ESP controls for various fuel boilers based on the ODEUS method.

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1 Abstract

The article presents the principle of ESP control for a boiler burning with different fuels. To develop the principles of ESP algorithm the ODEUS method for object creating and managing was a better solution.

With the ODEUS method a designer or a manager of ESP control system makes sure that all aspects of complex design, management or control will be exhausted and implemented efficiently. The key features of this method are the binary system (for each problem there are two contradictory potential solutions) and the pyramid principle (all systems consist of elements, all processes consist of operations).

2 ODEUS method description

2.1 Method's objectives

Identify all tangible and intangible elements of the created or managed object and its surroundings. The ODEUS method applies the principle of complexity (i.e., every element belongs to the team) and dualism (i.e. the use of alternatives to make a clear distinction and the choice of attributes).

2.2 Method's sources

According to Descartes, there are two types of "substances", material and immaterial. This duality is the basis of a binary system. Descartes, in his work "Discourse on The Method", introduces the approach to research through analysis and synthesis.

2.3 Method's procedure

The ODEUS method distinguishes the following information about the object :

Purpose of the object – apply for higher-level object.

Status of the object - a status of each substance (no action, increasing, maintaining, reducing)

Intangible substances (invisible):

1. Requirements - what features should the object have? (E.g. law, characteristics, specifications)

2. Skills - what actions are needed to implement an object? (process, method, users)

Tangible substances (visible):

3. Structure - what elements are making up the object? (physical components),

4. Energy - what are the characteristics of activities, who and how long does the activity need to be performed? (Scheduling)

Substances on the outside of the object may be associated with it in order to:

Order the operation of changing the object (the initiation of the object change).

Add requirements for the new object (the characteristics to be satisfied by an object).

Transfer of the energy needed for the operation (the characteristics to be satisfied by the process).

Add procedures for the realization of changes to the object (the process composition, or otherwise, what to do).

Transfer raw materials needed to change the object (changes in the composition of the object).

Using of different words such as „add" and „transfer" is appropriate:

Material substances (raw materials and energy) are transmitted (transferred), their total quantity is constant. The law of conservation of mass, the principle of conservation of energy and the equivalence of mass and energy, as for bodies at rest has a well-known formula $E = mc^2$.

Intangible substances are added (copied) without reducing their number in the source. Teachers teaching a student do not lose their knowledge. A similar relationship as between mass and energy is found between the requirements, characteristics of the object that is a truth, and procedures, instructions or skills that is an experience. The Truth (the verbalization of the truth) is a function of experience (an analysis of performed experiments) and the intelligence quotient (the rate of synthesis, rate of learning). A truth may be defined as $D = iU$ (where $D = 0$ or 1, that is false or true, U = number of samples, experiments, $i = 0 \ldots 1$, it is the speed of the investigation of the truth after a finite number of tests or samples).

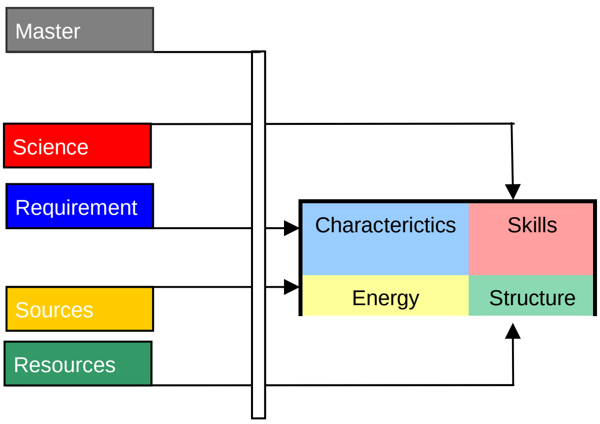

Fig. 1: Source and receiver objects

2.4 Method's stages

The ODEUS method applies to itself and therefore consists of four main stages:

1.To understand the requirements created or to manage an object, which is defined by:

1.1. the need for characteristics

1.2. the need for energy resources

1.3. the principles of procedures

1.4. the features of the structure

2.To plan the resources needed, for the creation of an object, for :

2.1. the requirements

2.2. the energy resources

2.3. the procedures

2.4. the structure

3.To prepare a method to create the object in four steps :

3.1. to collect the initial information

3.2. to identify sources of information

3.3. to select the tools

3.4. to write the operations

4.To collect the methods of documenting how to create the object:

4.1. the characteristics of the object

4.2. the schedule for human, financial and energy resources

4.3. the procedure to create or change the object

4.4. the list of parts of the object

3 ODEUS system description

All existing operations can be simplified to one and only one **O**peration, which specifies the target characteristics and composition, process and object.

Distinguishing characteristics or composition, object or process, we have four, and only four aspects (four substances) :

1.The characteristics of the object, or **D**efinition (characterization, requirements, set point, law, knowledge)

2.The characteristics of the process, or **E**nergy (human and financial resources, schedule)

3.The composition of the process, or **U**tilities (skills, method, procedure, instruction, algorithm, tools)

4.The composition of the object, or **S**tructure (raw materials, parts list, contents, components)

The operation to change the mass (the structure) or the position (the energy) is an action that needs a space. The operation to change skills or characteristics is a learning that needs memory.

Notation for the documentation is created according to the name of the substance of the object elements:

NNNNNN_O_VXYZ_EEEEEE

NNNNNN = name of the object

O = status of the object

V = substance of the object

X = sub-substance

Y = sub-substance

Z = sub-substance composition

EEEEEE = name of element

For unambiguous names a dictionary of basic terms (synonyms) will be created in the future. This system can be used for object modeling. The software tools for automatic classification of subjects, and to set objective criteria of models quality, such as quality of control system will be created in the future.

The intuitive color code for common groups of documents is defined to facilitate the identification of the substances of the object as follow:

D = requirements list - blue (like sky)

E = schedule of resources and energy - yellow (like sun)

U = process operations and tools - red (like fire)

S = list of materials - green (like forests)

all documentation of the object - black (a combination of four aspects)

all documentation of the operations - white (a combination of four aspects, too).

4 Example for design process

The design process is one of the four substances of an object (it’s a list of the operations to realize the object):

X	object
X_O	object and status
X_O_d	1. object characteristics
X_O_e	2. object cost and schedule
X_O_u	3. object engineering
X_O_s	4. object structure

The design process is simplified to four main steps. These steps are associated with four types of substances (like four main documents) for all created objects. The codification of the chapters is digital, because everyone knows and uses this system:

u	3. Object Engineering
ud	3.1. Requirements Procedure
ue	3.2. Resources Procedure
uu	3.3. Method Procedure
us	3.4. Project Documentation

usd 3.4.1. Guidelines

use 3.4.2. Schedules

usu 3.4.3. Basic Engineering

uss 3.4.4. Detail Documentation

ussd 3.4.4.1. DD Use System Design

usse 3.4.4.2. DD Power System Design

ussu 3.4.4.3. DD Control System Design

usss 3.4.4.4. DD Construction Design

ussud 3.4.4.3.1. CSD Requirements List

ussue 3.4.4.3.2. CSD Signals Resources

ussuu 3.4.4.3.3. CSD Conception

ussus 3.4.4.3.4. CSD Detail Documentation

ussusd 3.4.4.3.4.1. CSDD Set points List

ussuse 3.4.4.3.4.2. CSDD Signals List

ussusu 3.4.4.3.4.3. CSDD Algorithm

ussuss 3.4.4.3.4.4. CSDD Equipment

5 Example for ESP algorithm

ESP is designed for one type of boiler fuel. Another difficult is to design an ESP with a constant efficiency for different coals, biomass and waste.

Apart from the maximum boiler efficiency, which determines the size of the ESP, other control parameters can be adapted to changing ESP work parameters. The self-adaptation of control algorithm parameters should be very fast.

They are four steps algorithm :

5.1 Set point reading

Set points are typically entered through a master control system (DCS) :

- ESP mode (e.g. start-up, normal operation, shutdown)
- minimum emission
- minimum energy consumption

5.2 Input signals

Dust removal efficiency depends on two groups of parameters:

- static, such as size and shape of the design and selection of the electrodes,

- dynamic:
1. instantaneous real value associated with set point :
- emission

2. electrical supply and quasi-power media, or instantaneous gas characteristics :
- energy consumption
- quantity of burned fuel
- gas distribution
- “electrostatic viscosity"
- gas characteristics

3. associated with the additional information that was collected from other sites or this one. The information collected for different work parameters, it allows the relationship between the control algorithm parameters and ESP work parameters:
- resistivity
- viscosity
- particle size
- HV control parameters
- rapping time

4. associated with a instantaneous characteristics of the ESP structure:
- the amount of dust on the discharge electrodes,

Fig.2. Example of discharge electrode with dust

- the amount of dust on collecting plate,
- different local gas velocity distribution,

5.3 Data processing

The division into four main steps facilitates the development of this task:

1. Depending on the input signals and ESP work parameters they are selected:
- appropriate algorithm,
- HV controller parameters.

2. Depending on the algorithm a set of control parameters is selected depend on the historical performance of the ESP. This will allow for the appointment of new parameters, e.g. for biomass:
- to increase the insulators temperature,
- to increase the hoppers wall temperature,
- to determine the optimal rapping ratio,
- to increase the hopper vibrators frequency,
- to reduce the HV during the rapping,
- to change the mode of HV control,
- to change to HV level,
- to change the operating parameters of HV controller.

5.4 Output signals

ESP is an object with a delay resulting from long dust road. But the instability of the different fuel combustion process determines the use of high-speed, multi-processor controllers for :
- HV
- gas distribution devices

Auxiliary actuators do not require rapid response time, but only to adapt to the new work parameters :
- rappers,
- hopper and insulator heaters.

6 Conclusion

The main advantages of the ODEUS method are:

The certitude to take into consideration all aspects of the system design or the development of control system algorithm.

The alternative for each problem, because for each question there are two contradictory answers to choose from: between feature and composition, object or process,

With ODEUS method is evident need to include in ESP design all aspects of ESP control: not only the dust setpoint, but other control loop, change of the gas characteristics and the ESP structure (mass and gas distribution).

The next stages of this research will be:

1. to develop a software for the self-learning ESP control system,
2. to demonstrate the deficiencies of actual methods of ESP control,
3. to develop a quality evaluation coefficient for each control system.

7 Literature

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[2] Descartes R., Lecture on the method, Paris, 1637;

[3] Wychowanski M., Elements of information theory and control, Warsaw, 2007;