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THE PROBLEMS OF ENGINEERING SUPPORT OF CHEMICAL PRODUCTION PLANTS UNDER OPERATION

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RESUME

Ces dernières années, les développements dans le domaine de l'informatique ainsi que les transducteurs et les actuateurs ont donné de bons résultats, eu égard à leur fiabilité, leur durabilité et les coûts d'entretien.

D'autre part, afin d'éviter des pertes économiques considérables, le développement de nouveaux procédés chimiques est accompagné par des mesures destinées à assurer un fonctionnement fiable de l'équipement et à améliorer la qualité du travail du personnel comme élément de contrôle, en liaison avec la réalisation des tâches d'optimisation du procédé. Ces deux raisons permettent d'entreprendre le développement de systèmes de technique de maintenance des unités qui sont déjà en fonctionnement et de fournir des recommandations aux créateurs de nouveaux procédés.

Pour favoriser l'analyse et la programmation des systèmes techniques d'entretien d'unités, presque n'importe quelle unité chimique peut être divisée entre les quatre unités suivantes :

a) Le procédé lui-même, et la tâche la plus importante de cette unité est de choisir les conditions optimum (conditions économiques optimum du procédé).

b) L'équipement (procédé) de l'unité chimique, et la tâche d'assurer un fonctionnement fiable pendant une période donnée de temps est fournie dans cette unité.

c) Système de contrôle du procédé, et la principale tâche ici est d'obtenir l'information de meilleure qualité (ceci veut dire l'exactitude des mesures de paramètres et la durée des processus intermédiaires).

d) Un homme (opérateur, ingénieur mécanique ou d'énergie) comme partie constitutive du système de contrôle, et la principale tâche de l'unité est de fournir l'exactitude de ses décisions par rapport aux interventions dans le fonctionnement du procédé pour fournir un fonctionnement optimum et sûr.

Cette classification permet de concevoir plus exactement les caractéristiques des systèmes en développement ou déjà existants, qui peuvent être intégrés ensuite dans un certain système général, sous la terminologie classique générale : "Système assurant le cycle opératoire optimum d'un procédé chimique".

Naturellement, la réalisation des tâches précisées repose sur l'application des installations informatiques fournies avec des algorythmes spéciaux de décisions dans chaque Unit.

Dans le rapport, pour chaque unité, les moyens de résoudre les problèmes sont considérés et les spécifications de base pour les systèmes offerts sont données.

Considérant la production d'ammoniac comme exemple, un essai de réalisation d'évaluation technico-économique considérant l'opportunité des développements et des stades de leur mise en oeuvre est donné dans le rapport.

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When considering the technical progress in the chemical industry, one can easily notice that development of high-capacity production plants forms the main route of development for the last 50 years, this making it possible to solve simultaneously several problems that seem to be most crucial ones:

- to reach a substantial decrease of the final product production cost;
- to reach a considerable increase of labour productivity;
- to obtain feasible and acceptable economic characteristics of the production process.

The above could be easily seen from the data specified in Table 1 - based on the process of production of synthetic ammonia from natural gas.

Table 1

Year of commercial introduction of the 1-st (sample) part of the final product	Synthesis reactor capacity t/day	Production cost, %	Labour productivity arbitrary units	Discharges into atmosphere and water basins % per tonne of the final product	Area occupied by the production facilities of the same capacity, m^2
1955	200	100	-	100	90000
1965	350	90	1	98	79000
1969	600	65	3	70	22000
1972	1360	52	8	55	21000
1980	1500	50	8.5	40	21000

Along with increase of the production capacities, the production plants acquired certain specific characteristics as follows:

- the high unit capacity requires the prolonged cycle of continuous operation in order to eliminate possible economic losses, and that, in turn, brings forward quite strict requirements with respect to operational reliability, repairability and long service-life of the machines, vessels and control-and-monitoring devices.

- the lack of intermediate tanks, the desire and necessity to create the maximum possible closed production loop - with respect to feed-stock and power (especially with respect to utilization of the heat of chemical reactions for production of vapour) has led to quite a considerable amount of cross- and back- heat and product flows, that in turn leading to the fact that the process of control and monitoring of such a production process becomes complicated both in the static and the dynamic (especially in the dynamic) process duties.

Thus, there arises the problem of practically continuous selection of optimum conditions of carrying out chemical transformations within the limits and conditions of the commercial production. It's quite natural, that operating personnel of the plant shall have a certain set of systems "at hand" which could enable them to perform the task. Such a set of systems can be defined as the engineering support of the chemical production. Separate elements that constitute such a system - like the production process regulations, process and maintenance instructions to be used by the personnel, "a pool" of spares and equipment available, preventive maintenance inspections and repair works are widely used in every-day operation.

Taking into account the fact that recently the developments in the field of computer software, measuring transmitters and actuators have shown good results with respect to long service life and reliability, and their cost enables to realize in practice the tasks of reservation or majoritaric logics, - there emerges the possibility to create the systems of engineering support. It shall be emphasized that such systems can be both the special (i.e. built-into the specific technological process) and the universal ones - those possible to be applied to any process operated at the corporate level.

Practically, any chemical production process can be split into certain blocks - for the purpose of making the analysis and determination of the number of engineering support systems, - as follows:

- the production process in itself or the system/scheme of process flows (a set of the processes);
- the equipment (process) of the chemical plant;
- the system of control and monitoring of the process;
- the alarm system and de-blocking system to ensure protection of equipment and environmental protection;
- a person (plant manager, operator, mechanical engineer, etc.) - as a constituent part of the control and monitoring system.

Let's consider one by one the tasks solved by each of above blocks and determine the main directions of work to be done in order to create the system of engineering support for each of them.

Block No. I

The process in itself. The main task of this block is to maintain continuous selection of optimum operating conditions (optimum economics of the process) taking into account the tasks set forth by the administration and characteristics of the equipment just in this specific situation.

These problems are successfully solved by means of widely applied control and monitoring systems with making use of computers; they are well described in special literature, but as a rule they work within a rather narrow range of process parameter fluctuations being determined by the production process regulations. Apart from that, at the plant there always takes place the change of catalyst activity, the deterioration of heat-transfer in heat-exchangers or mass-transfer in the mass-transfer equipment, the change in quality of feed-stock, cooling agents or the change of other process parameters. In such cases, as a rule, one turns for help to specialists-consultants or to the authors of the process (those who developed the process) - they will always need time to investigate the background of the process procedure and to re-calculate the process parameters; within the conditions of operation of large-scale production plants it could lead to considerable economic losses.

Availability of computers in the control system (with insignificant expansion of their parameters as compared with the usually designed ones) provides for initiation of development of simulation mathematic production models in which real information of an industrial plant is used in order to solve the above mentioned tasks. Based on our calculations that permits to obtain revenues by 2-5% more than under the current conditions.

Block No. 2

Equipment (process) of a chemical plant. The primary task in this case is to ensure reliable operation (without significant modifications of the parameters) within the given period of time. In our opinion fulfillment of that task should be followed by solution of two problems:

- A system for automatic diagnostics of the equipment conditions should be included in the control system,
- At a plant or at a factory universal systems for non-destructive control of conditions of vessels, piping and etc. should be available, as well as a special schedule of their utilization for periodic preventive diagnostics of the plant.

Block No. 3

A system for control and monitoring of a process. A lot of papers are dedicated to theory and practice of such system developments, mainly pertaining to solution of the problem of high quality information retrieval (precise, reproductive and prolonged from the point of view of transformation processes). As computation means we use either special computers and means for information presentation or separate units that perform computation operations (for example, introduction of correction factor into flow measurements when the temperature of the atmosphere changes). Availability of computation means that it is possible to develop a system of industrial follow-up, a task for discovery of a faulty information transducer, presently all the above mentioned is very important for modern plants in which there are several thousand such instruments.

Block No. 4

A system of alarm initiation and protection of a process, equipment and environment.

As a rule this system is based on principles of duplication of measurement signals or majoritaric logics, it is conservative and operates strictly within the given statistical limits.

To our opinion there is no need to develop systems of engineering follow-up for this block.

Block No. 5

A person (a manager of a plant, an operator, a mechanical engineer and etc.) as an integral part of control system.

The primary task here is analysis of the available information, evaluation of its authenticity, taking a decision and physical interference in the process (via control system or directly via a control body) they ensure safe conditions for its fulfillment. Its execution acquires specific significance in shutdown and start up procedures, it is not possible yet to realize it in the available control systems due to extraordinary complicated character of the algorythms of these operations.

Another peculiarity of a person in control system is a modification of his personal characteristics (he forgets instructions, loses skills of process control, speed of information reception is reduced, etc.) all that permanently affect economics of the process. In the critical case it is necessary to try to shift maximum functions to instrumentation systems and determine very carefully the range of every person's actions within the system.

Obviously there is no need to look for special proofs of necessity to develop systems for engineering follow-up in this block.

On the first hand in this respect we must mention development of simulation training units that would develop in a person practical skills of the given process control (here we can use the imitation models of Block No. 1), testing check-ups of a person (after holidays, illnesses and etc.). Modern properties of computers and instrumentation units provide for availability of such training units for moderate fee for every production process.

Some of our experiments have proved efficiency of development of verbal prompting systems for operators (based on script previously recorded in tapes) to be used in start up and shut down procedures as commands "close", "open", "compare" and etc. Naturally these tape recordings should very precisely correlate with an operator's physical potentialities to perform and realize in real time scale.

Development and practical introduction of engineering follow-up systems could be possible only at those operating plants where computers are used to control the process and where that is economically feasible.

It is necessary to mention that production processes for manufacture of chemicals which are characterized by high fire and explosion hazards, increased negative effects on environment demand the introduction of computer-aided control systems supplemented with engineering follow-up systems.

The present paper is the result of several years's investigations and thoughts about ways for development of complicated chemical processes and in particular means for ensuring their safety and economical feasibility.