldots \to \Theta_n \to \Theta_{n+1} \to \cdots. \end{cases} \quad (16)$$

Integral intelligence can be in a stationary state for a long time and, if the conditions are present, jump into a non-stationary state (Fig. 6).

Integral intelligence in the interval $(t_0, t_0 + \Delta t)$ is in a steady state, because the acts of dispersing external information prevail over the acts of generating new information. The reason for this is that the number of individual intelligences in a state of intellectual passivity (N_1) at equilibrium is always greater than the number of individual intelligences in a state of intellectual activity (N_2):

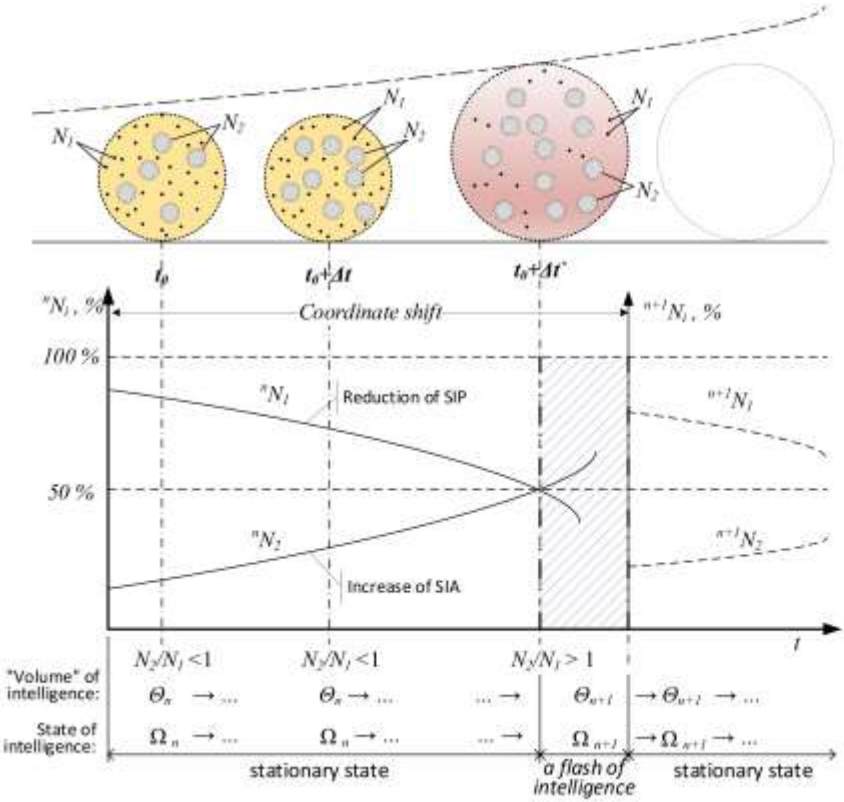


Fig. 6. Model of intellectual transitions of integral intelligence

$$N_1 > N_2, \text{ that is, this } \frac{N_2}{N_1} < 1. \tag{17}$$

Indeed, if

$$\frac{N_2}{N_1} = \frac{B_{12}\rho_\omega}{A_{21} + B_{21}\rho_\omega}, \tag{18}$$

therefore, at equilibrium (steady state)

$$B_{12}\rho_\omega < A_{21} + B_{21}\rho_\omega, \tag{19}$$

where $B_{12}\rho_\omega$ – is the probability of transitions with the generation of new information by individual intelligence;

B_{12} – probability of arousal of individual intelligence (transition from the lower level and "volume" of intelligence ϑ_n to the next level "volume" ϑ_{n+l}, $\vartheta_n \to \check{\vartheta}_m \to \vartheta_{n+l}$;

ρ_ω – is the energy density of the field (information field) in the frequency interval $(\omega, \omega + d\omega)$;

$A_{21} + B_{21}\rho_\omega$ – full probability of transitions with the generation of new information (spontaneous and stimulated);

A_{21} – probability of spontaneous generation of information;

$B_{21}\rho_\omega$ – is the probability of stimulated generation of information.

Thus, if (18) is true, we have $N_1 > N_2$.

In order for the integral intelligence to go into a non-stationary state, at the moment $(t_0 + \Delta t')$, and thus received an increase in its "volume" (transition $\theta_n \rightarrow \theta_{n+1}$, see Fig. 6), it is necessary to create conditions so that the number of individual intelligences in a state of intellectual activity (SIA) is greater than the number of individual intelligences in a state of intellectual passivity (SIP), in such a way that:

$$N_2 > N_1, \text{ or } \frac{N_2}{N_1} > 1. \quad (20)$$

If condition (20) is true, the acts of generating new information prevail over the acts of dispersing information. So, as a result, there is an "intellectual flash" - a breakthrough to a higher level; the "volume" of integral intelligence increases ($\theta_n \rightarrow \theta_{n+1}$), a new paradigm emerges.

Two directions (methods) of creating conditions when $\frac{N_2}{N_1} > 1$ are possible:

1) artificially (in an indirect way) to create an "excess" of the number of individual intelligences that are in SIA in relation to the number of individual intelligences that are in SIP, $N_2 \rightarrow \infty$;

2) on the contrary, to artificially reduce the number of individual intelligences, which are in the CIP, $N_1 \rightarrow 0$.

In quantum mechanics, to obtain a non-stationary state, molecular (masers) and quantum (lasers) generators are used, which ensure that condition (20) is met.

For conditions of integral intelligence:

✓ the first direction is implemented by concentrating a significant number of scientists in *scientific centers,* in the so-called "silicon valleys", which allows to almost completely exclude the influence of individual intelligences that are in a state of intellectual passivity,

✓ and the second direction – the maximum, comprehensive coverage of the population of the planet with higher, mainly technical, education; in other words, by *forming a global creator*.

The growth regularity of the "volume" of integral intelligence obeys the exponential law:

$$\Theta(t) = \Theta_0 e^{\omega t}, \quad (21)$$

where Θ_0 – is the initial level of "volume" of integral intelligence;

ω – is the frequency of oscillation of integral intelligence (flashes of intelligence):

$$\omega = \frac{2\pi}{T}. \quad (22)$$

If we take as the time period T the duration of the "great Kondratiev cycle" (long cycles of the economic situation), which are equal to 40-50 years, then we will have a constant parameter of the development of integral intelligence - the lag of integral intelligence λ, which belongs to the interval (6.37, 7.96) years old.

Indeed, if, for example, T=50, then from the expression (22), we have the value of the lag $\lambda = \frac{T}{2\pi} = \frac{50}{2\cdot 3{,}14} = 7{,}961783 \approx 7{,}962$ years.

Then we will rewrite the expression (21) taking into account the proposed parameter (λ) and we will have the regularity of the development of the integral intelligence of the species (Fig. 7):

$$\Theta(t) = \Theta_0 e^{\frac{t}{\lambda}}. \quad (23)$$

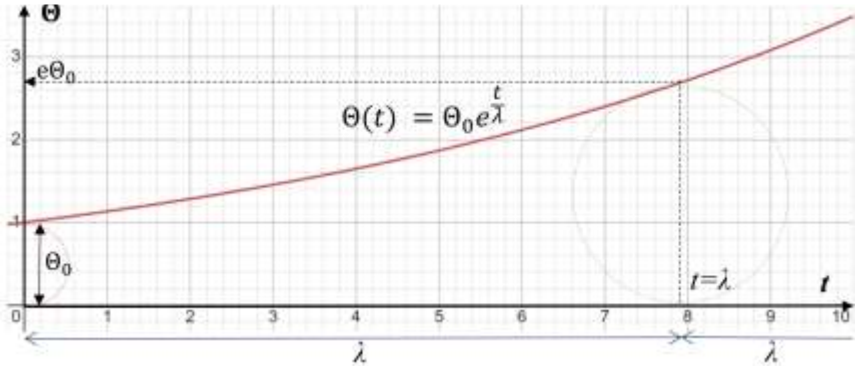


Fig. 7. The regularity of growth of the "volume" of integral intelligence

Thus, for each lag of integral intelligence λ, its "volume" $\Theta(t)$ increases, relative to the initial level Θ_0, by the amount e, and each "big Kondratiev cycle" has from 6 to 8 lags of integral intelligence, which precede waves of technical inventions and their practical application in the form of innovations – innovative products and technologies (see Fig. 8).

The development of integral intelligence (intelligence of creators) determines the directions and pace of development and improvement of construction technologies.

The development of construction technologies, as complex technological systems, is a continuous and irreversible process of increasing their effectiveness over time (τ), and in general, like the development of integral intelligence, obeys the exponential law (Fig. 9):

$$\Omega = \omega_0\, e^{a\tau}, \quad (24)$$

where Ω – is the integral effectiveness of social labor, units of production per unit of labor costs and material and technical resources;

ω_0 – the initial level of social labor efficiency; development is possible if there is history (experience);

a – is a constant, proportionality factor.

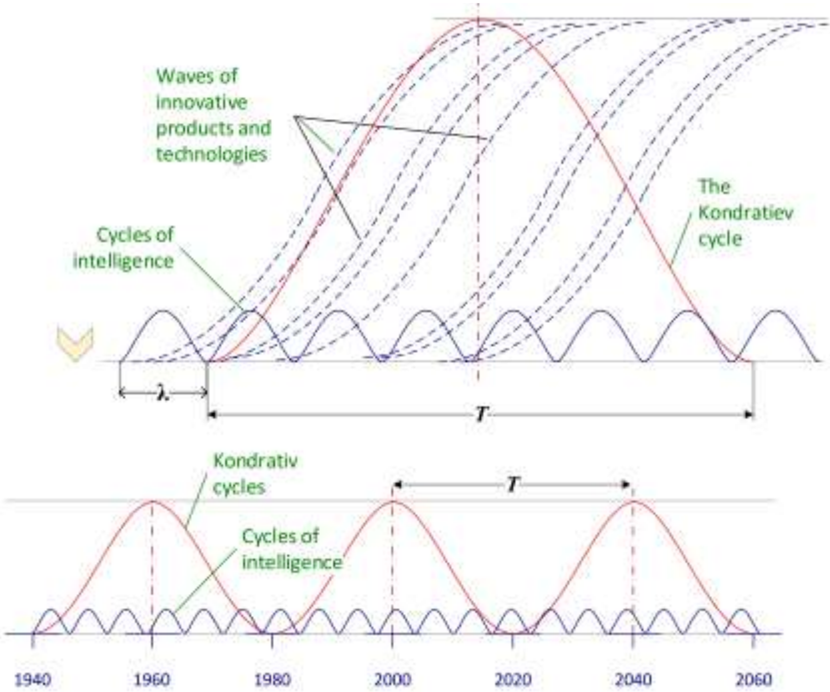


Fig. 8. Interrelationship of cycles of integral intelligence (development) with "Kondratiev's big cycles"

Integral performance Ω is a contour curve of a family of *s*-shaped curves of the form:

$$F\big(\varphi, \tau, \omega_n, \omega_{(n+1)}, \dots, \omega_{(n+k)}\big), \tag{25}$$

where φ, τ – are the coordinates of points on the plane formed by the time scale τ and the scale of relative performance φ;

$\omega_n, \omega_{(n+1)}, \dots, \omega_{(n+k)}$ – relative levels of development at the corresponding time intervals (as the limit value of relative productivity – (φ]).

Each *s*-shaped curve describes the dynamics of changes in the performance of one or another construction technology at the stages of their operation, on the so-called life cycle (Fig. 9).

For example, for technology A, the efficiency at time τ ($\varphi^A(\tau)$) can be given by the expression; let's use Lenz's expression, see (1):

$$\varphi^A(\tau) = {L_{n+1}}\big/{(1 + e^{-b\tau})}, \tag{26}$$

where L_{n+1} – is the predicted upper limit of the effectiveness of technology A; for example, the value of the productivity of public labor in construction in the relevant units of measurement;

b – is the proportionality coefficient, which is set by the researcher; can be actual, if a retrospective analysis is performed, or estimated, if a forecast of the implementation of technology A is performed.

The question arises when it is necessary to start the development and implementation of a new technology (for example, technology B) in order to ensure the necessary level of implementation of innovations (technologies).

Preferably at the beginning of the period of maximum spread (section on the curve $[\alpha_1, \alpha_2]$, Fig. 9), that is, when previous technologies (for example, technology A) give the maximum effect in terms of achieving the required level of effectiveness ω_n and reaching the next (n + 2) level of technological development.

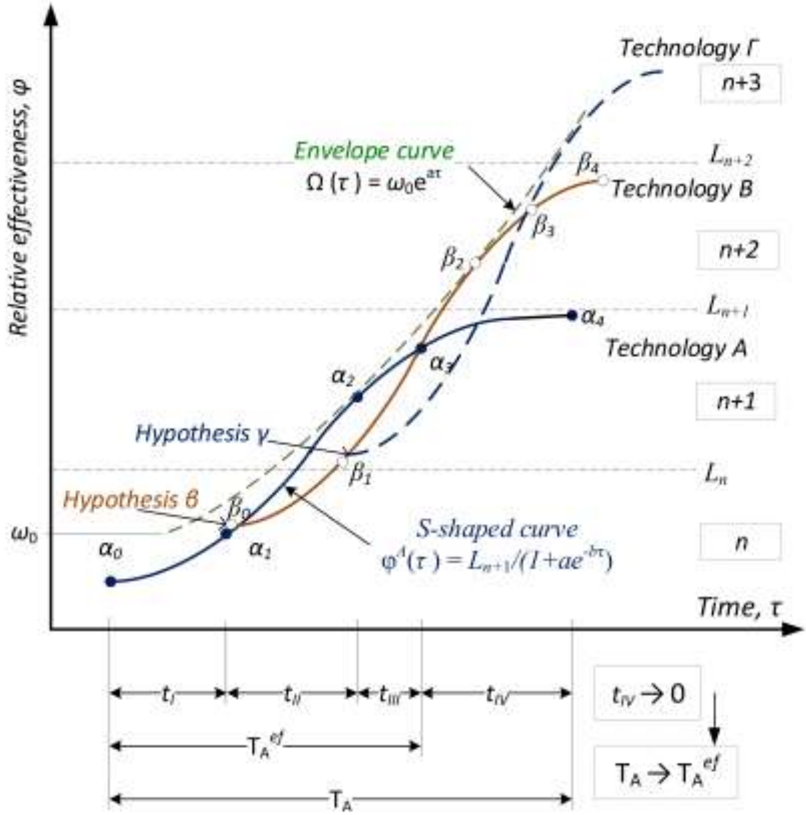


Fig. 9. Technology life cycle

In general, four main stages of the life cycle of technologies can be distinguished (see Fig. 9):

I stage – is the stage of implementation and initial distribution; new technology or innovation. The first stage (segment $[\alpha_0, \alpha_1]$ on the curve A), which changed the intellectual flash, which actually made it possible to create a new technology A, prepares a technological breakthrough from the initial level n to the next $(n + 1)$ level of development; at this stage, experience in the implementation of technology A is accumulated, its shortcomings are revealed and eliminated, as well as inconsistencies and contradictions of the parameters of technology A in the foreseeable future, that is, an impetus is given to the formulation of a new problem, the necessary conditions are created for the next intellectual outburst – hypothesis β about technology B is put forward.

II stage – maximum distribution; progressive, innovative technology. The second stage (segment $[\alpha_1, \alpha_2]$) is a technological breakthrough, the new technology gets the maximum spread and gives the maximum increase in the efficiency of social labor, raises the overall level of technological development to the next $n + 1$ level. At the second stage, a wide variety of experience in the application of technology A is accumulated, its informativeness or scientific intensity approaches the integral scientific intensity, since the upper limit of this stage, point α_2, belongs to the contour Ω, which characterizes the average or integral level of scientific intensity of technologies (as an assessment of the level of development) for a certain moment in time. During this period, the intensive increase (improvement) of the function of technology A continues due to the gradual change of its morphology – the introduction of relevant rationalizations and inventions. At the beginning of the second stage, conditions are created for the realization of the β hypothesis, the implementation of $n + 2$ level technologies, for example, technology B, is created and started.

III stage – rationalization (traditional technology). The third stage (segment $[\alpha_2, \alpha_3]$); during this period, technology A still provides an increase in labor efficiency, but already on a much smaller scale, the rationalization of the main parameters of technology A (improvement) gives little effect, the costs of rationalization pay off much more slowly than in the previous stages, especially at the end of this stage. The general knowledge intensity no longer corresponds to the integral knowledge intensity of the production sphere ($\omega_\alpha(\tau_3) < \Omega(\tau_3)$), although the performance of technology A (technologies of level $n + 1$) is comparable to the performance of technologies of level $n + 2$, for example, technology B ($\varphi_\alpha(\tau_3) \approx \varphi_\beta(\tau_3)$), which are either at the stages of implementation or at the beginning of the stage of maximum distribution, see Fig. 9.

IV stage – aging (obsolete technology). The fourth stage (segment $[\alpha_3, \alpha_4]$) – the relative effectiveness of the application of technologies of the $n + 1$ level (A technologies) sharply decreases, the costs of rationalization do not pay off, the level of knowledge intensity of technologies does not correspond to the integral knowledge intensity for a long time. If we take into account that before the beginning of the fourth stage, technologies of level $n + 2$, for example, technology B, are in the period of maximum distribution, then the existence of technology A (technologies of level $n + 1$) in this interval $[\alpha_3, \alpha_4]$ is impractical.

Thus, it is also necessary to take into account that it is not only very important to ensure (prepare and implement) the introduction of new technologies in a timely manner, but it is equally important to ensure the timely removal of outdated technologies, that is, to ensure the fulfillment of the condition (see Fig. 9):

$$t_{IV} \rightarrow 0, \quad (27)$$

then

$$T_A \rightarrow T_A^{ef}. \quad (28)$$

Timely removal of obsolete technologies, which are at the IV stage of the life cycle (segment $[\alpha_3, \alpha_4]$), is expedient not only from the point of view of reducing unproductive public costs, but also from the point of view of reducing, which is especially important, expenditure of intellectual resources, because the rationalization of outdated technologies "pulls away" a significant part of integrated intelligence to solve "hopeless problems".

Therefore, the "volume" of integral intelligence, which is free to solve promising issues of development, is decreasing; $\Delta\Theta \rightarrow min$. Under these conditions, the value of the delay in the reflection of ζ by the integral intelligence of the general production situation will increase, because it depends on the "volume of intelligence"; $\zeta = \zeta(\Theta)$.

An increase in the value of the display delay ζ "distances" integral intelligence from understanding modern construction and technological situations, the increase in the "volume" of intelligence ΔΘ progressively slows down (Fig. 10):

$$\begin{cases} \text{if}, \zeta \neq 0 \text{ and } \zeta_{i+1} > \zeta_i, \\ \text{then } \Delta\Theta(t - \zeta_{i+1}) \ll \Delta\Theta(t - \zeta_i). \end{cases} \quad (29)$$

In addition, as the value of the display delay ζ increases, the diversity $H(t)$ of knowledge about systems of technologies increases (Fig. 10):

$$\begin{cases} \text{if}, \zeta \neq 0 \text{ and } \zeta_{i+1} > \zeta_i, \\ \text{then } \Delta H(t+1) > \Delta H(t). \end{cases} \quad (30)$$

So, the negative consequences "pile up" like an avalanche:

- ✓ the conditions for an intellectual outburst are sharply narrowing;
- ✓ there is no new knowledge and skills or they are insufficient;
- ✓ knowledge about technology systems is too diverse, disorganized;
- ✓ preparation of a technological breakthrough is problematic;
- ✓ the scientific and technological lag behind advanced societies is increasing.

Therefore, under these conditions, it remains to apply "outdated technologies", i.e. technologies in the interval $[\alpha_3, \alpha_4]$, and this does not ensure a decrease in the value of the delay ζ(θ), i.e. the value of the delay of the display of the general production situation by the integral intelligence will continue to increase $\zeta \rightarrow max$, therefore, the rate of increase in the "volume" of intelligence will continue to decrease $\Delta\Theta \rightarrow min$.

Under such conditions, society will be in an intellectual and technological deadlock.

Conclusions. Solving any issue begins with putting forward ideas – an idea is born by the intellect. Intelligence is able to learn, the learning process is functionally stable, unbalanced and irreversible. Intelligence is a complex system, it is dynamic and develops faster, the more intense the influence of the external environment. The volume of intelligence is accumulated knowledge about the real world, including the degree of its use; conditionally divided into two groups: fundamental knowledge (general laws of the universe – metaphysics); applied knowledge (regularities of effective application of the laws of the universe – technique).

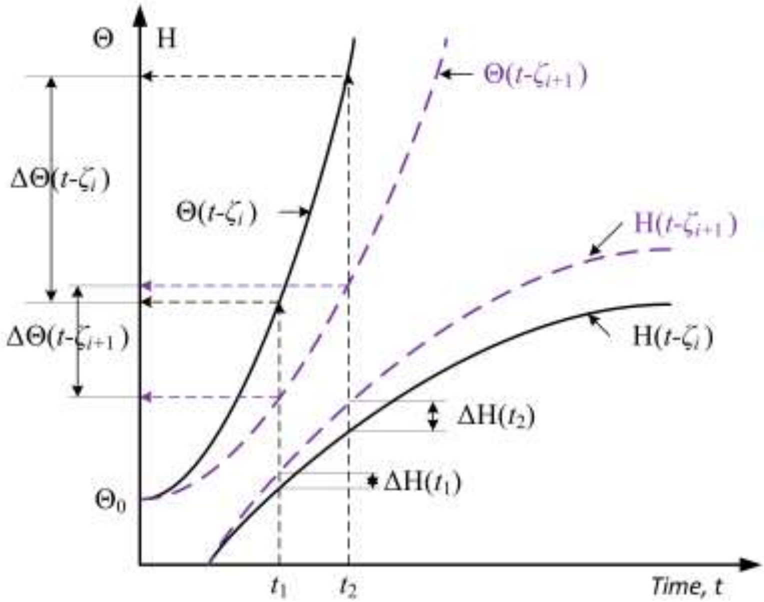


Fig. 10. The dynamics of the growth of the "volume" of intelligence $\Theta(t)$ and the variety $H(t)$ of knowledge about technology systems at different levels of display delay ζ

The growth regularity of the "volume" of integral intelligence obeys the exponential law. According to the author, the logical essence and regularity of the development of intelligence is most successfully revealed by the proposed quantum model of intelligence development. Individual and integral intelligences can be in stationary states for a long time, in which the intelligence and the system of intelligences have "volumes". Any change in the "volume" of intelligence occurs only with a complete transition from one state to another, the mechanism of intellectual transitions is a discrete process.

The volume of integral intelligence increases like an intellectual flash; the process of development of integral intelligence is discrete and has a constant parameter – the lag of integral intelligence, which belongs to the interval of 6–8 years; that is, we have cycles of intelligence development.

The dynamics of changes in the effectiveness of construction technologies at the stages of the life cycle is described by an s-shaped curve, which is tangent to the contour curve characterizing the integral productivity of labor in the industry. Labor efficiency in the construction industry depends on both the rate of introduction of new technologies and the rate of withdrawal of outdated technologies.

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Квантова модель розвитку інтелекту як теоретичне підґрунтя теорії технологічного розвитку. Життєві цикли будівельних технологій

У статті викладено основні положення та виконано аналіз основних моделей розвитку інтелекту з використанням історичного підходу. Запропонована квантова модель розвитку інтелекту, яка розкриває логічну сутність інтелектуальних процесів, що відбуваються на рівнях індивідуального та інтегрального інтелектів. Індивідуальні і інтегральний інтелекти можуть *тривало перебувати у стаціонарних станах, в яких інтелект і система інтелектів володіють "об'ємами". Будь-яка зміна "об'єму" інтелекту відбувається тільки при повному переході з одного стану в інший, механізм інтелектуальних переходів є дискретним процесом. Показано, що закономірність росту «об'єму» інтегрального інтелекту підкоряється експоненціальному закону. Об'єм інтегрального інтелекту збільшується як інтелектуальний спалах; процес розвитку інтегрального інтелекту дискретний, циклічний та має сталий параметр – лаг інтегрального інтелекту, що належить інтервалу 6–8 років. Встановлено взаємозв'язок між циклами розвитку інтегрального інтелекту (його спалахами) та «великими циклами Кондратієва». За кожний лаг інтегрального інтелекту його «об'єм» збільшується, відносно вихідного рівня, на величину експоненти, а кожний «великий цикл Кондратієва» має від 6 до 8 лагів інтегрального інтелекту, які передують хвилям технічних винаходів та їхнього практичного застосування у вигляді інновацій, тобто інноваційного продукту та технологій. Розвиток будівельних технологій є безперервним і незворотним процесом підвищення їхньої результативності у часі, та у цілому описується s-подібними кривими, які є дотичними до обвідний кривий, що характеризує інтегральну результативність суспільної праці у будівельної галузі. Технології мають власні життєві цикли, що складаються з етапів, які відрізняються рівнем відносної ефективності, а саме: етап впровадження і початкового розповсюдження, етап максимального розповсюдження, етап раціоналізації, етап старіння. Існування технологій на етапі старіння є недоцільним.*

Ключові слова: будівельні технології, технологічний прогрес, квантова модель розвитку інтелекту, життєвий цикл технологій