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UTILIZATION OF METHODS OF CONTROL SYSTEMS ACTIVE DIAGNOSIS FOR IMPROVEMENT OF CONTROL QUALITY COEFFICIENTS

Key words: PID algorithm, control system, self-tuning, active diagnosis, quality coefficients

Abstract: The principal problem in process of control there is to lead a control value to a set value as quickly as possible and most dynamically with an assumption to operational safety of controlled process and the controller at the lowest energetic cost and minimum material consumption. The paper presents, basing on servo-mechanism with control system, the advantages of active diagnosis to obtain the quality coefficients improved, to achieve the improvement of system reliability and availability, the quality of process controlled and system's safety. According to the latest world trends and considering the solution achieved on base of fuzzy logic rules the paper shows the possibilities to use them entirely while building the new diagnosis algorithms.

1. QUALITY APPROACH TO SAFETY CONTROL OF SELF-TUNED CONTROLLER

The role of controllers in automatics systems and control processes is in fact the task to provide such a control signal that it will ensure the desired behaviour of the object under control. This principal function of the controllers is performed by means of proper controller settings selection based on the knowledge of the object, e.g. the model of the object or on experience and user's practice (fuzzy logic or neuron controllers), also based on right selection of the algorithm selected or adopting right structure algorithm for a process given. Practically, such a situation may often occur that despite the settings of the controller were properly selected, according to all "art" rules, the effects were not the ones that had been expected or moreover they caused additionally the worsening of control quality. It may also quite often happen using the self-tunning controller or adaptive controller is not sufficient solution.

There are a lot of reasons that cause the above mentioned situations, particularly in industry environments. Among the others there are the following reasons:

- unsufficient knowledge on the object and its characteristics (linear, non-linear, difficult, easy, innertion class, delays, etc.);
- non-typical properties of the object, particularly when connectedd to executive devices;
- not considering the influence of executive devices (e.g. integrating in case of piston or electric hydraulic motors, proportional properties or dynamics in case of membrane pneumatic motors) and the possibility of failures to occur;
- not considering or wron estimation of interferences;
- non-perfection or non-linearity of controller operation in particular conditions of frequency and amplitude of signal;
- interaction of settings;
- improper or ineffective method of settings selection;
- peculiar settings selection causing a "shot" within the area being a specific case of process phase (mainly at chemical processes);

- settings done without any analysis according to recommendations given in publications causing e.g. the loss of stability due to wrong frequency area selected;
- irrespective algorithm structure and controller structure for a given process;
- effect of metrologic mistakes, e.g. approximations, roudings, simplifications;
- operator's mistakes, lack of skills, negligence or unserious attitude of operator towards operations performed during making calculions or/and making controller's settings.

Even in case no one of the above mentioned critical condition has taken place the modern technology and techniques to obtain the control value adjusted to the set value is not sufficient any more. <u>It has been found that one of the most important problem is to perform an adjustment of the set value to the given value in the fastest way, the most dynamic way but simultaneously keeping all safety rules regarding the process being controlled and the controller itself, i.e. at the lowest energy costs and minimum consumption of operating devices.</u>

There are several opinions saying that the response to above requirements should be the application of additional procedure(s), that would assist the selection of settings (and would be the integrated part of it), i.e. the procedure of verification of settings selection. The issue seems to be simple and not so complicated at the first sight however looking from technical point of view quite a lot of difficulties may be met. In current available publications, despite there are few producers who use verification procedures for self-tunning controllers - e.g. Hartmann & Braunn, Siemens A.G., Mera-Pnefal S.A., so far the problem of verification has been generally omitted (it may be justified with trade and company's secrets to some extent).

The most vital elements ensuring the operating safety of the self-tunning controller have been presented in the operating block diagram below (Fig.1).

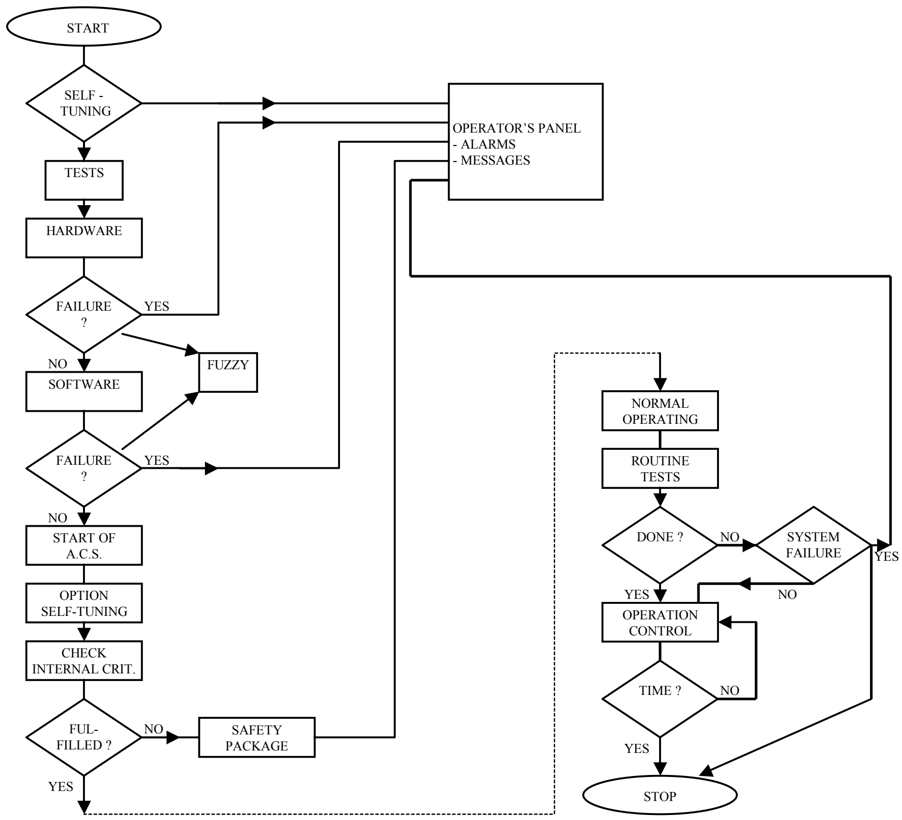

Fig. 1 Operating block diagram of self-tunning controller with safety procedure.

The feasibility of tasks provided in the diagram above may be considered as complete or partial. It depends on the number of levels of hardware tests provided - see item .... or on number of software test levels, particularly the following tests on:
* correct selection of controller configuration
* correct selection of identification method
* correct selection of dynamic settings and possible improvements
* correct selection of user options
The results of tests may be strict ones (result "run" or "stop") or not so strict, giving only the warning message to the operator. In case of technological production processes requiring such controls (e.g. fire or explosion risk processes, traction or kinematic processes) , a non-strict result of test should be accompanied by starting the package of emergency procedure [1,2,4,5] or the terminating procedure of the process.

2. HARDWARE DIAGNOSIS PROCEDURES

Verification process of programme symptoms is performed with an iteration procedure - each time the changes occur in controlling system then it should undergo reestimation - to adapt to new conditions. In case of hardware symptoms - the diagnosis is usually single step procedure, directly after start-up or periodically, depending on MTBF adopted (so called resource exploitation system).
On the contrary to most of typical computer controlled devices, the self-tunning controller may restart its operation with partially failured peripherals. The level of its possible permissible unefficiency is determined by the producer. Generally, elimination in 100% takes place in case of:
* failure of controller's central processing unit
* failure of several elements or entire input sub-systems
* failure of several elements or entire executive sub-system (however, sometimes e.g. positioner failures are permitted, recognized as a type of interference)
Generally, performing the hardware tests for the electric servo-mechanism is usually the most favourable. The test may be carried out in two variants:
Rest test - under normal conditions, taking relevat quantity of energy causes relevant signal levels to appear on the outputs. The difference is the failure signal.
Start-up test - under particular conditions for controller inputs the testing signal is sent. Simultaneously the signals on outputs are checked (usually 4-20 mA) or e.g. the standard range of servo-mechanism stroke is checked. Depending on the phase of control process the tests mentioned above may be "express" or "full" tests.
The group of software tests play particular role in diagnosis. There are two or three levels of the and the most often used ones are as follows:
a) diagnosis in terms of methods/tasks
b) diagnosis by method selected and possible options
c) operational diagnosis
In case a, there are several cases of operation of industrial self-tunning controllers. Mostly they are:
* object option - it usually means that the library of settings is introduced and stored within the controller. The settings are determined on base of object parameters introduced into the controller. This option lets the operator to insert object parameters. This method allows to avoid mistakes occuring often while determining settings or additional mistakes when inserting them into controller
*(settings) algorithm option - operator inserts direct settings values. Verification of settings values starts at the time they are being inserted as the controller is equipped with a procedure disabling to insert illogical values, e.g. $Kp < 1\%$ or $Ti/Td < 3$, etc. This option enables the authorised operator

(password, key fields) to modify the library of condition checking, however it is done on user's own risk.

The programme tests in this phase check the correctness and feasibility of the actions declared (configuration, correctness of values and address blocks, etc.) The object option is much simpler as only the value corectness is checked. It may sometimes need additional dialogues with operator (e.g. system asks for process type, measure unit names, etc.).

The above described tests guite often lead to the other group of tests. They are very detailed and most often verify real skillfulness of operators. Within the class of self-tunning controllers for electric servo-mechanisms it is of great importance regarding the safety of the device and technological process [1,6,8].

Fig. 2 illustrates the controller operational diagram using test example of the group mentioned.

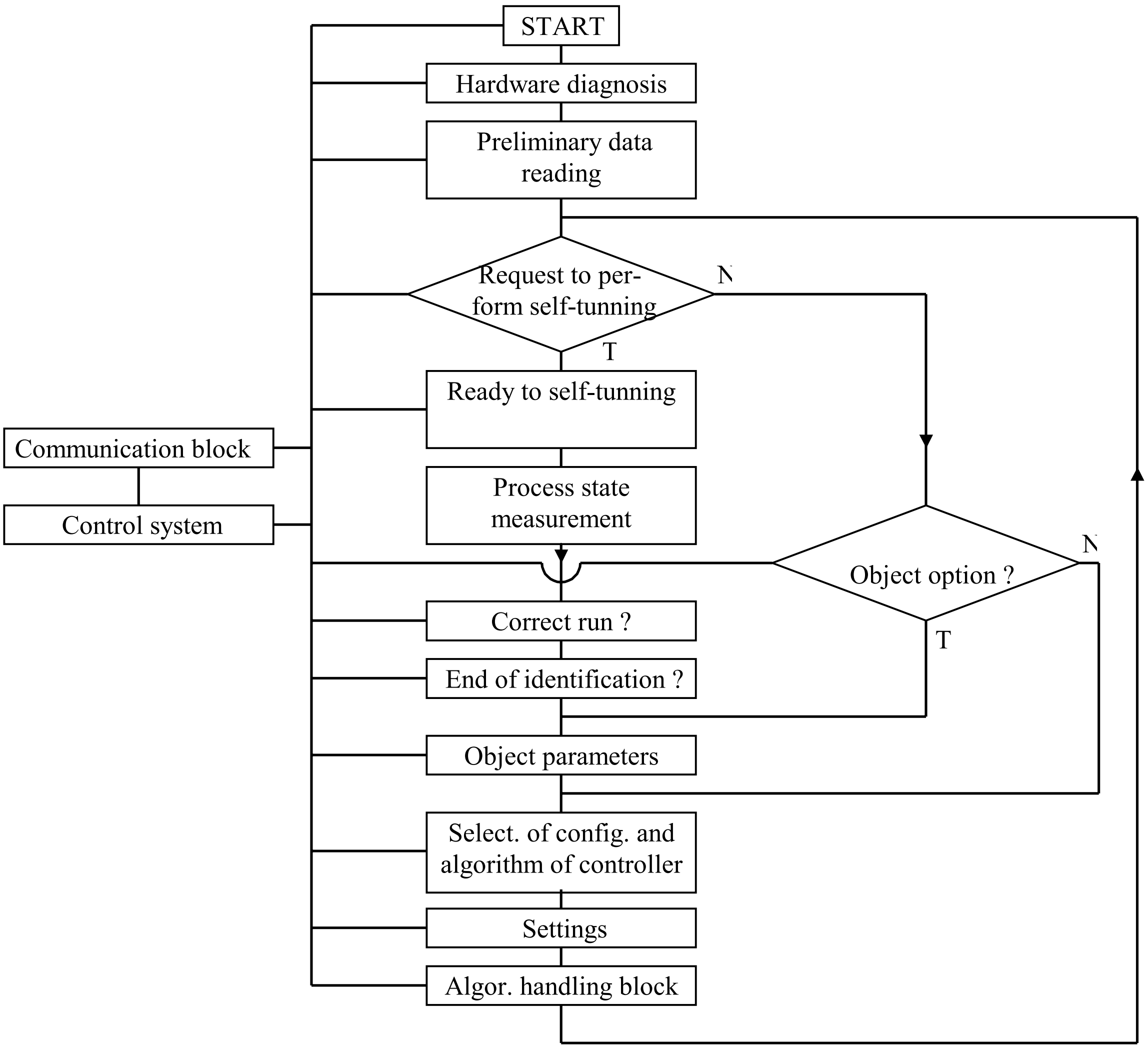

Fig. 2 Simplified diagram of controller algorithm operation.

3. PROCEDURE OF OPERATION OF SETTINGS BLOCK INCLUDING VERIFICATION OF SETTINGS AND THEIR EFFECT ON THE STRUCTURE

In case the setting values are inserted manually, the estimation of their correctness and reliability may be done in several steps:

- programme rough mistakes elimination (e.g. proportion range less than 1%) by means of:
    * request to acknowledge (confirm) them once more
    * jump to safe option stored in settings library
- improving the quality of adjustment along with checking system stability in that case, i.e. the task using self-tunning procedure.

Application of basic structure PID, with separated courses of P, I and D allows to perform software change of settings and moreover using some other combined variants: PID-PID, PI-PID, I-PID, PD-PI, PD-PID referring respectively to a given value and adjusted value, ensuring at the very beginning the possibility to decrease or even to eliminate over-control and also to avoid the saturation (block I), to lower the influence of interferences, etc.

The attempts to select the configuration and settings during the control process, even if it results in failure, in fact enrich the knowledge of "controller" about the process enabling in the same time to make adjustments using fuzzy logic rules. The basic safety rules introduced resulting in the messages e.g. "Too high over-control .... (e.g. - then terminate integrating process)", "Given value not reached ... (e.g. then increase amplifying)", shall guarantee safety of the process. Moreover, it seems that application of those logic rules may constitute the future of control systems just due to their programme non-linearity.

Self-tuning procedure as well as process control one performed in traditional way, has to be equipped with verfification procedures for settings selection if it is to be entirely safe. Such procedures may only operate basing on great piece of knowledge delivered to the controller by operator, inserting the data about the object, its type and properties, about executive devices and such elements of the system as detectors or converters.

More and more often it reflects the situation of collecting data and information to create so called decision table based on expert knowledge that is found in case of fuzzy type controllers.The following thesis might be brought forward: to maintain safe and high quality control it is sufficient to apply fuzzy logic controllers instead using traditional controllers or self-tuning additional verification procedures, as the effects are concurrent. Unfortunately, the above thesis has not been proved while analysing the effects. The controllers basing on expert knowledge only are good to such an extent to which the operator was able to predict possible operating conditions including over-load and failure states. Even if controller's self-teaching process is considered and its ability not to repeat the same mistake in similar circumstances is almost certain then the conception of process control safety itself is void. Moreover, the decision table based on traditional, value based assumptions (the one used by controllers of fuzzy logic) is very big and occupies a lot of controller's memory.

However, it seems obvious there is no way back from using options containing fuzzy logic algorithms in safe and high quality control processes. Fuzzy option is more and more often used one among available control options for control processes and it can also be seen that its application may ensure additional safety and e.g. shorten the time of control process. As only some slight changes of standard structure are possible (e.g. those suggested in this paper referring to controller operating algorithm) the table of rules for the controller, considering all possible cases that might occur during process of control, may be constructed quite easy.

The characteristics of the system obtained this way is remarkably similar to adaptation systems characteristics which, as it was mentioned before, due to technological complications could not be commonly used. Such a system, due to fuzzy logic technique used, may be successfully applied to control difficult non-linear objects that having been controlled so far with classical algorithms appeared to be to much parameter sensitive.

4. OPERATIONAL TESTS

The range and efficiency of tests depends on the technological level of servo-mechanism and its control system. It is usually possible to separate two levels within this group of tests:
1) routine test level: voltages, currents, vibration level (+ noise level in some cases), current analysis of particular sub-systems (BITE)
2) algorithmic test level that can be based on:
a) estimation of puposeful control steps following some patterns, i.e. time, energy consumption, permitted range of free movements/signals
b) estimation of internal phenomena within controller [1,5]
c) estimation of particular motoric properties of the device, e.g. response times, correlation function.

Usually, to simplify the estimation procedures the techniques of comparison between the test results and producer's given results are used. However, the group of tests mentioned above may give ambiguous results in case of some decisive processes (e.g. the device is only partially inefficient). In practice, the best executive instrument to use the results of the above tests is the usage of decisive algorithms based on fuzzy logic technique [1,6,7,8].

5. FINAL REMARKS

Considering the present state of technology it is rather difficult to accept such an automatics system - particularly comprising self-tuning controller - that would not be assisted with more or less expanded system of tests. The range of functions of testing sub-system depends usually on three conditions related one to the other: costs of equipment/device, costs of possible failures or costs of specialistic service

At the present level of technology it seems cost-efficient to maximize the executive capabilities of test sub-system and to limit operators' trainings gradually to necessary minimum. This way of proceeding has its base also in terms of legal aspects. The regulations in that range make the producer or the dealer responsible for designing relevant safety systems within devices or for operator staff trainings. Producers more and more often choose the option to install relevant safety devices. The efficency and costs of the latter remain problematic, i.e. complete and good verifying and safe systems cannot be cheap and on the contrary - the cheap system usually does not provide sufficiently efficient safety system. Additionally, the problem of possible priorities of operator's actions should be added to both above mentioned problems.

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ИСПОЛЬЗОВАНИЕ МЕТОДЫ АКТИВНОЙ ДИАГНОСТИКИ ДЛЯ УЛУЧШЕНИЯ КАЧЕСТВА РЕГУЛИРУЮЩИХ СИСТЕМ

Аннотация: В статье, на основании систем сервомеханизма снабженного в систему регулирования, найдено несколько прейшуществ активной диагностики из которых самые важные это: повышение

надежности мобильности, повышение качества рэгулуриемого процесса. Вторигный эффект это: повышение надёжности правильной доборки настройки и структуры регулятора, дополнительные возможности эксплуатацийные. Полностью проблеммы пассмотренны через призмат безопасности процесса, а также связанного с ним технических проблем. В связи с новейшими всемирными направлениями угитывающие функционирование в процессе регуляции правило „fuzzy logic”, рассмотренно также возможность использования их в строительстве диагностического алгоритма.