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### A BASIC EXAMPLE OF THE MATHEMATICAL LOGICS INTERPRETATIONS TO THE TRIBOLOGICAL PROCESSES CHARACTERISTICS REVEALING

*It is made an attempt to propose some appropriate adaptation of the mathematical logics apparatus to the determination of the group of tribological processes and the category of effects observed when there are the friction and wear processes that could happen in the considered structural elements of the engineering units being under investigation. The circumstances at which there is the group of the tribological processes and there is the category of the effects observed are not deemed to be identified undoubtedly in the conditions of the experiments conducted or the performed observations. In some situations a definite answer can be given to the questions put about the combinations of the processes and the effects that are happening. This is possible in conditions of uncertainty in regards with an additional portion of a defining piece of the information obtained and the mathematical logics rules implementation. In the considered and presented in the given paper simplified example the additional portion of the defining piece of the obtained information is that each of the three mentioned in the example problem setting statements includes either correct identification of the process related or the effect observed. Also it is supposed to be known for sure that there was just one of the mentioned processes and effects happened, i.e. there was the only phenomenon, which was with the only one process of the three investigated and the process could be combined into the phenomenon with the only of the observed effects. In terms of the algebra of logics it means, for the taken into account statements transformed into the view of the expressions of the mathematical logics, the existence of the sought definite answer and the presence of the only combination of the process and the effect. The approach has a significance of a powerful tool for the phenomena identification.*

**Keywords:** tribology, friction, wear, tribological process, observation, observed effect, uncertainty, mathematical logics, algebra of logics.

**Introduction.** In the sphere of tribology it is very important to identify correctly both the processes going on and the effects observed [1]. Also, it is necessary to operate with the appropriate models of the friction and wear processes that happen in the considered structural elements of the engineering units. In the aircraft airworthiness support and aeronautical engineering maintenance technologies [2] it is an actual problem too. At this, a significant influence of the processes' parameters, their functions uncertainty is a crucial thing. Reliability of equipment [3], for instance, depends a lot upon the wear resistance [4]. In order to identify the tribological phenomena properly, there must be a good training provided for the specialists involved, the dynamics of the demand for such specialists, probably, is similar to the aviation maintenance and air navigation specialists demand for the next 20 years forecasted in the conference report [5]. On one way or another, the individuals making responsible decisions about the tribological phenomena should be able to make right judgments in the circumstances of incomplete information. Application of the mathematical logics apparatus, even of the simplest form, can be of a great help.

**State of the problem.** The most up-to-date survey in the area of subjective preferences influence upon the decision making in general and for aviation safety in particular

[6, 7] allow developing the multi-optional doctrine with the uncertainty degree evaluation [8-21]. The unsolved part of the general problem is the variant with a logical conclusion in the conditions of uncertainty.

**Problem statement.** According to the state of the problem, it is required to find the definite answer in case when there is incomplete initial information, however it is possible to use some additional knowledge about the tribological phenomenon.

**Purpose of the paper.** The presented paper is aimed at discovering the correct combination of the process and effect based upon the simplest theorems of the algebra of logics.

**Problem setting.** Consider the circumstances at which there is a group of tribological processes and there is a category of effects observed. However, both of them (the processes and effects) are not undoubtedly of certainly (definitely) identified in the conditions of the experiments conducted or the performed observations.

Let the group of the studied processes be designated as a set of  $(A, B, C, \dots)$  whereas let the category of the observed effects be designated as a set of  $[\alpha, \beta, \chi, \dots]$ .

In some situations a definite answer can be given to the question put about the combination of the processes and effects that happen. This is possible in conditions of uncertainty in regards with an additional portion of a defining piece of information obtained and mathematical logics rules implementation.

**Example.** There were reported that:

1. The process  $(A)$  has occurred in conjunction with the effect  $[\beta]$  observation, or
2. The effect  $[\alpha]$  was observed in the presence of the process  $(C)$  developing, or
3. The process was of  $(B)$  however the effect observed with that was not of  $[\beta]$ .

The additional portion of the defining piece of information obtained is that each of the three mentioned above statements includes either correct identification of the process related or the effect observed. Also it is supposed to be known for sure that there was just one of the mentioned processes and effects happened, i.e. there was the only phenomenon, which was with the only one process of the 1 – 3 and it combined into the phenomenon with the only effect. In terms of the algebra of logics it means for the statement 1

$$(A) + [\beta] = \text{True}, \quad (A) \cdot [\beta] = \text{Wrong}, \quad (1)$$

where the mathematical signs of “+” and “ $\cdot$ ” stand for logics operators “or” and “and” correspondingly. The expressions in (1) are the statements whose truthfulness is predetermined in the combination of both the initial statement and additional information. Therefore for the two other statements of 2 and 3

$$[\alpha] + (C) = \text{True}, \quad [\alpha] \cdot (C) = \text{Wrong}, \quad (2)$$

$$[\bar{\beta}] + (B) = \text{True}, \quad [\bar{\beta}] \cdot (B) = \text{Wrong}, \quad (3)$$

where  $[\bar{\beta}]$  means negation, i.e. “not of  $[\beta]$ ”.

The equations of (1) – (3) are the mathematical logics expressions constructed in accordance with the mathematical logics rules on the basis of the problem setting verbal structures. Hence, treating the mathematical statements (1) – (3) as the algebra of logics expressions it yields

$$\{(A) + [\beta]\} \cdot \{[\alpha] + (C)\} \cdot \{[\bar{\beta}] + (B)\} = \text{True}. \quad (4)$$

Making transformations in (4)

$$(A)[\alpha][\bar{\beta}] + (A)(C)[\bar{\beta}] + [\beta][\alpha][\bar{\beta}] + [\beta](C)[\bar{\beta}] +$$

$$+ (A)[\alpha](B) + (A)(C)(B) + [\beta][\alpha](B) + [\beta](C)(B) = \text{True} . \quad (5)$$

The truthfulness of formula (5) is an undoubted thing which follows the logics rules and the procedure of (1) – (4). This means that at least one of the members of (5) is correct (true). Thus, checking for correctness each of the members of (5), we find the sought solution:  $(A)[\alpha][\beta] = \text{True} .$

**Conclusions.** It is discovered the correct definite answer in terms of the mathematical logics on conditions of the initial ambiguity and additional determining portion of information. Parameters of the problem need further investigation.

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### **БАЗОВИЙ ПРИКЛАД ІНТЕРПРЕТАЦІЙ МАТЕМАТИЧНОЇ ЛОГІКИ ДО З'ЯСУВАННЯ ХАРАКТЕРИСТИК ТРИБОЛОГІЧНИХ ПРОЦЕСІВ**

У наведеній роботі здійснено спробу запропонувати адаптацію, що підходить, апарату математичної логіки до визначення групи трибологічних процесів та категорії ефектів, що спостерігаються, коли у наявності є процеси тертя та зношування, котрі могли би відбуватися в конструктивних елементах технічних виробів, які беруться до розгляду із дослідницькою метою. Обставини, за яких є наявними вказані групи трибологічних процесів та категорії спостережених процесів не вважаються ідентифікованими безсумнівно в умовах експериментів, що проводяться, або спостережень, які виконуються. У певних ситуаціях однозначну відповідь можна надати на питання щодо комбінацій таких процесів та ефектів, котрі відбуваються. Це можливо за умов невизначеності з огляду на додаткову частину отриманої визначальної інформації та застосування правил математичної логіки. У розглянутому та представленому у даній статті спрощеному прикладі така додаткова частина отриманої визначальної інформації полягає у тому, що кожне з трьох згаданих у прикладі постановки проблеми тверджень містить вірно ідентифіковані або відповідний процес або спостережений ефект. Також припускається достеменно відомим, що відбувалися лише один зі згаданих процесів та ефектів, тобто було тільки таке явище, при якому був лише один процес із трьох досліджуваних і цей процес міг комбінуватися у вказане явище лише із одним спостереженим ефектом. В термінах алгебри логіки таке означає, з урахуванням тверджень перетворених на висловлювання у вигляді виразів математичної логіки, існування шуканої однозначної відповіді та наявності однієї комбінації таких процесу та ефекту. Даний підхід має значущість потужного інструменту для означеної ідентифікації вказаних явищ.

**Ключові слова:** трибологія, тертя, зношування, трибологічний процес, спостереження, спостережений ефект, невизначеність, математична логіка, алгебра логіки.

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