ISSN: 0976-3104
ISSUE: Multidisciplinary Science & Technology

ARTICLE

VISUAL DATA REPRESENTATION SYSTEM FOR ICE TESTING

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ABSTRACT

Leading engine manufacturers carry on investigations and R&D work to improve reliability and durability of internal combustion engines (ICE), particularly, diesel engines. Diesel engine examination and testing are the main methods, allowing to verify manufacturing quality of parts and assembly components, units and engine in whole, accuracy of assembling, correspondence of main diesel engine characteristics to the requirements of technical specifications. The types of diesel engine test procedures are regulated by the state standards (GOST) and international standards (ISO), which define the procedures for engine commissioning and requirements to engine performance standards. Manufacturers continue to improve the construction of engines and performance indicators even after their commissioning and installation. Current diesel engine test procedure is complex and time-consuming process that can be compared with experimental studies. For this reason, automation systems for engine testing (AST) are created. The need for constant improvement of performance standards of diesel engines raise the costs with respect to test procedures in the course of development of new engine prototypes. In particular, high costs are associated with a mismatch between a level of automation of manufacturing and R&D works. Therefore, automation of test procedures is one of the main goals to be achieved in order to improve the level of technology at production and quality of manufactured diesel engines.

KEY WORDS
engine; decomposition; automation; test; diesel; simulation.

Received: 8 Aug 2019
Accepted: 26 Sept 2019
Published: 30 Sept 2019

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INTRODUCTION

Effective interaction facilities used by product engineer and ECM play an important role in automation systems for engine testing (AST) development [1]. As a rule, internal data is represented in the computer systems in a specific format that cannot be understood by a common user.

In order to solve the problem with effective interaction of human and ECM it is necessary to use a working language that should be close to natural language (NL). NL interaction can be developed with the help of cognitive graphics [2].

For a long time, tasks and task-solving procedures were divided into formal-logical and graphical-intuitive. However, this approach does not meet current requirements any more. Effective solution even of a perfectly formalized task requires graphical-intuitive reasoning to be applied both at the stage of hypothesis generation and at all consequent stages, including the stage of decision making. This fact is stipulated both by the necessity of complete data representation that cannot be achieved with formal-logical tools, and by much higher pass-through rate of visual analyzer in case of integral-graphic representation of information in comparison with serial-character representation, for example, textual. In human-computer systems designed to solve such tasks, taking into account specific capabilities of ECM and human with regard to data processing, the computer may play such a role that would allow to transform input data within the framework of formal-logical description in a way that makes it possible to reveal a pattern contained in it by representing such data in a form that is convenient to a specialist.

If to consider graphics as a modeling tool, firstly, it is necessary to note that a model should fit the represented phenomenon adequately. In other words, not every type of graphical representation suits every specific phenomenon [3]. Secondly, like every model, graphical representation of a phenomenon is not a detailed representation. Besides, a model may require (in most cases implicitly) an assumption concerning the character of phenomenon to be fulfilled. For example, representation in the form of surface assumes a continuous character of the phenomenon. For this reason, it is desirable to have a possibility both to observe a model, and to rebuild it dynamically by changing information content (a set of variables and their multiple values) and modifying the parameters: scale, appearance of components, consistency between values of displayed attributes and visual variables, representing them [4].

MATERIALS AND METHODS

Decomposition of test procedure should be implemented to create graphic structures, describing test process. The paper [5] offers decomposition principle, allowing to split the procedure into units, blocs, modes, modules, and elementary operations. Elementary operations represent indivisible procedural components, like switch actuation, signal pick-up from a specific device, etc. In our situation this principle doesn't work, as graphic structures of high information capacity will be used in technology language [6]. For this reason, they cannot be used as elementary operations. We will decompose enlarged structures.
Let's represent the procedure in the form of control operations. Let's define the following levels of a control operation:

- Engine crankshaft speed control;
- Brake assembly control;
- Oil, fuel, cooling fluid temperature control;
- Environmental simulation (for example, imitation of weather conditions).

In its turn, each control operation should be also decomposed [7]. As we are going to deal with characteristic curves, consisting of specific segments (for example, in case of engine crankshaft speed control process a user will use rotation speed/time curve with specific segments: drive, brake, constant speed), it is necessary to carry out decomposition by those segments [8]. As a result, we obtain the elementary components, i.e. the components, which constitute the whole engine test procedure, allowing to display the task with the help of graphical representations, to control the procedure [9].

Hence, we obtain four levels of detailization and concretization of general test tasks, when using adopted principle of decomposition:

- General procedure (P),
- Control operation (CO),
- Control operation for a specific device (COj),
- Elementary control operation (ECOi).

Control operations allow to manage test modes [10]. Besides, they are functionally dependent from ECO. Other levels represent the bunch of underlying components.

Elementary control operations and measurements represent the complex groups, consisting of uniform sub-programs used to fulfill a specific task [11].

Hence, it is possible to represent random test procedure P as a function of control operation C:

$$P = [C_{ij}]_{mn}$$

where

$[C_{ij}]_{mn}$ – is a set of unified i-th parametrically customized technological control operations of j-th functional type;

m – is a number of elementary operations with regard to a specific control operation implemented on different types of control devices;

n – is a number of functional types of control operations.

Let's represent a random unified parametrically customized technological control operation y_{ij} as follows:

$$y_{ij} = \{d'_{ij}; W_{ij}(d'_{ij} | w_{ij}); d_{ij}\}$$

where

d'_{ij} is an input data vector for a control operation,
d_{ij} – is an output data vector for a control operation,
W_{ij} – is an algorithm of transformation of input data into output data,
w_{ij} – is a vector parameter for control operation adjustment.

Functional types of technological operations follow the adopted principle of decomposition and generalized cycle of test operations [12]. This type of operations includes engine mode control operation, load device control operation, etc.

Let's assume that engine crankshaft speed control operation is the control operation of the first functional type and j=1, then we will obtain the following random elementary engine shaft speed control operation:

$$y_{i1} = \{d'_{i1}; W_{i1}(d'_{i1} | w_{i1}); d_{i1}\}$$

Consequently, test procedure can be represented as a matrix with a number of elementary control operations [13]. Matrix columns are the elementary control operations of a specific functional type. This decomposition was carried out in order to apply graphical representations in AST. For this reason, it is necessary to decompose graphical test language in accordance with the decomposition principle suggested above by specifying typical linguistic tools for elementary control operations of corresponding functional type [14].

Decomposition of engine test language means language representation in the form of its possibly intersecting fragments with specified purposes, which, being taken together, allow to describe random automatic test procedures [15].

Possibility to decompose AST language on the basis of graphic elements results from earlier mentioned decomposition principle used with regard to test procedure. Hence, we obtain the following equation by analogy with:

$$L = [L'_{ij}]_{mn}$$

where

$[L'ij]mn$ – is multiple fragments of AST language, which is the language of i-th technological control operations of j-th functional type.

As unified parametrically customized technological operation is the basic concept of test procedure, it is necessary to take the following unified linguistic description of the operations as a basis for language unification $L'ij$ (i=1...m, j = 1...n):

$$l'ij = \{t'ij; G'ij(t'ij)\}, i=1...m, j = 1...n$$

where

$t'ij$ – is a graphical representation of input data for i-th control operation of j-th functional type,
$G'ij$ – are the grammatical forms of algorithm descriptions with regard to control operation.

The grammatical form is the most rational tool for language representation of technological operations [16].

Equation results, taking into account the specific character of graphical representation of technological operations [17]. We have no input data here, as it does not make sense to represent it in graphical form [18]. It is supposed that setting data contains data-intensive graphical elements of input data.

Grammatical form uses essential notions and definitions of automated test domain [19].

If j=1, we obtain a linguistic description of the operations of the first functional type, i.e. control operations (i.e. engine crankshaft speed control operation mentioned above) [20]:

$$l'i1 = \{t'i1; G'i1(t'i1)\}$$

Hence, linguistic support consists of a matrix that contains the components of technology control language [21], in which the matrix columns contain linguistic description of elementary control operations of a specific functional type [22].

Taking into account condition-action rules it is possible to represent the system as follows [23]:

$$GEaij = Waij$$

where

$GEaij$ and $Aaij$ – are condition (graphical element) and action of a-th production (a=1...a) respectively;

a – is a number of variants of execution of technological control operation yij (i=1...m, j=1...n).

Hence, variants of execution of control and measurement operations are explicitly bind to graphic elements, defining them [24].

RESULTS AND DISCUSSION

The following unified conditions necessary to launch and complete component execution, and transition conditions for sequential execution of components are used [25]:

- Expiration of predefined time period [26];
- Arrival of specified triggering signal [27];
- Band fault (alert condition) [28].

Hence, the unification of composition fragments $L'ij$ (i = 1...m, j = 1...n) of engine test system language is provided by [29]:

- Unified linguistic description of technological control operations with six functional types of basic control operations [Table 1];
- Unified linguistic description of variants of execution of technological control operations in the form of condition-action rules.

System analysis of automatic engine test procedures described above and suggested principles of formalization of their linguistic description allow to proceed with modeling of characters for graphical test language, and then with modeling of its grammar rules.

Representation of operations in the form of condition-action rules is the most suitable form of representation of test procedures used by a test engineer. This was demonstrated by psychological investigations of human decision-making process: when reasoning, an individual uses “condition-action” rules, i.e. the rules, which are similar to the productions. Besides, the productions are the most important components of the production systems, which are used as a basis for the development of the major part of intelligence systems, particularly, for the development of expert systems. Moreover, a test engineer uses task-oriented graphical representations by setting the conditions for execution of technological operations,

THE IIOAB JOURNAL

which significantly simplify his work, as the appearance of representation allows to assess the final result – the representation is identical to control operation. Consequently, the application of graphical representations and production representation of technological operations promotes the development of automation systems for engine testing with the involvement of intelligence systems.

CONCLUSIONS

The process of test procedure development with the help of graphical language comes down to the creation of desirable technological parameters-time dependency graphs from the graphical representations of elementary operations.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

FINANCIAL DISCLOSURE

None.

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