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H. Inter – and Transdisciplinarity in Science and Technology

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Energonics, fundamental and engineering sciences

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Abstract. The particularities of contemporary science are comparatively analyzed with those of Energonics, an integrative and transdisciplinary chapter of science.
Current chapters of science, in general, but also of engineering science cannot solve concrete problems, such us: – superposition and/or cumulation of loads in the case of nonlinear behavior of matter; – superposition and/or cumulation of loads of different natures (mechanical, chemical, biological etc.); – calculation of the synergistic effect of a group of loads in the case of nonlinear behavior of matter; – calculation of the equivalent load with any group of loads of the same or different nature; – considering the influence of deterioration (not only cracks) and residual stresses on the result of a load; – consideration of load rates influence on the result of the loading of a structure; – influence of the statistical distribution of the physical characteristics of the structure material; – introduction influence of irreversibility into resistance calculation; – unitary treatment of loads on technical structures, living organisms and the environment.
All these problems were solved based on the principles and laws of Energonics. Energonics, refers to real physical bodies, not to ideal models.
Through Energonics we pass from the linear, deterministic, reversible and undeteriorated to the nonlinear, non-deterministic, irreversible and deteriorated matter i.e. from the ideal or perfect, to the real and often imperfect.
Moreover, the truths expressed in the principles and laws *of Energonics, through the simplicity and clarity of their formulation, highlight the beauty of scientific truth.*

Keywords: superposition of loads; cumulation of loads; loads of different nature; nonlinear behavior; deterioration; principles and laws of Energonics.

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1. Introduction

The paper makes a comparison among the possible solutions of the concrete scientific and technical problems based on the chapters of contemporary sciences (fundamental and engineering science) and the Energonics, an integrative and transdisciplinary chapters of science.

Mathematical correlations in the various chapters of fundamental sciences have „mathematical beauty”, they are relatively simple and suggestive, and they are so because they come from the consideration of perfect, *idealized models* of reality. In fact, Paul Dirac stated that „*Physical law should have mathematical beauty*”.

In engineering sciences, mathematical correlations are often more elaborate than in fundamental sciences; they consider all aspects of reality. Otherwise, genuine engineering would not be possible.

In the majority chapters of science, the linearity in cause – effect relationship were adopted. As a result *the classical principle of the effect superposition* may be used. But only if the effects have the same unit of measurement. In this case the order of applying the external loads does not influence the final state of the matter, what does not correspond to reality.

The concrete solution to the problem of different natural loads superposition can be done by resorting to Energonics, based on the concept of *energy*. Energy and as well as other concepts related to energy (specific energy, specific energy participation etc.) have the following advantages: – is a scalar variable/quantity, whose value does not depend on the system of coordinate axes to which the motion, or the process under analysis refers; – is an invariant variable/quantity; – loadings can be characterized by amount of specific energy (J/m^3 or J/kg …) they „carry”; – enables to foster unlimited and unscripted applications.

2. Considerations regarding ideal and real bodies

In most chapters of science, ideal/perfect models of the loaded material are used. Energonics refers to real materials with nonlinear behavior, with statistical distribution of physical characteristics, deteriorated and involved in irreversible processes.

Energonics contains the following 4 principles and 4 laws of its own [1]:

- principle of energy accessibility;
- principle of irreversibility;
- principle of critical energy;
- principle of reluctance;

- law of critical states of matter;
- law of equivalence of process or phenomena;
- law of coexistence and complementary of order and disorder;
- law of transient regimes.

These principles and laws transcend the boundary of contemporary chapters of science. With their help we can solve load problems with real body models. They were applied to the evaluation of technical structures, living organisms and environment [1-3].

For example, the truth expressed by the *principle of critical energy* [1; 2] is, when superposition and/or cumulation of loads is analised, different for an ideal or perfect physical body and, for a real physical one, respectively:

- ***for an ideal (perfect) body*** the critical state is reached when the total participation of the specific energies corresponding to the loads to which a material body is subjected is equal to the unit,

$$P_T = 1. \tag{1}$$

The total participation is the sum of the participations of individual specific energies $P_i(Y_i)$, corresponding to the external loads written as Y_i,

$$P_T = \sum_i P_i(Y_i). \tag{2}$$

Relation (1) is a *deterministic and time-independent* relation; it corresponds to a *reversible process*;

- ***for a real body*** (cracked, with residual stresses, deterioration, or likely to be deteriorated by various external actions, which ages over time) the critical state is reached when

$$P_T \geq P_{cr}(t), \tag{3}$$

where $P_{cr}(t) \neq 1$ is the *critical participation*, whose value depends on time, *t*.

The nonlinear, power law, behavior of the matter, is given by the eq.,

$$Y_i = C_i \cdot X_i^k, \tag{4}$$

where Y_i is the load, X_i – the effect of the loading process; C_i and k_i are constants of the matter under load.

For such a material the total participation of specific energies [2],

$$P_T = \sum_i \left(\frac{Y_i}{Y_{i,cr}}\right)^{\alpha_i+1} \cdot \delta_i, \tag{5}$$

where $Y_{i,cr}$ is the critical value of load Y_i, the exponent $\alpha_i = 1/k_i$ and $\delta_i = 1$ if Y_i acts in the sense of carrying out the process of phenomenon; $\delta_i = -1$ if Y_i opposes the to evolution of process or phenomenon.

For technical structures [1;3], the *critical participation*

$$P_{cr}(0) = \begin{cases} P_{cr}(0) - D_T(t) - P_{res} \text{ – for static loading;} \\ P_{cr}(0) - D_T(t) - P_{res} - P_{ir}(t) \text{ – for variable (fatigue) or vibration loading.} \end{cases} \tag{6}$$

In the relations (6) there intervene:

- the statistical distribution of the initial participation, at $t = 0$,

$$P_{cr}(0) \in \left[P_{cr,\min}(0);\ P_{cr,\max}(0)\right], \tag{7}$$

where $P_{cr,\min}(0) > 0$ and $P_{cr,\max}(0) \leq 1$. In the case of deterministic values of mechanical characteristics $P_{cr}(0) = 1$;
– **for technical structures the total deterioration**, time-dependent [4;5], determines the irreversible character of the load effect [3],

$$D_T(t) = \sum_k D_k(t), \tag{8}$$

where $D_k(t) \in (0;1]$ is the individual deterioration.
For *technical structures,* individual deterioration can be caused by *internal factors*, $D^{(in)}$, or *external factors*, $D^{(ex)}$ [3;6].
The *internal factors,* specific to the material and the structure, responsible for the deterioration $D^{(in)}$ are, for example: - the aging of the material in time, $D(t)$; - microcracks, defects and cracks (with depth *a* and length 2*c*), $D(a;c)$.
External factors involved in deterioration $D^{(ex)}$ can be, for example: - pre-stresses, $D(-t)$; - corrosion (during t_{cs});- thermal stress that produces creep (during t_{cp}), $D(t_{cp})$; - the action of hydrogen, $D(H^+)$; - neutron action , $D(ntr)$; - magnetic action, $D(B)$; - radiant flux, $D(\Phi)$; - pollution, $D(c_p)$ etc…
• **For living organisms** the total deterioration consists of the deterioration caused by some external actions and is noted $D_T^{(ex)}(t)$, from the deterioration caused by internal imbalances of the organism, noted $D_T^{(in)}(t)$, and by aging, noted $D(t)$ [3;6],

$$D_T(t) = D_T^{(ex)}(t) + D_T^{(in)}(t) + D(t). \tag{9}$$

*Deterioration caused by external actio*ns can be generated by: chemical pollution, radioactive pollution, flux of electromagnetic radiation, ultrasound, viruses, bacteria, toxins, etc.
The *deterioration caused by internal imbalances*, comes from the lack or insufficiency of some important intimate components of the body, such as some nutrients, vitamins, trace elements, etc.
– the *participation of the residual stresses*, σ_{res} [1;3],

$$P_{res} = \left(\frac{\sigma_{res}}{\sigma_{cr}}\right)^2 \cdot \delta_{res}, \tag{10}$$

where σ_{res} is the residual stress, whose critical value is σ_{cr} and $\delta_{res} = 1$ if σ_{res} acts in the sense of process or phenomenon evolution and $\delta_{res} = -1$, if otherwise;
– the *degree of irreversibility*, ξ_{ir}, is the *participation of specific energy dissipated in heat*, Q_{ir} [3],

$$P_{ir}(t) = \frac{Q_{ir}}{E_a}, \tag{11}$$

where E_a is the action energy or the energy involved in the process or phenomenon.
The relationship (3) specific to engineering sciences refers to a real physical body, with *non-deterministic* characteristics, involved in an *irreversible* process. The value of the right term in relation (3) is not a constant, as in the ideal relation (1),

but a variable dependent on time and the *stochastic character of the behavior of matter* (statistical distribution).

In engineering sciences, reality has made it imperative to consider dissipative effects, which - in general - has complicated the mathematical expression of processes and phenomena.

In most chapters of contemporary science, one takes into consideration the linear behavior of matter and processes with a deterministic and reversible character and undeteriorated.

Energonics allows the consideration of the *nonlinear behavior of matter, of non-deterministic (stochastic) processes, irreversible processes and deteriorated structures*. As a result, Energonics provides the background for solutions that are not accessible to classical theories and, among other things, also makes it possible to [1-3]:

– solve the problems of the superposition and / or cumulation of loads of any nature, which is impossible in the chapters of contemporary science, especially in the case of the nonlinear behavior of matter;

– ensure the equivalence of different processes or phenomena;

– evaluate the irreversibility of processes or phenomena with the use of classical concepts in mechanics and electrodynamics;

– solve problems of fracture mechanics by resorting only to the concepts of the mechanics of deformable solid, without resorting to the new concepts introduced by Fracture Mechanics.

For example:

– *The principle of independence of forces,* used in physics, mechanics, strength of materials, shows that the effects of forces (eg stresses, strains…) applied to a material body are independent of the order of their application. In other words, each force produces effects (effect) independently of the presence of the other forces.

Energonics shows that this principle is true only in the case of materials with linear-elastic behavior statically (or quasi-statically) loaded.

– If the loading feature different speeds, some applied statically, others rapid or by shock, then *the order of the loads influences the final result.* Such a load problem can be solved correctly only on the basis of the *principle of critical energy* in Energonics [1-3].

–The summation of the actions of different loads (mechanical, chemical, electrical, magnetic, biological, thermal, etc.…) cannot be done in the current chapters of science, but only by using *the principle of critical energy*, based on dimensionless variables that can include both different behaviors of matter (linear and / or nonlinear), as well as different speeds of applied stresses (static, fast, shock, transient, etc…).

– The application of Energonics concepts t*o the evaluation of the synergistic effect* of several loads applied to a material body led to the following conclusions [7]: in the case of the linear behavior of matter there is no synergistic effect; the total effect is equal to the sum of individual effects in the case of nonlinear behavior the synergistic effect can be positive (the total effect is greater than the sum of individual effects), or negative (the total effect is less than the sum of individual effects).

3. Energonics vs. classical theories

A parallel is drawn between Energonics and Classical Theories with respect to the way each of them approaches issues like:
– the behavior of matter (conservative-dissipative), reversibility-irreversibility; -deterministic-stochastic (non-deterministic); - undeteriorated-deteriorated. The behavior of matter is described by laws of behavior or material laws.
In Mechanics, in general, bodies are considered rigid, non-deformable; no laws of behavior are required [8].
Conservative behavior laws describe reversible transformations (the law of elastic deformation in the Strength of Materials, the laws of electrical and magnetic induction in Electrodynamics).
Dissipative behavior laws describe irreversible transformations (the laws of plastic deformations, the laws of friction, the law of thermal conduction, the law of electrical conduction).
A special category is represented by *chemical reactions*, which may be considered behavioral laws of physical chemistry.

3.1. Classical theories

a. Behavior of matter
Today, most chapters of science consider the behavior of matter (substance and/or radiation field, etc.) to be linear. This means that between the load/stress, Y, to which a material body is subjected and its response, X, the correlation is linear, of general shape

$$Y = B \cdot X, \qquad (12)$$

where B is a constant of matter under load.
In reality and according to the postulate of Energonics [1;3], *under stress Y, there are always at least two effects*: main effect X and thermal effect X_{th}.
Since, in general, the thermal effect depends on the load rate, it means that the value of X in relation (12) depends on the load rate. Consequently, *the linear behavior is approximate*. It can only be accepted if the thermal effect is negligible or neglected.
b. Deterministic processes. In the case of deterministic processes, for each value of the external load, Y, there corresponds a single value of the effect, X. For example loading with Y_1 results in a unique effect X_1, while loading with Y_2 results in the unique effect X_2 etc.
c. Reversible processes. A certain process under the action of load Y evolves and is characterized by the values of the effect X characteristic of this process.

– *In a mechanical process* of loading a specimen with a force *F*, deformation Δl is obtained. With an increase in *F*, the deformation Δl will increase – according to a certain law (Fig. 1), where $\Delta l = l - l_0$, with *l* - length after loading; l_0 - initial length.

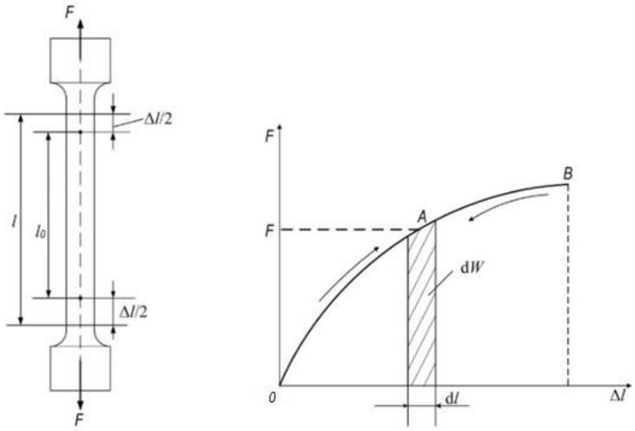


Fig. 1.

The area under the OAB curve represents the mechanical work of the deformation (loading) process,

$$W = \int_{l_0}^{l} F \cdot \mathrm{d}l \,. \tag{13}$$

If the unloading process (BAO) is the same curve as in the loading process (OAB), the process is considered to be *reversible*.
That means the loading – unloading process was perfectly elastic.
– *In a thermal process*, in the cylinder of a motor car (1), the pressure *p*, in front of the piston (2), move the piston (Fig. 2) and increase the volume, *V*, occupied by the gas, from V_1 to V_2.

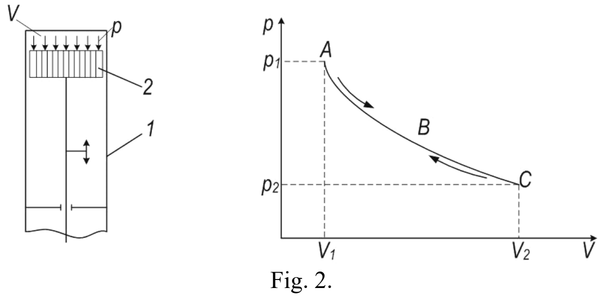


Fig. 2.

At the initial moment the pressure is p_1, and the gas occupies the volume V_1. By moving the piston, the volume increases continuously from V_1 to V_2, and the pressure decreases continuously, from p_1 to p_2.

The process characterized by the ABC curve, generally corresponds to an isothermal, polytropic or adiabatic transformation of the gas. The ABC curve refers to the process of gas expansion, initially at pressure p_1.
If in the reverse process, gas compression - from the final state parameters p_2; V_2, to the initial state parameters p_1; V_1, follows the same curve - but in the opposite direction - CBA, we may claim that the thermal process is reversible [9;10].
In reality, however, part of the work involved in the process turns into heat and, as a result, the compression follows a curve that is different from CBA.
Reversibility describes an ideal process. Certain real processes are sometimes considered - within the limits of a certain approximation - as reversible processes However, real processes are irreversible.
d. Deterioration. The classical chapters (Mechanics, Mechanics of Deformable Solids, Strength of Materials, Thermodynamics etc.) doesn't consider the influence of deterioration about the strength of technical structure [8-12]. The chapter of Fracture Mechanics takes into consideration only the deterioration due to cracks/flaws [13-16].

3.2. Energonics

a. Behavior of matter.
In general, the behavior of matter under load *Y is considered nonlinear*. The very fact that the main effect of the stress, *X,* is always accompanied by a thermal effect X_{th} dependent on the speed of the load, leads to a nonlinear dependence between *Y* and *X* (4).
Some other times, the behavior of matter depends on time (viscous, viscoelastic, elastoviscos matter, etc.). The presence of the viscous component of matter, as well as the external friction of the moving material body, produce thermal effects and may cause a nonlinear dependence between *Y* and *X*. For these reasons Energonics generally considers the behavior of matter as nonlinear. The simplest law of nonlinear behavior is (4).
With $k_i = 1$ one obtains the law of linear behavior (12). The value of exponent k_i may be sub-unitary or supra-unitary or even equal to unit. This determines the shape of the curve $Y(X)$ (Fig. 3).

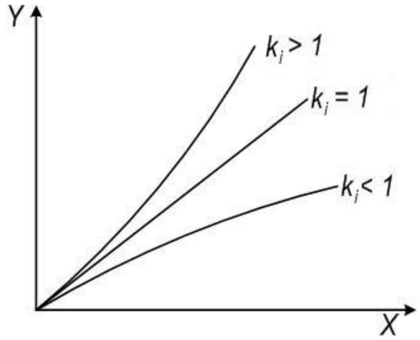


Fig. 3.

The value of exponent k_i depends - in general - on the speed of the load variation, $v_Y = \frac{\mathrm{d}Y}{\mathrm{d}t}$, where t is time.

Some examples: - *in the case of perfect gases*, one notes $Y = p$ and $X = \frac{1}{V}$, where V is the volume occupied by the gas. In this way, the law of perfect gas behavior $(pV^n = N \cdot R \cdot T$, where N is the number of gas moles in volume V; R - the molar constant of the perfect gas and T - the gas temperature) becomes

$$p = (N \cdot R \cdot T)\left(\frac{1}{V}\right)^n, \tag{14}$$

or

$$Y = C \cdot X^n,$$

where $C = (N \cdot R \cdot T)$ is a constant in a given case.

The exponent $n(= k)$, in this case, depends on the rate of change in pressure, volume and / or temperature [9;10];

– *in the case of a solid body* under mechanical stress $\sigma \equiv Y$, which locally produces a strain $\varepsilon \equiv X$ the correlation is of the form (4), namely

$$\sigma = M_\sigma \cdot \varepsilon^k, \tag{15}$$

wherein M_σ and k are constants of the body material.

The law of behavior (15) corresponds to perfectly elastic, nonlinear behavior.

In the particular case when $k = 1$, one obtains the law of perfectly elastic, linear behavior, known as Hooke's law,

$$\sigma = E \cdot \varepsilon, \tag{16}$$

wherein E is the modulus of longitudinal elasticity (Young) of the material.

b. Non-deterministic processes.

In the case of non-deterministic or stochastic processes the same value of the load, for example Y_0, corresponds to several values of the effect, X. The values of the effect X are in a range between $X_{\min}$ and $X_{\max}$

In Energonics, one considers the general case of *non-deterministic processes* as well as particular deterministic cases.

The effect values form a statistical distribution $X(Y)$, for example according to the Gaussian distribution, characterized by the average value X_m (Fig. 4, *a*). In this case, relation (12) may be written as,

$$Y = B \cdot X_m$$

while law (4) may be written as

$$\left.\begin{array}{l} Y = B \cdot X_m \\ Y = C \cdot X_m^k . \end{array}\right\} \tag{17}$$

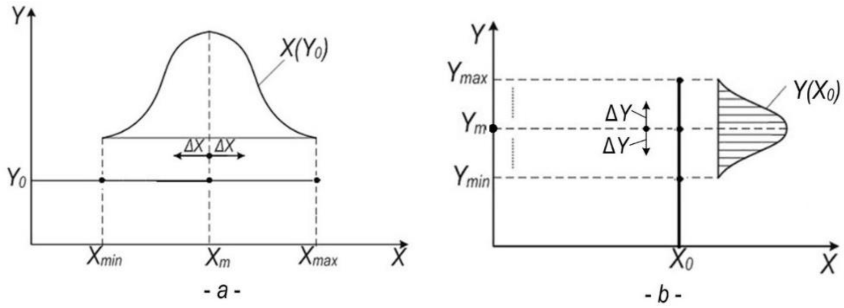


Fig. 4.

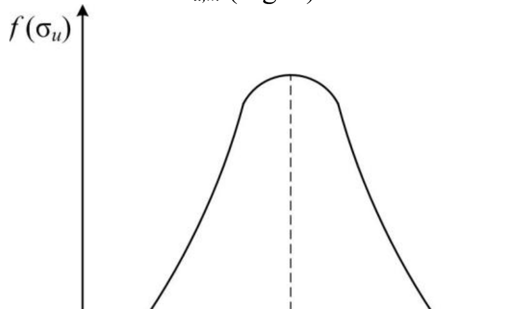
Deviations $\Delta X = X - X_m$, characterize the statistical distribution of *X* and are rarely referred to.

But the problem may be reversed. Namely, by correlating the values of a distribution of *Y* stresses that determine the same value, X_0, of the effect (Fig. 4, b). In this case the load *Y* is characterized by a statistical distribution with the average value Y_m. Relationships (12) and (4) are written in the form,

$$\left.\begin{aligned} Y_m &= B \cdot X; \\ Y_m &= C \cdot X^k, \end{aligned}\right\} \qquad (18)$$

wherein one attaches to load Y_m the statistical distribution. In this case the load deviations is $\Delta Y = Y - Y_m$.

For example, a number of metal specimens are made from a certain material. When they are under a tensile stress up to failure, a relatively large number of ultimate stresses values are obtained. These are grouped according to the relative frequency of the values of the ultimate stress, σ_u. One obtains their probabilistic distribution characterized by the relative frequency, $f(\sigma_u)$, or the distribution density and the average value of the tensile stress $\sigma_{u,m}$ (Fig. 5).



$p_r \leq 5\%$ $\quad$ $p_r = 50\%$ $\quad$ $p_r \geq 95\%$

$P_{cr,max}(0) = 1.0$ $\quad$ $P_{cr,m}(0) = 0.5$ $\quad$ $P_{cr,min}(0) = 1.0$

Fig. 5.

The *critical participation* $P_{cr}(0)$ contains the effect of statistical distribution of mechanical / physical characteristics of the material.
It is accepted that (Fig. 5):

$P_{cr}(0) =$
- 1.0 – if it is assumed that the upper limit of the stress, σ, does not exceed the minimum ultimate stress, $\sigma_{u,\min}$, respectively $\sigma \leq \sigma_{u,\min}$;
- 0.5 – if σ does not exceed the mean ultimate stress, $\sigma_{u,\mathrm{m}}$, respectively $\sigma \leq \sigma_{u,\mathrm{m}}$;
- 0.1 – if σ does not exceed the maximum ultimate stress, respectively $\sigma \leq \sigma_{u,\max}$.

That means that critical participation $P_{cr}(0)$ is correlated with the probability of rupture, p_r, (Fig. 5), respectively:

$P_{cr}(0) = P_{cr,\max}(0) = 1.0$ – at the probability of rupture $p_r \leq 5\%$;
$P_{cr}(0) = P_{cr,\mathrm{m}}(0) = 0.5$ – at the probability of rupture $p_r = 50\%$;
$P_{cr}(0) = P_{cr,\mathrm{m}}(0) = 0.1$ – at the probability of rupture $p_r \geq 95\%$.

If a single, deterministic, values is indicated for the ultimate stress, σ_u, without specifying the probability of breaking or destruction, it can be accepted that is corresponds to $\sigma_{u,\min}$ and consequently $P_{cr}(0) = 1.0$.
The probability of survival of a material structures is,

$$p_s = 1 - p_r. \tag{19}$$

For example, if $p_r = 5\%$ one obtains $p_s = 1 - 0.05 = 0.95$ or 95%.

c. Irreversible processes.
According to the *postulate of Energonics* [1;3], any external load applied to a physical body has at least two effects, one of which is always the thermal effect X_{th}. Since the thermal effect is proportional to the loading speed, $X_{th} \sim v_y = \mathrm{d}Y/\mathrm{d}t$, it means that the dependence $Y(X)$ is not unique and obviously not linear.
One has found that in any process or phenomenon there occurs the conversion of some forms of energy into others. However, mention should be made that among the effect energies $E(X)$, there is always a certain amount of heat, Q. In other words, the loading energy $E(Y)$ is equal to the sum

$$E(Y) = E(X) + E(X_{th}), \tag{20}$$

where $E(X_{th}) = Q$.
In Energonics one considers *the physical bases of irreversibility*: internal friction, external friction, volume variation, non-uniformity of intensive quantities.

The principle of irreversibility in Energonics introduces the concept of degree of irreversibility which is actually *the participation of specific energy irreversibly transformed into heat* (11).
Let us consider a process where both *Y* and *X* vary continuously, their correlation being described by the curve A_1B_1 in the stage when *Y* decreases continuously and by the curve B_1A_2 in the stage when *Y* increases, tending to attain the initial value A_1. Then, one gets discharge curve A_2B_2, followed by re-charge curve B_2A_3, etc. (Fig. 6).

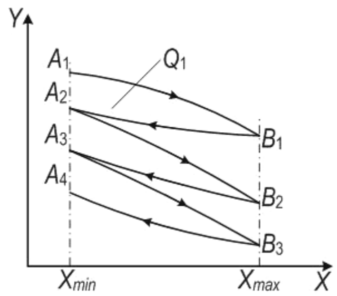


Fig. 6.

The area under curve A_1B_1 represents the work corresponding to the discharge, W_1, while the area under the curve $B_1A_2$is the work corresponding to the reload, W_2. There is a relationship between the two,

$$W_1 = W_2 + Q_1, \tag{21}$$

where Q_1 is equal to the energy dissipated as heat between the two processes considered.
From the succession of relations of the form (21), where at each discharge-recharge stage a part of the initial energy $E(Y)$ is transformed into heat, it is possible to attain - after a large number (theoretically infinite) of such pairs of processes– the dissipation of the whole amount of energy $E(Y)$ in the form of heat.
The entire amount of energy is conserved, while *the quality of the energy changes over time*; there is an increase in the amount of disordered energy (heat) due to the decrease in the amount of ordered energy (work).
To these one should add the fact that matter ages and sometimes deteriorates over time. Both are irreversible processes.

d. Deterioration.
The relations for calculating the strength and lifetime of *technical structures* obtained in Energonics are more general than the classical ones and contains – unlike the latter – the influence *of the deterioration* (8); (9), produced by different external factors (action of neutrons, hydrogen, corrosive agents, temperature, vibrations, pre-loading, etc.) and internal factors (ageing, cracks, defects) as well as the influence of residual stresses (10).

In the case of *living organisms*, the deterioration (9) may be determined by certain factors that may be external (pollution, viruses, bacteria, toxins, ultrasounds, etc.), or internal (lack of nutrients, vitamins, disequilibria, etc.). The latter, together with the participations corresponding to the medical treatments and adaptive self - adjustment have an impact upon the lifetime of the living or organism. But the deterioration of living organism may be calculated *only* by Energonics [3].

4. Conclusions

Calculations of strength, critical states and lifetime are issues that are specific to engineering structures. One cannot transfer them to the case of living organisms or the environment by using the classical types of relations underpinning technical structures.

Recourse to the concepts, principles and laws of Energonics makes it possible to use the calculations of strength, critical state conditions and lifetime with unique relationships, *based on dimensionless concepts*, applicable to technical structures as well as living organisms, environment etc.

For example, in contrast to the Strength of Materials, in Energonics one considers: – the speed influence on the final outcome, which makes it possible to be dependent on the order of loads; – the influence of the behavior of matter on the result of loads superposition, which makes it possible to highlight the positive, negative and/or neutral synergistic effects.

Calculation of the results of the superposition and/or cumulation of different types of loads (mechanical, chemical, thermal, electrical, magnetic, radioactive, biological etc.) cannot be done within the chapters of contemporary science, but only on the basis of Energonics.

In Energonics we should start from the law of behavior of processed matter; this made it possible to provide a unitary treatment of processes, independent of the state of matter aggregation (gas, vapors, liquid, melt, solid…) and the consideration - when needed - of the time factor in the behavior of matter, like for example: the aging of matter, the deterioration of matter, the creep of materials, the fatigue of matter caused by variable stress, etc.

Also, Energonics allows us to consider *the statistical distribution of the physical characteristics of materials under load, the nonlinear behavior*, *the process irreversibility and the matter deterioration*, based on known concepts, correlated with the movement of matter (internal friction, external friction, non-uniformity of intensive parameters etc.).

With Energonics one passes from a linear, reversible, deterministic and undeteriorated view to one that is nonlinear, irreversible, nondeterministic and deteriorated. In other words, one passes from an ideal or perfect outlook to one that is real and generally, imperfect.

For example, reversibility and determinism apply to all the simple, ideal cases, while *irreversibility and non-determinism* actually map out real cases.

Energonics is a transdisciplinary and integrative approach and marks the beginning of a road towards both qualitative knowledge as well a quantitative knowledge, beyond the horizon of individual science.

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