

BALKANTRIB'05
5th INTERNATIONAL CONFERENCE ON TRIBOLOGY
JUNE.15-18. 2005
Kragujevac, Serbia and Montenegro

THE CONTACT APPROACH IN TRIBOLOGY

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Abstract

As interdisciplinary approach, the contact approach in its content unifies methods, means, and instruments for the identification, description and solving of complex problem situations. Complex are the situations of contradictions and/or systems of contradictions in nature, techniques or society, whose appearance or overcoming are essentially related to contacts, contact webs, and contact interactions. The approach is called contact approach in correspondence with the system-building role of contacts. Four fundamental cross-sections are found to form every contact whole: ontological, spatial, temporary and functional. Four principles for the being of the whole are formulated and substantiated.

Keywords: *contact, contact systems, wholness*

Introduction

The essential of the contact approach is hidden in the maxim of Newton, who says that: “God is not in the things, but between them” and in the aphorism of Goethe: “Between the extremities is not the truth, but the problem”. A generalized expression of both maxims is shown in the saying of Prof. N. Manolov, the founder of the contact approach: “The fundamental problems in our complicated life are generated and reveal the contacts and the contact webs in nature, society and techniques”.

The elemental contact system, which is the basis of all functional systems of the being, would be called a **functional atom**. It is triunique and consists of two alternatives and the contact between them. The functional atom is similar as presumption to the physical atom in the modern science.

As geometry, the functional atom represents a part of the functional space determined by four points: the whole (A), its two alternatives (A_1, A_2) and the contact between them (A_3) - Fig.1. The four points

A, A_1, A_2, A_3 are four independent elements, which, like the whole A , can be structured on different levels in vertical direction and in different configurations horizontally. The first level, on which is represented a given element (a whole), is called fundamental (contact) level, and the following, downwards, are called I-st, II-nd, III-rd analytical levels of the whole. By vertical movement upwards are obtained I-st, II-nd, III-rd synthesizing levels. The essence of the functional atoms on contact level corresponding to different cross-sections, determines the whole on that level in integral way.

If moving horizontally and vertically, and applying consecutively the model of the triunique whole for each level, we identify and describe the whole essentially and functionally in the context of its surrounding. The number of levels and of the cross-sections for the analysis of the given whole, are determined by the character of the problem situation related to that whole. The described procedure defines the operative essence of the contact approach.

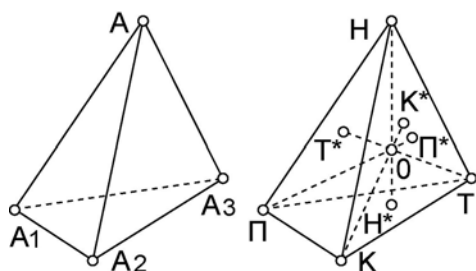


Fig. 1.

Fig. 2.

Every thing from the being exists on contact level in the space of its functional atom. The alternatives A_1 and A_2 of its being are represented through its special dimension (Π), its time dimension (T) and the contact between these alternatives, which is the hybrid temporary-spatial formation (K)- Fig. 2.

The plane opposite to the thing ($\Pi - T - K$) depicts the ontological cross-section of the thing and in this plane H it is updated through its orthogonal projection H^* . The plane opposite to the space Π ($K - H - T$) depicts the spatial cross-section of the thing and there the thing is updated through its orthogonal projection Π^* of Π . The plane opposite to the time T ($\Pi - H - K$) depicts the temporary cross-section of the thing and in this plane it is updated through its orthogonal projection T^* of the time T . The plane opposite to K depicts the purely functional cross-section of the thing H through its orthogonal projection K^* of K on this plane.

In ontological cross-section, the actual state of the thing is expressed as a function of its three ontological components: spatial, temporary, and temporary-spatial. In spatial cross-section the state of the thing is expressed through the change of its spatial characteristics with the time and of its contact state. In temporary cross-section, the actual state of the thing is expressed through the change of its temporary characteristics as a function of its spatial and contact state. In contact cross-section, the actual state of the thing is expressed through the change of its behavior in time and space.

Theorem for the sustainable being of H: The necessary and sufficient condition for sustainable being of each thing is that its orthogonal axes to the opposite walls of the tetrahedron from the four picks of the

functional atom cross in the center of the sphere inscribed in it.

This theorem follows from the fact that the stable atom presupposes sustainable being of the thing as a whole and of its three elements separately. The points expressing the actual state of the thing and its components H^*, Π^*, T^*, K^* coincide with the points of contact of the inscribed sphere with the walls of the tetrahedron of the functional atom. The radius of the sphere is the distance from the center O to any of those points of contact.

If the axes, where we put the three components Π, T, K of the whole, are orthogonal, then it is seen from Fig. 3 (as per the above described procedure) that the thing H coincides with the origin of the coordinates O and with the center of the sphere of its stable/sustainable being. The radius of the sphere in this case is reduced to $R = OH^*$.

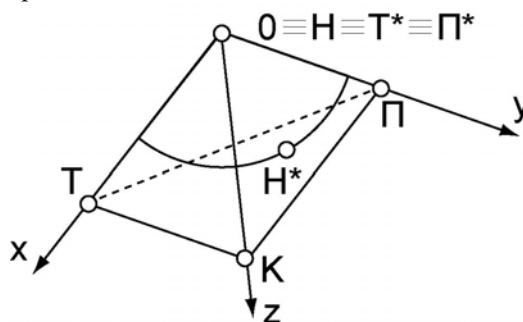


Fig. 3.

In that case H^* should not leave the ontological plane $K - T - \Pi$. If orthogonal axes available, the thing H is composed through superposition of the actual dimensions of its three components ($O \equiv H \equiv \Pi^* \equiv K^* \equiv T^*$). The orthogonal tribological model of the triunique whole is optimal, because it provides optimum stability compared to all other tetrahedric models.

The principle status of the contact approach

In the process of differentiating the contact as an independent third origin with own structure, essence and behavior between the interacting two partners, is replaced the dual elemental whole with triple one. Moreover, the central place of the contact between the other bodies determines its central role for the formatted tribological whole. Based on this model follow the principles for every elemental whole.

Principle for unity of the whole: Each functional whole of the being is triunique on

the first contact (fundamental) level, including two alternative partners and the third one - the contact between them according to the formula of the triad for every whole триадата за всяко цяло: “тяло-контакт-противотяло”. For example, the whole “sliding bearing” is represented as per this formula by the triad “slider-contact-guiderail”. Without contact the sliding bearing does not exist, hence, friction, lubrication, wear do not exist. The unity of the whole is obtained through the connecting functions of the contact, and the detachment of the alternatives – through its demarcation role. The quality of the whole as functional formation is determined not by the alternative bodies, but by the contact between them. That is why the whole is identified as a “contact body”.

Principle for the variety of the whole:

Every independent whole is exhibited as multifaceted, because it is multi-contact one. One and the same functional whole considered in depth, width and functionally, can be described as “mosaic whole” formed by different fragments related through contacts. In their unity the contacts form the connecting tissue of the whole in the form of contact web. Going in depth and width, it could be stated that all elements of the basic triad are autonomous, and should be characterized, according to the first principle, by their own triads, which form the second level of the initial whole. This process of differentiation of the whole in depth is unlimited and can reach any level n with a total of 1.3^{n-1} contacts and 2.3^{n-1} fragments. Similarly, by the analysis in width, can be formed unlimited number of contacts with alternative elements of their surrounding. Further, the picture will be completed if we add the fragmentary and contact elements of the functional chains, which are obtained by cutting with technological and more general cultural cross-sections (aspects). There are four fundamental cross-sections of every contact whole: ontological, spatial, temporary and functional.

Principle for changing the whole:

Every whole is in process of continuous changing, adaptation and self-organization; by that is possible a stable coexistence between its unity and variety. The fundamental ways of changing a whole are three: *destruction-realization-building*. Three are also the levels of exhibition for each of them: *macrolevel*,

contact level and microlevel. The first one is the level where the whole operates as element of a more general whole, the second is its own fundamental level, and the third is the level of exhibition of its elements. The development goes on the first essential level through the phases: *preparatory, stationary, pathological*, i.e. in the beginning the whole gathers resources, then enters in the maturity, and at the end is exhausted.

Principle for the whole: The three principles for unity, variety and changing of the whole form the functional space of the forth, general principle for the whole. It gives the answer to the question for the sense of the whole represented by its principles. The formulation of the last principle is as follows: In order to exist, operate and develop, every whole is triunique, diverse and changing. The development of the whole is determined by the attained structure, volume, form and position of the fundamental cell. The end of the whole comes with the leaving (loss of actuality) and annulling the volume of this cell.

About the general law of the contact approach

The unity of world is one of the few ideas in human evolution which is related to a wide and long-lasting consensus. This idea stimulates the creative potential of human beings as reasonable individuals and defines the direction of the progress. The idea was marked by several visions, e.g. the idea of God, the idea for the occult stone, the idea for the objective science, the idea for the universal gravitation, for the general theory of the field, etc.

Basic notions in the general contact law are the alternative quantities and alternative potentials. Alternative quantities are those exhibiting proportional relationship. For example, with increasing time T , increase the spatial elements of being by adding spaces of the newly created elements during the corresponding increase in time. Alternative potentials are formed from the alternative quantities so, that they are complementary, i.e. increase in one alternative leads to decrease in the other one.

The general law of the contact approach is expressed by two alternative potentials (β, γ) and one contact potential between them (α) according to the formula:

$$\alpha \cdot \beta \cdot \gamma = 1. \quad (1)$$

The law is to be read as follows: Every thing H (and each element of it), if regarded as one (designated by the figure 1), is defined through the multiplication of its three potentials: active β , reactive γ and contact (communicative) α . The active potential β is directed inwards to H and is expressed by the ratio of the change ΔC of external perturbation C as per the formula $\beta = \frac{\Delta C}{C}$.

The reactive potential γ is directed outwards from H and is expressed by the ratio of the reaction R corresponding to the perturbation C , and its change ΔR generated by ΔC : $\gamma = \frac{R}{\Delta R}$. The contact (communicative) potential α is determined by the volume of the cognitive space of both alternative potentials β and γ through the contact K between them by the formula:

$$V = \nu \cdot K \cdot \beta \cdot \gamma, \quad (2)$$

and for α is obtained:

$$\alpha = \frac{K}{K_o}; \quad K_o = \frac{V}{\nu}.$$

The parameter ν is a number, which expresses what part of the volume V of the parallelepiped $K \times \beta \times \gamma$ occupies the volume K_o of the functional space of the thing H in cognitive cross-section. The contact (communicative) potential α is expressed by the ration of the volumes of both functional spaces K and K_o .

The law of the contact approach can be represented by two differential and one algebraic equations in the form:

$$\frac{dR}{dC} = \alpha \frac{R}{C}; \quad \frac{dC}{dR} = \lambda \frac{C}{R}; \quad \lambda \cdot \alpha = 1 \quad (3)$$

where $\lambda = \frac{1}{\alpha}$ is the measure for no communicativeness of the alternative quantities.

According to the structure of the law, the presence of the perturbation and the reaction is symmetrical, but their role can be nonsymmetrical. Three cases are possible:

1. If at exchanging the places of C and R in the law the communication remains unchanged, the role and place of both factors are symmetrical. In this case, $\lambda \cdot \alpha = 1$ and

$\lambda = \alpha = 1$. The processes are linear and reversible.

2. If $\lambda \cdot \alpha = 1$, $\lambda \neq \alpha$ and $\lambda = const, \alpha = const$, then β and γ are not equivalent in their role. The processes are nonlinear and reversible.

3. If $\lambda \cdot \alpha = 1$, $\lambda \neq \alpha$ and $\lambda \neq const, \alpha \neq const$, the processes are nonlinear and irreversible.

The necessary and sufficient conditions a given phenomenon to be reversible are: $\lambda \cdot \alpha = 1$, $\lambda = const, \alpha = const$.

For example, the force \vec{F} and the acceleration \vec{a} are related by the equation $\vec{F} = m \cdot \vec{a}$, which means that both vectors \vec{F} and \vec{a} are proportional and the product of their alternative potentials is $\frac{d\vec{F}}{\vec{F}} \cdot \frac{\vec{a}}{d\vec{a}} = 1$.

Actually, from $\vec{F} = m \cdot \vec{a}$, where $m = const$, follows $d\vec{F} = m \cdot d\vec{a}$, hence

$$\frac{d\vec{F}}{\vec{F}} \frac{\vec{a}}{d\vec{a}} = \frac{m \cdot d\vec{a}}{m \cdot \vec{a}} \frac{\vec{a}}{d\vec{a}} = 1.$$

Tribological processes and phenomena belong to the second and third cases. An external manifestation are the cases of anisotropy, hysteretic, in general the cases of uniqueness, irreversibility and ambiguity. This part of the world can be called the "postdeterministic world". That is the world that should cognize the modern science, because it hides the virgin treasures of the future.

Law for contact deformation of the bodies

The law for contact deformation of the bodies in differential form has the form

$$\frac{dp}{p} = k \frac{d\delta}{\delta}, \quad (4)$$

where p and δ are contact pressure and contact deformation, accordingly. The coefficient k is related to the communicative factor in the General law, but in that case is the measure for contact non-linearity. By $k = 1$ the law is expressed with the linear relationship between p and δ ; by $k = const \neq 1$ the relationship is nonlinear, and by $k = k(\delta)$ the relationship is of variable nonlinearity.

Under the aspect of the General tribological law (1) the active potential is $\alpha = \frac{dp}{p}$, and the reactive $-\gamma = \frac{\delta}{d\delta}$, then follows

$$\alpha \cdot \frac{dp}{p} \frac{\delta}{d\delta} = 1 \text{ or } \frac{dp}{p} = \lambda \frac{d\delta}{\delta}. \quad (5)$$

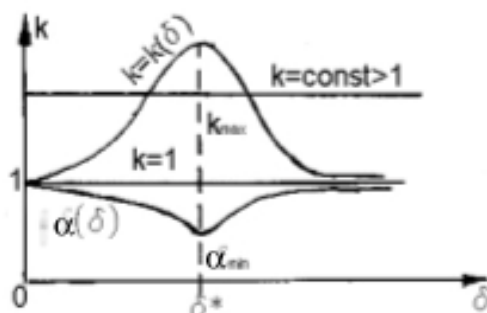
If comparing both laws for the contact potentials is obtained:

$$\alpha(\delta) = \frac{1}{k(\delta)}, \quad (6)$$

Which means that the communication between p and δ is minimum for $\delta = \delta^*$ and $p = p^*$, i.e.

$$\alpha(\delta^*) = \frac{1}{k(\delta^*)} = \alpha_{\min}. \quad (7)$$

The character of the relationship of the communication α between p and δ is given graphically in Fig. 4.



Фиг.4

Fig.4

Law for the jet-abrasive wear

The mass wear of the wall Δm under erosion is proportional to the pressure load F of two-phase stream on it and to the mass Δm_a of the abrasive particles in the stream, i.e.

$$\Delta m = k \cdot F \cdot \Delta m_a. \quad (8)$$

The parameter k is a coefficient of proportionality of dimension $[N^{-1}]$, which represents a measure for the interaction between stream and wall surface.

According to the General law, in order to obtain the communicative potential of the interaction α , reactive $\gamma = \frac{\Delta m}{\Delta m_a}$ and active

potential $\beta = \frac{F}{F^*}$ are introduced, i.e.

$$\Delta m = k \cdot F^* \cdot \Delta m_a \cdot \frac{F}{F^*}. \quad (9)$$

and for the communicative potential α is obtained:

$$\alpha = k \cdot F^*, \quad (10)$$

which is also non-dimensional number. The nominal value F^* is determined by the condition:

$$\alpha = 1 \text{ при } \beta = 1 \text{ и } \gamma = 1, \quad (11)$$

or F^* is the normal load of the two-phase jet on the wall, by which appears wear of the wall equal to the mass of the used abrasive.

Finally, the law for jet-abrasive wear in integral form obtains the form:

$$\Delta m = \alpha \cdot \Delta m_a \cdot \frac{F}{F^*}. \quad (12)$$

The communicative potential α characterizes the structure, the properties and the kinetics of the contact between jet and wall under erosion. In the general case it is a complicated function of many factors like: the angle of falling of the particles to the wall, the friction coefficient of the two-phase jet and the wall surface, the material, dimensions, shape and hardness of the falling particles and the wall, the presence of moisture, aggressive components, etc. The study of the essence of α is a complicated problem, which presupposes the necessity of planned multifactor experiment, suitable method and regression analysis.

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