Міністерство освіти і науки України;
Одеська Міська Рада
Одеський державний екологічний університет
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Одеська державна академія технічного регулювання та якості
Харківський національний університет радіоелектроніки
Економічна академія "Д.А.Ценов", Болгарія
Інститут спеціального зв'язку та захисту інформації КПІ ім. Ігоря Сікорського
AGH науково-технологічний університет ім. Ст. Сташіца, Польща;
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Лодзький Технічний університет, Польща

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Збірка містить праці Міжнародної науково-практичної конференції з інформаційних технологій, систем та засобів штучного інтелекту, обчислювальних машин, систем, мереж та їх компонентів, автоматизації систем та процесів керування, систем захисту інформації, кібернетики, управління проектами, електротехніки та телекомунікацій, інтелектуальних приладів та систем.

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Information Model for Potentially Detonative Object

Anastasiya Kovalenko
Educational department
Odessa National Academy of Food Technologies
Odessa, Ukraine
virgonass@gmail.com

Viktor Volkov
Department of Theoretical Mechanics
Odessa I.I. Mechnikov National University
Odessa, Ukraine
viktor@te.net.ua

***Abstract*—Arbitrary potentially detonative object is considered from the point of view of the system analysis as the complex hierarchical system. The first stages of elaboration of the information model for this complex system are fulfilled: the system is structurized, its elements are described with their attributes and relationships, and appropriate information structure diagrams are composed.**

Keywords—detonation, potentially detonative object, elementary potentially detonative object, information model, structuring

I. INTRODUCTION

Progress in computing machinery and telecommunicational equipment enlarged greatly the human potentialities in sphere of the decision making for solving different problems. It concerns also the problems of prevention and mitigation of industrial and transport explosions. The explosion prevention is one of the most topical and most difficult problems of the present-day industry and up-to-date transport. There are two kinds of explosions: deflagration explosion (sometimes called simply “explosion”) and detonation. Detonations are more devastating and less studied than deflagration explosions. It is obvious the necessity of creating special program-technical systems to prevent detonations. Such a system (the computer complex) may be the decision support system (DSS). But to construct suitable DSS it is necessary to compose general information model for potentially detonative object of arbitrary type. Constructing of such information model is the main purpose of this study.

II. THE MAIN CONTENT

An arbitrary **potentially detonative object** (PDO) can be viewed from the standpoint of system analysis as a complex system. The architecture of this system consists of some components (subsystems) and of the hierarchical relationships between these components. As a matter of fact, hierarchy is the first feature of a complex system, since only systems with a hierarchical structure can be in principle investigated [1].

The first stage for the development of an information model of every system is its structuring.

The complex detonative explosive object is considered a potentially detonative object of the zero level with the number 1 (PDO_0). This object can be divided into subsystems; those subsystems are potentially detonative objects of the 1st level (PDO _1), each of which has its own individual number n_1 ($1 \le n_1 \le m_1$), where the general number of PDO _1 is equal to m_1; these potentially detonative objects of the 1st level are marked as PDO_1_1, PDO _1_2, ..., PDO _1_ m_1 .

Some of the PDO_1 (for example, PDO _1_ i_1, PDO-_1_i_2, ..., PDO _1_$i_к$, where$1 \le i_1 \le ... \le i_k \le m_1$) can also be divided into subsystems – potentially explosive objects of the 2nd level (PDO_2), which are numbered as follows: - PDO_2_ 1_i_1_1, PDO_2_ 1_i_1_2, ..., PDO_2_ 1_i_1_ $m_{2,1}$; PDO_2_ 1_i_2_1, PDO_2_ 1_i_2_2, ..., PDO_2_ 1_i_2_$m_{2,2}$; …; PDO_2_ 1_i_k_1, PDO_2_ 1_i_k_2, ..., PDO_2_ 1_i_k_$m_{2,k}$. The general number of PDO_2 is equal to $m_2 = m_{2,1} + m_{2,2} + \ldots + m_{2,k}$.

Some of the PDO_2 can also be divided into subsystems – potentially explosive objects of the 3rd level (PDO_3) in the general number of m_3, and so on (Fig.1).

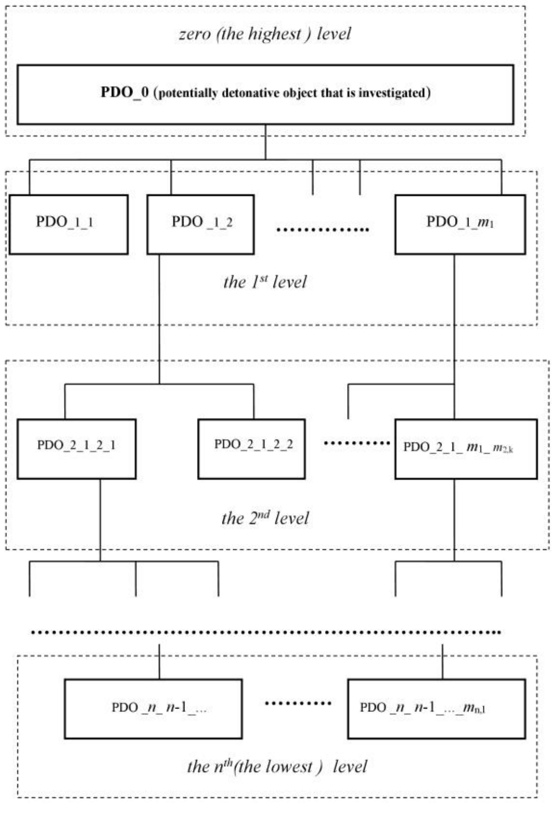


Fig. 1. The general structure of the complex potentially detonative object

The total number of sublevels in a complex potentially detonative object (which itself is considered an object of the zero level) is not limited in principle and is largely determined by the developer of the information model. The developer, in turn, focuses on the specifics of the object and features of the formulation of the problem of ensuring detonation safety. The general structure of a complex potentially detonative object is shown in Fig.1. The numbering of the levels is "top-down", i.e. the lower level has a larger number.

It is quite obvious that the generalized structure of a complex potentially detonative object can be represented by an oriented tree (a connected directed acyclic graph) [2] with a root corresponding to PDO_0. This graph (tree) can be sorted [2]; the outgoing degrees of all vertices, except the external ones (i.e., except the terminal nodes or leaves) are at least 2.

Fig. 2 shows a graph image for the structure of a complex potentially detonative object. The external vertices (terminal nodes) of the graph (tree) shown in Fig. 3 are vertices 2, 4,7,8,9,10,11,12. It is obvious that terminal vertices can be in any level, except zero level. The subsystems corresponding to the terminal nodes of the graph in the graph representation of the structure of a potentially detonative object, considered as a complex system, are the elementary components of the system. These components are called **elementary potentially detonative objects** (EPDO).

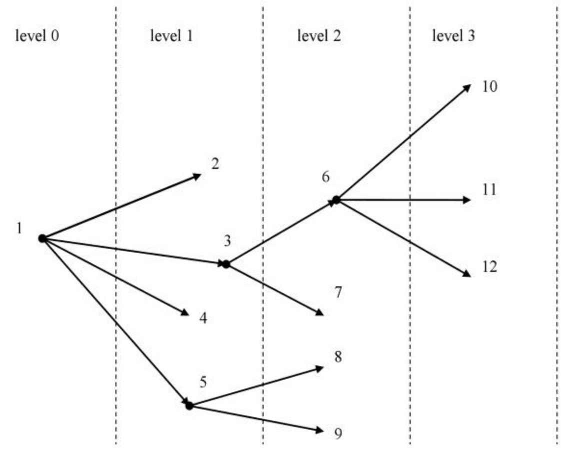


Fig. 2. Graph of the complex potentially detonative object structure

According to [1], the choice of elementary components of the system under study is relatively arbitrary and is largely determined by the researcher himself. However, such arbitrariness in the choice of the researcher is actually always limited: such a restriction is primarily dictated by the need to have all the information required for solving the task set about each of the elementary components of the system – its characteristics, possible states and reactions to the effects of other components of the system or external influences. In the case of modeling a potentially detonative object of an arbitrary nature, one of the following objects should be (to a certain extent) considered as an EPDO (model of a real object): 1. Open space; 2. Flat channel: a) infinite (unlocked), b) of the finite length, half-open (closed at one end), c) of the finite length, closed (closed at both ends), d) of the finite length, open (open at both ends); 3. Round cylindrical tube: a) infinite (open), b) of the finite length, half-open (closed at one end), c) finite length, closed (closed at both ends), d) finite length, closed (closed at both ends). 4. Joint of two different objects of type 1-3 (for example, joint of two tubes with different diameters or channel output in the open space).

The choice of such potentially detonative objects as elementary is due to the following considerations:

- For objects of type 1-3, mathematical models have been developed [3-7], allowing to evaluate the possibility of the detonation explosion developing in each of such objects.
- For objects of type 4 there are investigations [5,8] for estimating the possibility of the detonation transition from one object of type 1-3 to another. Object of type 4 is principally new object in comparison with the information model of potentially explosive object [9]. The necessity of considering such object is connected with possibility of the detonation attenuation during the transition of detonation wave from tube or channel to open space or from tube or channel to another tube or channel with smaller diameter.
- Any real potentially detonative object can be virtually modeled by a composition (combination) of these elementary potentially detonative objects.
- Real potentially detonative objects or their components (subsystems) are easily identified as the above mentioned elementary potentially detonative objects.

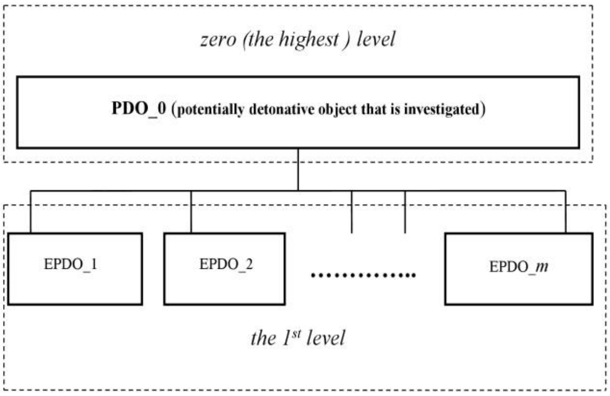
Any PDO is characterized by physicochemical properties (dynamic properties) and geometry of its borders (walls) (static properties). It is the type of boundary geometry that allows (as was done above) to identify and simultaneously classify EPDO. The above classification of EPDO can be considered a topological classification (as opposed to other types of classification — systemic and parametric). Thus, 10 classes are distinguished. The object of each of these 10 classes of EPDO can be a model of some element (subsystem) of a real explosive system. The details about 9 classes of types 1-3 are outlined before [9].

Note EPDO of class 2 and 3 can simulate not only channels of rectangular cross section and pipes of circular cross section, respectively, but also pipes of elliptical cross section. Moreover, if the length of the major semiaxis of the ellipse in the section of the pipe slightly exceeds the length of its minor axis, then the pipe can be modeled with a circular section pipe with a radius of a circle equal to the length of the major axis of the ellipse, i.e. potentially explosive class 3 facility; if the length of the major semiaxis of the ellipse in the section of the pipe significantly exceeds the length of its minor semiaxis, then the pipe can be modeled with a rectangular channel with a rectangle within which this ellipse can be inscribed, and such a channel, in turn, is modeled as one of the potentially explosive objects of class 2.

Consider the completeness of the classification of EPDO. It is quite obvious that the only often-observed common element of real PDO not covered by the 10 classes mentioned above is a round tube with a bend. The detonative hazard of pipes even with a smooth bend is significantly higher than for straight pipes. A detailed consideration of this problem shows [8,10,11] that the analysis of the detonation hazard of an object simulated by a curved circular tube, in one way or another, boils down to an analysis of the detonation hazard of an object that is simulated by a straight circular tube, i.e. one of the PDO of class 3. But at the same time, the obtained estimates of the detonation hazard are very approximate.

So the first stage of development of the information model for real PDO is its decomposition, which must be done by the rules described above. The indisputable advantages of such decomposition are its naturalness and the possibility of obtaining, along with the assessment of the detonation hazard of a complex PDO as a whole, the explosion rating of each of its subsystems. However, such a multi-level decomposition of PDO as a complex system is in most cases superfluous.

In fact, if one particularly evaluates the detonation hazard of each technological or technical subsystem of a complex PDO, then this object can be considered a simple set of EPDO. It should proceed from a simple postulate that the level of the detonation ability of a complex PDO as a whole corresponds (equal to or not less) to the level of the detonation ability which among all the elementary potentially detonative objects this PDO contains is maximum. Then a complex PDO (PDO_0) is represented by a system with only one sublevel containing "equal" EPDO, denoted as EPDO_1, EPDO_2, ..., EPDO_*m*, where *m* is the total number of such objects (Fig. 3).



Fif. 3. Simplified structure of the complex potentially detonative object

Thus, the hierarchical structuring of a complex detonative system has been carried out. The next step after structuring in the information model developing is the identification of conceptual entities, or objects, which constitute the subsystem for analysis [12]. In the case of PDO, first of all it is necessary to identify the EPDO (with their attributes and relationships).

As a matter of fact it was done as it is done in [13]. The major difference is replacing of notions (and attributes) **Explosion hazard** and **Relative explosion hazard** by notions (and attributes) **Detonation hazard** and **Relative detonation hazard.**

Explosion hazard is fuzzy variable for estimation of the possibility of explosion (deflagration or detonation), **Detonation hazard** is fuzzy variable for estimation of the possibility of detonation [14]. Algorithms for calculating these estimations are described before [13, 14]. **Relative explosion hazard** is fuzzy variable for estimation of the possibility of explosion when ignition already takes place. **Relative detonation hazard** is fuzzy variable for estimation of the possibility of detonation when ignition or deflagrative explosion already takes place. Algorithms for calculating of these estimations are also developed before [13, 14].

All kinds of EPDO are described with their attributes and with the relationships between them and with the complex PDO. Information structure diagram [12] for complex PDO is composed for general case. Information structure diagrams for different kinds of PDO are also built in general terms.

III. Conclusions

Arbitrary potentially explosive object is considered from the point of view of the system analysis as the complex hierarchical system. This system is structurized, elementary potentially detonative objects are indicated. All kinds of these objects are described with their attributes and relationships. Information structure diagrams are also built.

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