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Formation and Implementation of Comprehensive Science-Intensive Informational System of an Enterprise

A.V. Sarkin, N.G. Bagautdinova and B.A. Averianov

Kazan Federal University, Kazan, Russia

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Abstract: The paper explains methodological approach to the formation and implementation of the comprehensive informational system of a science-driven enterprise based on the consideration of the interrelation of technological basis development levels, business processes and levels of informational technologies (IT) development. The analysis of the developed model shows that the efficiency of active changing of suppliers lineup increases if a relative range of suppliers offer prices oscillation and their characteristic period increase.

Key words: Comprehensive informational system · Science-intensive manufacture · Manufacturing enterprise · Adaptive management · Business processes · Informational technologies · Technological basis

INTRODUCTION

Stable development of science-intensive manufacture creates conditions for keeping and development of the whole range of branches in terms of great duration and branching of technological networks. Besides, stable development of science-intensive manufacture has an important social function keeping highly professional personnel potential both in science-intensive manufacture and allied branches.

In connection with this, there is a necessity to find modern management technologies which implementation at enterprises will allow to restore their competitive potential, guarantee appearing of science-intensive products that can replace import on world markets [1-3]. One of the ways to achieve the set goals under contemporary conditions is the use of contemporary principles and technologies of the enterprise adaptive management taking into account the peculiarities of a science-intensive manufacture and its today's state.

RESULTS

The undertaken study offers a set of economic and mathematic models for optimizing the use of science-intensive enterprise resources in the context of adaptive management of the enterprise as an element of innovation value network. It helped to develop a typical set of organizational and economic events to discover and make qualitative estimation of internal reserves.

In many cases optimization of management decisions on the use of science-intensive enterprise resources (materials, labor force and equipment) is based on the use of linear programming tasks which target goal expresses maximization (minimization) of its value. In this case for the consideration of unformalized goals, the individual taking the decision (ITD) fixes a part of variable indicators leaving another part free to satisfy formal limits [4].

Thus, in the context of strict task setting the ITD can use his experience preferring a definite variant of organizing multi-machines maintenance zones, placing machine operators in working zones, a new equipment model, definite technological route, leading technologies and methods of work. Herewith, in order to achieve the most satisfactory decisions the ITD can change the scope of fixed and free indicators multitude.

One of the peculiarities of the science-intensive manufacture is a variety of the used materials, for example the construction of an air HK-86 engine supposes the use of 85 materials supplied by various suppliers. Even relatively small decreasing of expenses for purchasing materials and components achieved due to the suppliers' change can lead to considerable saving

Corresponding Author: Bagautdinova, Kazan Federal University, Kremlevskaya, 18, Kazan, 420008, Russia.

of expenses and consequently to profitability increasing. We can propose the following integral efficiency indicator of active changing the enterprise agents:

$$Y = (Pfac - Pideal.)/(Pav.shop - Pideal.) \quad (1)$$

where P*fact.* and P*ideal* are factual and ideal values of the suppliers' sale prices; P*av.shop*. is an average shopping value of the suppliers' release prices.

The analysis of the developed model shows that the efficiency of suppliers' changing increases if relative range of suppliers' offers prices oscillation and their characteristic period increase; funds and time expenses for changing suppliers decrease; volumes of materials purchase (components, production service) increase.

The process of analyzing multi-machines work is rather difficult as while implementing it a range of admissible decisions (alternatives) may arise. A specific variant must be chosen by an individual taking the decision. The work offers options as how to solve the task of organizing multi-machines maintenance, selection and placement of machine operators in working zones (WZ).

The proposed task setting is focused on the person machine solving mode. If it is necessary to form the decision on the bay transfer on the multi-machines maintenance subject to the bay is equipped with M machines, N employees are confirmed at them at individual maintenance, the machine operator loading coefficient at servicing one machine.

The WZ groups the machines whose total loading coefficient must not exceed one. On the assumption of this condition, the ITD sets possible variants (on the number of machines) to WZ which can be organized at the bay. Lets' suppose that at the bay H WZ are grouped so that in each j of them there are m_j machines and they are serviced by n_{ij} machine operators.

As actual loading of a machine operator servicing machines depends on the scope of detail operations performed in a WZ; in addition to that the combination of detail operations can change many times during the shift, the formed WZ will significantly differ by machines down time while expecting for maintenance. In connection with this we can formulate the task of optimizing the WZ scope where down times of machines expecting maintenance will be minimal. Let's indicate a coefficient of down time expecting for maintenance of k machine of j WZ as Q_{kj} where k = 1- m_j, j = 1- H. Let's work in varieties x_{ij} and y_{kj}, which take the values: 1 if the machine operator of i profession serves the j WZ and k machine is from the j WZ where i = 1 – N, j = 1 – H, k = 1 - m_j : 0 – in the contrary case.

Then the task of choosing optimal WZ is reduced to the search of the target function minimum:

$$Q_{kj} = f(x_{ij}, y_{kj}) \quad (2)$$

Under the following restrictions:

$$\sum_{i=1}^{n_{ij}} x_{ij} \geq 1 (j = 1 - H) \quad (3)$$

Means that each WZ is serviced by at least one machine operator;

$$\sum_{k=1}^{m_{ij}} y_{ij} \geq 1 (j = 1 - H) \quad (4)$$

means that each WZ has at least one machine;

$$\sum_{i=1}^{n_{ij}} x_{ij} \sum_{k=1}^{m_j} x_{kj} (j = 1 - H) \quad (5)$$

means that the number of servicing machine operators must be lower than the number of machines in a WZ;

$$\sum_{j} \sum_{k=1}^{m_j} x_{kj} = M (j = 1 - H) \quad (6)$$

means that the number of machines having entered optimal WZ corresponds to those that are placed at the bay.

Let's make a linear connection Q_{kj} = f (x_{ij}, y_{kj}). In order to define Q_{kj} coefficients we will regard a WZ as a system of mass maintenance when machines that stopped working create a flow of requirements described by the Poisson distribution. The duration of one requirement maintenance (detail removing, its setting, machine rectifying) gears the demonstrative distribution law. The system parameters include: λ is an average number of requirements received per unit of time; $\frac{1}{\delta}$ is average time of one requirement maintenance if the unit time is an hour.

Let's indicate the possibility of receiving s requirements for maintenance in the j WZ per unit of time as P_{sj}; P_{sj} will take on value:

$$P_{sj} \begin{cases} \dfrac{m_j!}{s_j(m_j - s_j)!}\left(\dfrac{\lambda_j}{\delta_j}\right)^{s_j} P_{oj}(1 \leq S_j \leq n_j); \\ \dfrac{m_j!}{n_{ij}^{s_j - n_{ij}} n_{ij}!(m_j - s_j)!}\left(\dfrac{\lambda_j}{\delta_j}\right)^{s_j} P_{oj}(n_{ij} \leq S_j \leq m_j); \end{cases} \quad (7)$$

where ГДеP_{oj} is the possibility that all machines of the j WZ function, defined from the condition that $\sum_{s_{j=0}}^{m_j} P_{sj} = 1$

$$P_{oj} = \frac{1}{\sum_{s_{j=0}}^{m_j} \frac{P_{sj}}{P_{oj}}} \tag{8}$$

Coefficient of down time in expecting for maintenance of each k machine of the j WZ:

$$\frac{\sum_{s_{j=n_{ij}+1}}^{m_j} (s_j - n_{ij}) P_{sj}}{m_j} \tag{9}$$

The task of choosing optimal WZ reduces to the search of x_{ij} and y_{kj} values providing minimum of the target function Q_{kj} = f (x_{ij}, y_{kj}) and can be solved by the enumerative technique.

Management of science-intensive manufacture often faces the decisions of poorly formalized tasks and tasks for which no formal decision was found. In order to solve such tasks, the paper proposes the solving method suing the conclusion based on precedents.

The undertaken study allowed to explain the methodic approach to forming and implementing of the comprehensive informational system of a science-intensive enterprise based on the consideration of the interrelation of technological basis development levels, business processes and levels of informational technologies (IT) development as well as on the integration of informational systems opportunities, systems of modeling and automated expert estimation [5-12].

To explain the choice of an informational system (IS) at a science-intensive enterprise, it is necessary to analyze the existing systems that must be made on the following criteria: functional opportunities – correspondence of the automated system to basic business functions; total cost of the IS ownership – the amount of direct and indirect expenses born by the system owner for the period of its life cycle; perspectives of the IS development and support that are defined by the supplier and a set of standards put into the system and its components; technical characteristic – the IS organization; scalability, reliability especially as far as it concerns business procedures performance; recovery possibility in case of the equipment fail; availability of archiving means and backup; security means from pre-determined and casual technical attacks; supported interfaces for the integration with external systems.

Resource base for the creation of process-oriented informational systems at science-intensive enterprises can become only fully functional system comprising all life cycle of the science-intensive product and containing all necessary program and technical means.

CONCLUSIONS

The undertaken analysis of the existing and replicated informational systems allowed to make the conclusion that enterprises corporate informational systems focused on the issue of science-intensive products must include at least the following components:

ERP (Enterprise Resource Planning) – a system of planning and managing all enterprise resources;

MES (Manufacturing Execution System) – a manufacturing executive system including activation of manufacture capacities; following manufacture capacities; collecting on information related to the manufacture;

APS (Advanced Planning & Scheduling) that solves problems on composing optimized manufacture schedules;

EAM (Enterprise Asset Management) – a system managing basic enterprise funds and responding for managing technical maintenance and repairing of equipment;

PLM (Product Life – cycle Management) – the technology to manage the product's life cycle;

CALS (Continuous Acquisition and Life – cycle Support) – a system of continuous informational support of the product life cycle;

Work Flow – a technology of managing the project flow; Internet technology of creating the internal corporate network; Internet global computer network;

BPM (Business process Modeler) – technology of modeling business processes;

CASE (Computer Aided Software Engineering) – a system of automated development of software;

DOORS (Dynamic Object – Oriented Requirements System) – a dynamic object-oriented system of managing requirements;

SADT (Structured Analysis and Design Technique) – structured analysis and design technique;

COCOMO (Constructive Cost Model) – constructive product cost model;

TQM (Total Quality Management) – in the community (total) quality management;

PDM (Product Data Management) – product data management technique;

CAE/CAD/CAM (Computer Aided Engineering/Designing/Manufacturing) – means of computer support/development/design/manufacture;

SCM (Supply Chain Management) – systems of supply (purchasing) process management;

CPC (Collaborative Product Commerce) – systems of supporting joint business at the product manufacture and selling;

CAD, CAE, CAM, CAID – systems of computer support according to development, engineering calculations and modeling, manufacture preparation, manufacture design and virtual reality;

PDM – a system of managing project data and data about the product;

EDM – systems of managing engineering calculations data;

EDMS – systems of electronic document flow and tasks management;

LSAR – a system of logic provision;

IETM – a system of electronic exploitation documents development and support;

IPPD – an integrated development of products and processes;

PM – a system of projects management;

Office applications include text processors, electronic charts, presentation graphics, organizers, etc.; developed telecommunications systems performing joint work of teams and groups separated geographically according to the “virtual office” principles.

In this combination corporate informational systems can provide support of constructive, technological, manufacturing, logistic, exploitation data and quality data being a full electronic description of a product. The inclusion of the above technical modules into the corporate informational system guarantees the creation of a common electronic informational environment, the use of contemporary technologies of computer modeling and quick wire framing at the early stages of the product life cycle that, in its turn, allows to make a deep and comprehensive analysis of the designed product constructive parameters; to decrease the total number of changes in the product design and to make a considerable part of them at the early design stages when the price of changes is not so high and the project itself is the most flexible; to model processes of the product manufacturing, assembling and exploitation; to model a number of various variants of constructively technological decisions etc. in the whole life cycle, to find their optimal combination; to estimate cost and temporal indicators at separate stages and in the whole life cycle of the product and finally, to decrease the time of the product appearance on the market and minimize its cost.

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