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ONE THEORETICAL ASPECT OF ENTROPY PARADIGM APPLICATION TO THE PROBLEMS OF TRIBOLOGY

The paper theoretically considers the possibility of the subjective analysis core statement application to tribology. The subjective entropy extrimization principle is proposed to be used for solving tribological problems. Electrochemical potentials difference is obtained on the basis of multi-alternativeness and uncertainty of the alternatives preferences functions paradigm. With the help of a variation it is shown the optimality of the preferences distribution. The presented mathematical model has a significance of a universality characteristics proving to be a plausible explanation for phenomena stipulated by multi-alternativeness. In the discussed aspect the concept is applicable to the variety of issues.

Keywords: *tribology, electrochemical potential, potential drop, multi-alternativeness, preferences distribution, subjective entropy, uncertainty, variation, optimality.*

Introduction. It is an essential component of science that to discover a relation between intrinsic values. The zero level tasks are to describe a phenomenon at least with a statistical mathematical expression (it is the basics of the knowledge, i.e. its initial point). The first level then it is finding a relation between the parameters on the basis of some physical statements. Next step in such a research ideology direction (the second level) is determination of possible ranges of variables changes, extremums; investigations for the applicability restrictions, limitations of the previous theoretical speculations and so on. The top level (the third one) in this sequence would be a central concept which generalizes all lower levels and allows deriving all relations at them with the help of some variational principle. It means discovering a certain universal value whose extreme magnitude is ensured by the previous mathematical expressions models. In its turn it means that the discovered statement is not an occasional thing but fundamental property of the matter existence and development.

State of the problem. Philosophical speculations like those mentioned above imply an evolution of a scientific thought on a point of a scientific interest from the simplest (preliminary) forms of the basic levels up to the final ones (sometimes absolutely abstracted) of the highest possible levels for the human understanding involving plausible logical explanations.

It is generally accepted that problems of friction and wearing deal with a variety of different and complex physical-chemical phenomena [1]. The complexity of simultaneous processes occurring in electrochemical terrain [2], on friction surfaces [3], pertaining with the tribo-units lubricants properties [4], as well as to practically every heat release and exchange, in particular, discussed in paper [5] touching thermal states of the heavy loaded tribo-units, stipulates the widest range of theoretical approaches, hypotheses and their applications.

For all the issues described above, there is a common general entropy approach called as subjective entropy extremization principle (SEEP) developed in subjective analysis [6-8]. The concept evolved there has deep roots in a specific combination of mathematical substantiations for active systems subjects' behavior and problem-resource approach reflected in psychological area [9].

For now, there are still several unsolved parts of the general problem of theoretical description of tribological issues from the positions of some new ideas. The productivity of the subjective analysis entropy paradigm has been successfully demonstrated in very many different scientific fields' applications [10-18].

Problem setting. It is always important to propose a new method showing a deliverance of extremums to a certain value having a relevant significance in tribo-systems with the use of some variational principle.

In this respect the newly developed theory of subjective preferences entropy [6-8] gives a researcher a tool for such kinds of investigations.

Purpose of the paper. The goal of the presented paper is to elaborate a universal vision of the very different tribological phenomena on the basis of the multi-alternativeness, that is subjective entropy paradigm application.

Principle derivation applicable to important tribological dependences. Considering, for example, [2] one may characterize the electrochemical potential described in the view of [2, p. 5, (1.7)], from the Sub-Chapter 1.2 Thermodynamics and Potential, with respect to inevitable relations between parameters of the expression involving multi-alternative background:

$$\mu_i = \mu_i^{\theta} + RT \ln m_i \gamma_i \tag{1}$$

where μ_i is the electrochemical potential of species i, μ_i^{θ} is independent of concentration, R is the universal gas constant (8.3143 J/(mol·K)), T is temperature in Kelvin, m_i is the molality of species i (mol/kg), γ_i is the molal activity coefficient of species i.

Suppose the relations in equation (1) are organized in the type of alternatives and their preferences, [6-8, 10-18]:

$$\Phi_{\pi} = -\sum_{i=1}^{2} \pi_i \ln(\pi_i) + \frac{1}{RT} \sum_{i=1}^{2} \pi_i \left(\mu_i - \mu_i^{\theta}\right) + \gamma \left(\sum_{i=1}^{2} \pi_i - 1 \right). \tag{2}$$

Here, Φ_{π} – purpose (objectives) functional containing subjective preferences π_i related with the corresponding alternatives effectiveness functions $\left(\mu_i - \mu_i^{\theta}\right)$ existing objectively, γ – cognitive coefficient (function) for the preferences normalizing condition. The first member in functional (2) is the subjective entropy (measure of uncertainty) of the preferences distributed on the achievable set of the two available alternatives. Coefficient $1/(RT)$ stands for the parameter (likewise one more cognitive characteristics) engaged in the preferences distribution. Since its value is always positive the preferences will be greater for the bigger effectiveness functions.

Now, in accordance with SEEP [6-8, 10-18] the optimal distribution of the preferences is to deliver the extreme value to the objective functional (2). It yields the potentials difference:

$$\mu_1 - \mu_2 = \left(\mu_1^{\theta} - \mu_2^{\theta}\right) + RT \ln\left(\frac{\pi_1}{\pi_2}\right) \tag{3}$$

Assuming

$$\pi_i = x m_i \gamma_i , \tag{4}$$

where x is an unknown multiplier so far, and using the normalizing condition we obtain the desired preferences distribution:

$$\pi_1 = \frac{m_1\gamma_1}{m_1\gamma_1 + m_2\gamma_2}, \qquad \pi_2 = \frac{m_2\gamma_2}{m_1\gamma_1 + m_2\gamma_2}, \tag{5}$$

which finally gives

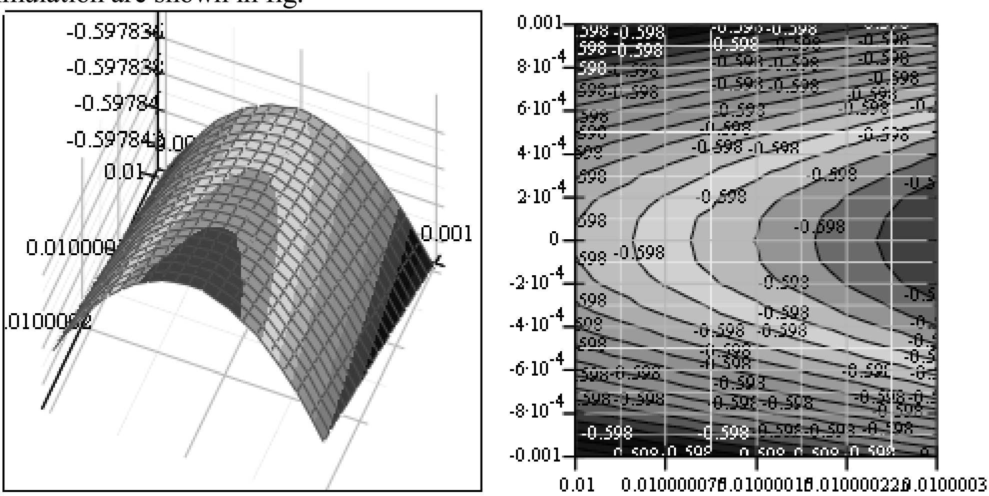
$$\mu_1 - \mu_2 = \left(\mu_1^\theta - \mu_2^\theta\right) + RT\ln\left(\frac{m_1\gamma_1}{m_2\gamma_2}\right). \tag{6}$$

On the other hand, the necessary conditions for the functional (2) extremum existence yield the so-called canonical distribution of the preferences:

$$\pi_1 = \frac{e^{\frac{1}{RT}\left(\mu_1-\mu_1^\theta\right)}}{\sum_{i=1}^{2} e^{\frac{1}{RT}\left(\mu_i-\mu_i^\theta\right)}}, \qquad \pi_2 = \frac{e^{\frac{1}{RT}\left(\mu_2-\mu_2^\theta\right)}}{\sum_{i=1}^{2} e^{\frac{1}{RT}\left(\mu_i-\mu_i^\theta\right)}}, \tag{7}$$

which follows SEEP and is identical to distribution (5) obtained through the procedure of (1-6).

Computer simulation. For the presented stage of the research it is conducted the numerical experiment with the mathematical model expressions (1-7) and following conditional calculation data: $m_1 = m_2 = 5$ conditional units (CU); $\gamma_1 = 0.1$ CU; $\gamma_2 = 0.01$ … 0.0100003 CU; for the preferences functions variation $\delta = -0.001$ … 0.001; $\mu_1^\theta = 1{,}000$ CU; $\mu_2^\theta = 700$ CU; $T = 273+25$ K. The obtained results of the computer simulation are shown in fig.



Φ π_1 Φ π_1

a *b*

Fig. 3D surface plot (*a*) and contour plot (*b*) showing the extreme value of the objective functional delivered by the optimal preferences distribution

Discussion on the proposed approach and its application results. The proposed method might be reasonably used wherever dependencies analogous to equations (1, 3, 6) are encountered. Namely, for instance, [2, p. 12, (1.22, 1.23), p. 19, (1.34)], etc.; [3], esp. pp. 3-13 … , Chapter 1. **INTERACTION OF SOLIDS**, § 1.2. Double Electric Layer at the Phase Interface, P. 9-11, ***Metal₁-metal₂ contact.***, "An equilibrium height of the barrier of the two metals", ***Metal-semiconductor contact.***, esp. P. 11, (1.11), P. 13, (1.12) … etc.; [5], esp. P. 79, (7). The main law of psychophysics (Weber-Fechner Law) [9], pp. 128-132, § 3.3.3, esp. P. 131, table 4, is also derived on the basis of SEEP [13-15]:

$$\Phi_S = -\sum_{i=1}^{2} S_i \ln S_i + \frac{1}{a}\sum_{i=1}^{2} S_i P_i + \gamma\left(\sum_{i=1}^{2} S_i - 1\right), \qquad (8)$$

where S_i – stimuli estimated with respect to their uncertainty entropy measure which play the role of preferences in traditional interpretation, P_i – perceptions (as responses to the corresponding stimuli) used for effectiveness functions, $1/a$ – relevantly evaluated coefficient. In order to avoid mathematically logarithmical operation with the having measurements values, it is possible using ratios to some units or threshold values.

After applying SEEP to the objective functional in the view of (8) with categories aspects and ideas considered and discussed in papers [13-15] one can obtain

$$P_1 - P_2 = a \ln \frac{S_1}{S_2}. \qquad (9)$$

In all cases presented here the preferences functions vary in the diapason of $]0\ldots1[$. Events with zero evaluated effectiveness functions need their further investigations. Regarding to the extremal (maximal) values of the purpose functional (2) shown in fig., they have to be there since the second partial derivatives of the functional with respect to the preferences are always negative. Hence, optimal distribution of the preferences really is where variation δ =0.

All this, in accordance with the concepts expressed in (1-9), means that the nature has alternatives and it treats them optimally with taking into account the uncertainty entropy of the treatment “preferences”.

Conclusions. The approach discussed in this paper seems applicable wherever there is dependences likewise (1, 3, 6). The correct defining of both the effectiveness (utility) and preferences functions related with the corresponding alternatives is indispensable.

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ОДИН ТЕОРЕТИЧНИЙ АСПЕКТ ЗАСТОСУВАННЯ ЕНТРОПІЙНОЇ ПАРАДИГМИ ДО ПРОБЛЕМ ТРИБОЛОГІЇ

Стаття розглядає теоретично можливість застосування до трибології ключового положення суб'єктивного аналізу. Пропонується використовувати принцип екстремізації суб'єктивної ентропії до розв'язання трибологічних проблем. Різниця електрохімічних потенціалів отримується на основі парадигми багатоальтернативності та невизначеності функцій переваг тих альтернатив. За допомогою варіації показано оптимальність розподілу тих переваг. Представлена математична модель має значущість характеристики універсальності, доводячи, що вона є правдоподібним поясненням для явищ, обумовлених багатоальтернативністю. У дискусійному аспекті, дана концепція є такою, що має можливість бути застосовуваною до найширшого кола питань.

Ключові слова: трибологія, електрохімічний потенціал, падіння потенціалу, багатоальтернативність, розподіл переваг, суб'єктивна ентропія, невизначеність, варіація, оптимальність.

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