УДК 681.518

INNOVATIVE PRODUCTION SYSTEM MANAGEMENT BASED ON PRODUCT LIFECYCLE

V. G. Matveykin, B. S. Dmitrievskiy,
Ya. P. Potrashilina, A. E. Filina

Tambov State Technical University, Tambov

Reviewed by Doctor of Technical Sciences, Professor C. V. Ponomarev

Key words and phrases: automated control system; full-scale production; innovative production system; management; manufacturing process; model; pilot production; product lifecycle.

Abstract: The main features of innovative production system as control object were considered. The peculiarities of innovative product lifecycle were expanded. The process of pilot production and batch production were singled out among manufacturing processes. A block diagram of innovative production system management was suggested, the purposes and objectives of automated product lifecycle management system were expanded. This automated system allows making effective control responses both at the development stage and manufacturing stage. The model of innovative production system was proposed and the mathematic control problem was formulated.

Introduction

A lot of articles cover production system management [1 – 5], however innovative production systems (**IPS**), with response to control, have their own features: a new product is created and at the same time its components are developed (scheme and design solutions, physical principles, technologies etc.); significant product lifecycle (**PLC**); PLC consists of several stages: from R&D to full-scale production and operation; large volume of R&D, production of experimental samples and their completion during all manufacturing time due to design changes and upgrades.

Матвейкин Валерий Григорьевич – доктор технических наук, профессор, заведующий кафедрой «Информационные процессы и управление», e-mail:ipu@ahp.tstu.ru; Дмитриевский Борис Сергеевич – доктор технических наук, доцент, профессор кафедры «Информационные процессы и управление»; Потрашилина Яна Павловна – аспирант кафедры «Информационные процессы и управление»; Филина Александра Евгеньевна – магистрант кафедры «Информационные процессы и управление», ТамбГТУ, г. Тамбов.

The main features of IPS management are defined by the complexity of the control object, a large scope of the problem, a huge amount of various disturbances and control actions in space and time, a large number of managers, storage and transfer of information as document flow.

The purpose of the research is to form a new approach to IPS management. This approach is based on the system integrity with different functions and processes, IPS model, the description of PLC, including product and processes data, and allows reaching maximum efficiency of the IPS operation under the input limits.

Main features of IPS as control object

IPS includes scientific research, design, production and after-sales support. We consider the main properties of IPS as a control object. "Innovativeness index" has been introduced to evaluate the IPS operation. It shows the part of pilot products in full-scale production. Profit from sales should defray expenses on all types of R&D, innovative activity, manufacturing of pilot and full-scale production and product distribution.

To increase the competiveness of the product it is necessary to archive the optimality of parameters and the following processes: production scheduling and control, marketing, purchases, sales etc. To achieve this we will control IPS via PLC.

The analysis of PLC showed that it has its own features in IPS. The definition of PLC is given in ISO as a set of stages for all lifetime. Consistent periods of time to perform the work were considered as stages below.

Innovative product lifecycle (**IPLC**) includes not only the set of stages, but also a closed circle of interrelated processes (Fig. 1). We highlighted the two main processes: pilot production of innovative products and full-scale manufacturing of products that have passed through the pilot production.

The large part of capital in IPLC goes to investments in innovations, increasing of innovation potential, R&D. R&D bears main innovative load and has high uncertainty and risk.

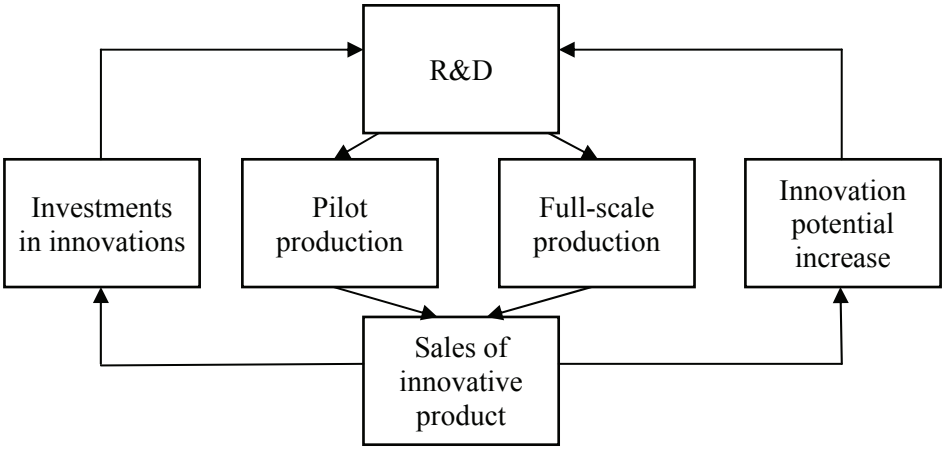

Fig. 1. Innovative product lifecycle

For highlighting the processes that take place in IPS it is necessary to determine the list of their functions based on the standards and instructions in each function area, and then combine the functions, used in the same process. The example of highlighted processes for some common structure of IPS is shown in Fig. 2.

Every process consists of subprocesses that can be analyzed as control objects. For example, in the production assurance the supply process can be marked out, in the supply activity – the acquisition process, in the acquisitions – the processes with suppliers etc.

Production processes in IPS include providing processes (research, information, transport processes etc.), product manufacturing processes (chemical and technological, mechanical etc.), service (repair) processes. Among this processes the organization aspects such as financial and economic processes, i.e. accounting, planning, data analysis, workflow, resource management, dominate.

The following items may be accepted as output values x_i, $i=\overline{1,n}$ (n – amount of factors, which describe state of the object) in management of financial and economic activities: synthetic accounts, subaccounts, analytical accounts and their groups (balance sheet accounts, techno-economic and financial indicators etc.) depending on the operating chart of accounts and management tasks at the particular stage of activity.

Disturbances can be classified into external (like deviations in terms of material supply, price changes etc.) and internal (like deviations from the rate of applications, unscheduled repairs etc.). Control actions u_j, $j=\overline{1,m}$ (m– number of control actions) in financial and economic management system are also extremely diverse. These are the production tasks on different periods of time, for the orders replenishment, for the shipping, for the movement of personnel and one's salary etc.

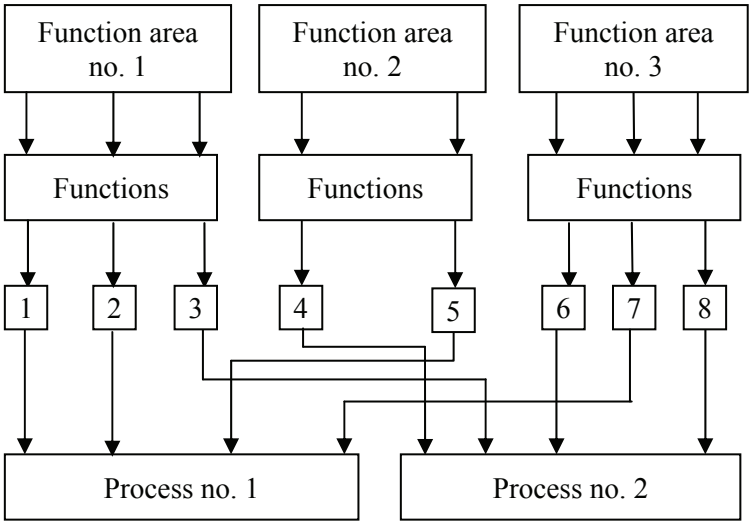

Fig. 2. Extraction processes for IPS

It is necessary to measure the output values (actual financial and economic indicators) to determine control actions as in average feedback looped system. Accounting is used to do it in financial and economic management system. When data are entered on *j*-account the output values are varying according to the equation

$$x_i^{j+1} = x_i^j + u_i^j.$$

The accounting system should allow realizing a flexible multi-level chart of accounts with advanced analytics. Then, the actual data must be compared with the task, i.e. with planned indexes x_n, the reasons of deviations $\delta = (x_n - x_i)$ are analyzed and the control actions are chosen to reduce these deviations.

IPS management problem

The control object is presented as a set of management processes which raise the "innovativeness" of IPS. The control system involves a process approach based on IPLC and feedback, which take into account the innovative potential and knowledge circulation. IPS management block diagram is shown in Fig. 3.

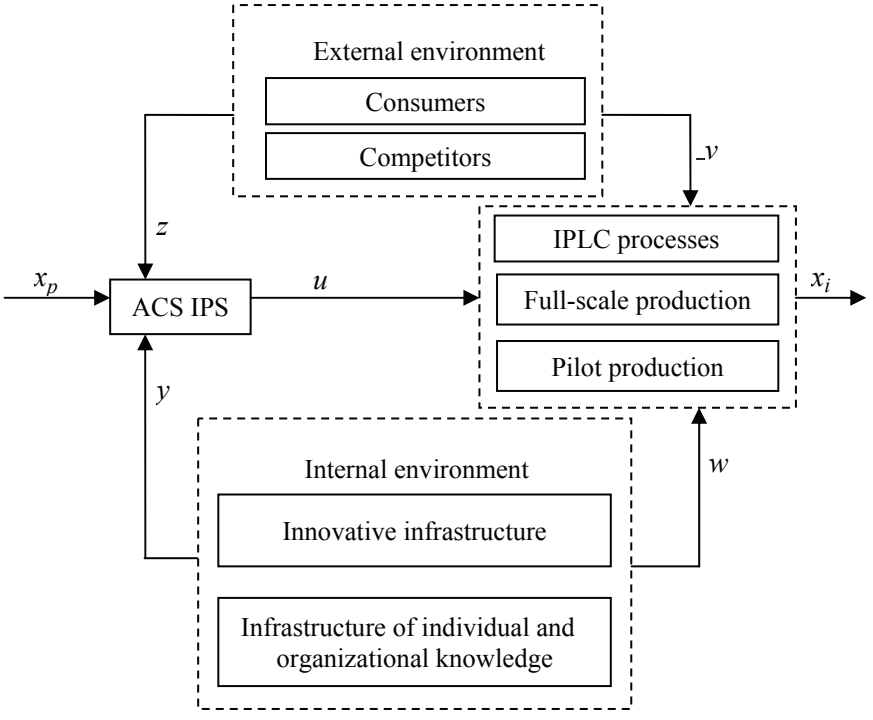

Fig.3. IPS management block diagram:

x_p, x_t– planned and current state of the enterprise parameters vectors;
u – control action vector; *v*, *z* – vectors of external environment influence;
w, *y* – vectors of internal environment influence

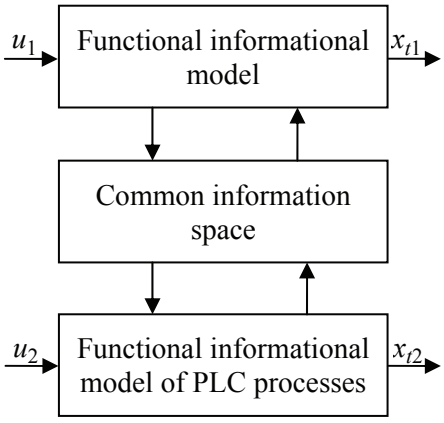

Fig. 4. IPS model

The development of innovative products management process is influenced by innovative processes, which are characterized by initiate activity, design and dissemination of innovations. It is necessary to manage product data, workflow within the company, suppliers and customers. The automatic control system (**ACS**) of IPS unites IPLC and solves all these problems and allows managing the IPS operation.

IPS requires monitoring and correcting of all PLC processes. For example, there must be a possibility to return the product to the stage of development. After scientific research, when we have pilot samples and checked their competitiveness, the product is launched into full-scale production. The PLC processes management involves the support of different procedures, such as storage and documents management, process control, composition of products control.

The ACS of IPS should control all information about the product: the structure, proportions, sketches, design and production plans, regulations etc. ACS of IPS users may be all participants of PLC: designers, engineers, marketers etc. The main problem of ACS of IPS is to provide the right information at the right time in a convenient form to the appropriate person.

During the IPS management we use the principle of concurrent engineering, which includes a number of processes for developing and designing innovative products together with simulation of manufacturing processes and operation. The concurrent engineering enables to deal with the problems, which may occur in the later stages of PLC, at the design stage.

Concurrent engineering represents replacing the traditional sequential approach with the iterative method that aims at the systematical improvement of the product development. The first design decision can be obtained with first option of the requirements (turn with the first problem statement). The research decision enables to clarify the problem, etc. The implement of this approach requires a common information space (**CIS**), in which all results are presented in electronic form and can be used by all users of ACS of IPS.

Let us represent the IPS model as a process description in CIS, connected with product data (Fig. 4). Thus, the model of IPS consists of two parts:

– functional informational model (**FIM**) of product, combining the product models on each stage of the PLC;

– functional informational model of PLC processes.

Input control vector $u(u_1, u_2)$ characterizes technological, informational and intellectual flows. State vector of IPS $x_t(x_{t1}, x_{t2})$ defines a system operation, which depends on the technological, technical-economic and innovative parameters.

The IPS management problem is to find optimal control actions on all stages of PLC, that achieves maximum efficiency of the IPS taking into account

internal and external environment and limitations on control actions and state functioning.

$$F(y, w, z, v, u) = \max(I);$$
$$u = f_1(x_p, x, y);$$
$$x_t = f_2(u, v, w);$$
$$y \in Y;$$
$$w \in W;$$
$$z \in Z;$$
$$v \in V;$$
$$x_t \in X_T,$$

where I – efficiency of the IPS; u – control action; U– set of states, determining the operation of IPS at each time point; Y, W– set of states of internal environment; Z, V– set of states of external environment.

Conclusion

Thus, the approach to the IPS management as an integral system, performing variety of related functions and processes of production and economic activity in a specific relationship with the external and internal environment is theoretically justified. The structural organization of the control system is suggested. During the formation of the ACS, IPS is considered as a set of interrelated processes, representing as a model. The model is a functional and informational, i.e. activity of units represented in the form of certain functions and their frames the motion of information documents is considered.

References

1. Попов, Н. С. К методике конструирования экспертной системы оценки промышленной безопасности / Н. С. Попов, Н. В. Лузгачева, Чан Минь Тьинь // Вестн. Тамб. гос. техн. ун-та. – 2013. – Т. 19, № 1. – С. 43 – 51.

2. Чижов, М. И. Разработка подхода к автоматизации технологической подготовки производства в системе Teamcenter / М. И. Чижов, А. В. Бредихин, М. Ю. Киянов // Вестн. Воронеж. гос. техн. университета.– 2011. – Т. 7, № 12-1. – С. 24 – 26.

3. Дякин, В. Н. Динамическая модель управления развитием промышленного предприятия / В. Н. Дякин // Вестн. Тамб. гос. техн. ун-та. – 2013. – Том 19. – № 2.– С. 304 – 308.

4. Литовка, Ю. В. Автоматизация технологической подготовки производства : учеб. пособие/ Ю. В. Литовка. –Тамбов: Изд-во Тамб. гос. техн. ун-та, 2002. – 33 с.

5. Путин, С. Б. Математическое моделирование процесса регенерации воздуха в замкнутом объеме / С. Б. Путин, Д. Л. Симонова, С. А. Скворцов // Вестн. Тамб. гос. техн. ун-та. – 2012. – Т. 18, № 4. – С. 953 – 956.

6. Дмитриевский, Б. С. Методология построения автоматизированных систем управления инновационными наукоемкими химическими предприятиями : дис. … д-ра техн. наук : 05.13.06 / Дмитриевский Борис Сергеевич. – Тамбов, 2011. – 303 с.

References

1. Popov N.S., Luzgacheva N.V., Chan Minh Tin. *Transactions of the Tambov State Technical University*, 2013,vol. 19, no. 1, pp. 43-51.
2. Chizhov M.I., Bredikhin A.V., Kiyanov M.Yu. *Vestnik Voronezhskogo gosudarstvennogo tekhnicheskogo universiteta*, 2011,vol. 7, no. 12-1, pp. 24-26.
3. Дякин В.Н. *Transactions of the Tambov State Technical University*, 2013, vol. 19, no. 2, pp. 304-308.
4. Litovka, Yu.V. *Avtomatizatsiya tekhnologicheskoi podgotovki proizvodstva* (Automation of technological preparation of production), Tambov: Izdatel'stvo Tambovskogo gosudarstvennogo tekhnicheskogo universiteta, 2002, 33 p.
5. Putin S.B., Simonova D.L., Skvortsov S.A. *Transactions of the Tambov State Technical University*, 2012, vol. 18, no. 4, pp. 953-956.
6. Dmitrievskii B.S. *PhD Dissertation (Engineering)*, Tambov, 2011, 303 c.

Управление инновационно-производственной системой на основе жизненного цикла изделия

В. Г. Матвейкин, Б. С. Дмитриевский,
Я. П. Потрашилина, А. Е. Филина

ФГБОУ ВПО «Тамбовский государственный технический университет», г. Тамбов

Ключевые слова и фразы: автоматизированная система управления; жизненный цикл изделия; инновационно-производственная система; модель; опытное производство; производственные процессы; серийное производство; управление.

Аннотация: Рассмотрены главные особенности инновационно-производственной системы как объекта управления. Раскрыты характерные черты жизненного цикла инновационного изделия. Среди производственных процессов выделены: процесс производства опытной партии изделий и производство изделий, которые впоследствии запущенны в серию. Предложена структурная схема управления инновационно-производственной системой, раскрыты цели и задачи автоматизированной системы на основе жизненного цикла изделия, позволяющей принимать эффективные управляющие воздействия как на стадии разработки изделий, так и на стадии производства. Предложена модель инновационно-производственной системы и на ее основе сформулирована математическая постановка задачи управления.

Статья поступила в редакцию 10.10.2014 г.