OPTIMIZATION OF INDUSTRIAL FLOWS OF MACHINE-BUILDING MANUFACTURE

© 2009 A.A. Koptev, S.F. Tlustenko*

Keywords: technological innovations, modeling, flows (streams), purposes, resources.

The problem of theoretical description of the development processes and peculiarities of the production environment behavior dynamics as the active system is touched upon. The technique of splitting of the initial set of system's states according to the signs and optimization of discrete models is suggested.

Construction of flexible automated manufactures of complex engineering is connected with determination of a set of Nx models structures of production and technical processes as the vector function in the form of the Boolean's product:

$$Nx = F(MoL),$$

where L is a set of structural components consisting of subsets of material components of the basic processes Mi ..., a set variants of functioning $Ki...K$ and a subsets of moments of time, which are adequate to them $tk ...T$, a set of operating influences $Vi...V$ in a combination with accidentally admissible indignations $gi ...G$, as well as construction and technological parameters.

On the other hand, the system complex management should be put over this structural model, as well as an operator, under condition of sufficiency of variations of possible solutions with the purpose of obtaining the planned parameters on quality, labour-intensiveness, materials consumption and others. A compromise between the expenses and quality under condition of optimization of different schemes on all components is getting important in aircraft industry.

Thus, the efficiency of technological innovations (TI) is connected with theoretic and physical essence of a set of models structures with a number of continuous, discrete and continuous-discrete processes:

$$Mx=N\{t,V,...G\} \text{ o } \{L\}.$$

Let us study the logic and dynamics of technological innovations (TI) with the purpose of developing the technique of optimal transition of the system from one state into another.

General directionality of the development strategy and perspectives of changing in production and technology as a whole are taken into account at resource distribution and in the first turn the expenses on the realization of the project in the framework of innovations (TI).

Consequently, the analysis of manufacture state on the initial stage precedes the project development (reformation) of the complex system (industrial, organizational, transportation, etc.). Approximate characteristics of the system are determined at the initial stage of manufacture such as financial and time expenses on its design and realization, payback terms, frame structure (architecture), principles of functioning (behavior) and others. The initial stage of analysis is called technical and economic basing as well. Since the real system does not exist yet at the initial stage, the workup is implemented at the level of different models. In other words, the analytical and imitation modeling is the basic technique.

There are four consequent stages of modeling at the initial stage of basing.

1. Laying down the purposes - formulation of the objectives, which determine the function of the system being developed, as well as the goals that are expected to be achieved at implementing the project.

2. Cognitive modeling - identification of factors influencing the development of the situation in the system, the assignment (on the base of experts' inquiry) of interrelations between the factors, prediction of the tendencies of the situation development, etc.

3. Operational modeling - developing the scenarios of the achievement of the purposes put forward on the base of the set of operations implemented in the certain order.

4. Stream modeling - imaging of the flows (financial, informational, material, power) sent

* Andrey A. Koptev, Professor of Samara State Aerospace University named after S.P. Korolev; Stanislav F. Tlustenko, associate Professor of Samara State Aerospace University named after S.P. Korolev. E-mail: titan250@mail.ru.

to the system entry, spread inside the system and taken from its outlet.

Streaming models known in the literature have been developed under the certain classes of systems. The models of flexible automated manufactures (robot-technological complexes, divisions, workshops in mechanical engineering), models of business systems represented by modular structures with the implementation in each module of their vital cycle of conversion of streams elements and others may serve as the example.

Some universal network models are used in the work. It can be applied for the imaging of the ways and the streams of the network representing the project of development of aviation enterprise (PDAE) as various stages of its implementation. The universal tooling of graph theory and network representation support both the model and the techniques of description and the analysis of the ways and the streams.

The suggested models of the analysis of the project of developing the aviation enterprise (PDAE) with the application of TI represent the structure consisting of two interrelated parts based on the imaging by some network both the project, and parameters of efficiency.

Let us consider the models that provide analysis of PDAE sequentially with the use of TI from this position.

The implementation of PDAE as the consequence of the events and the works may be represented by the directed network in the framework of the general network approach.

Proceeding from this, PDAE is a partially ordered set of works where this partial order arises from the technological limitations that demand finishing one amount of works before starting another. Besides, the cost of work implementation will linearly change in the interval between these two terms.

This would give one point on the curve of the project cost. Solving this problem for all admissible time intervals, we get the full curve of the project cost. Possessing this information the manager can answer the questions: "Should he allocate assignments?" or "What is the completion term of the project?" and so on.

Problem solution on determination of the cost curve of the development project may be obtained on the base of the stream model in the networks.

The directed network can represent PDAE model. Let us consider the construction of such network on the following example.

Example: The project consists of the works 1, 2, 3, 4, 5 and the only relations of the order are

1 precedes 3 and 4;

2 precedes 4;

3 and 4 precede 5.

Figure 1 shows the typical method of imaging of this partially ordered set, where some of the arcs display the works and the units may be regarded as the events in time. Existence of any unit means that all the works directed to this unit should be finished before the works directed to it can be started. Note that the arcs that do not correspond to any works may also be seen in the second representation of the project (pay attention to the arc in dotted line). It is quite admissible because any fictitious work corresponded to such arc can be added to the project, besides, we may assume that fictitious works have zero time of performance and zero cost. It should be stressed that allowing fictitious works, we may represent any project.

Using this project in the form of a network, we may show that the problem of calculation of the cost curve is the stream problem. Thus, we suppose that the network whose arcs correspond to works and the units correspond to events is given. This network does not have the directed cycles. At the same time, we may consider that each arc is contained in some directed chain from *s* and *t*, adding if it is necessary the initial and final units *s* and *t* together with suitable arcs, directed from *s* and *t*.

Three non-negative integer numbers $a(x, y)$, $b(x, y)$, and $c(x, y)$, where $a(x, y)...b(x, y)$ are put in conformity to each arc. These numbers are interpreted as the following: $a(x, y)$ is emergency time of work performance (x, y), $b(x, y)$ is normal time of work performance and $c(x, y)$ is the decrease of the cost of performance of this work on unit of time increase from $a(x, y)$ up to $b(x, y)$. In other words, the cost of work performance (x, y) for $...(x, y)$ units of time is determined by the known function

$$k(x,y) - c(x,y)\tau(x,y) \qquad (1)$$

at the interval

(2)

We assume that the project is supposed to be competed for T units of time. Then the prob-

Fig. **The network model of PDAE work representation**

lem is in the choice for each work (x, y) time ...(x, y) obeying the inequalities (2) at which the cost of the project would be minimal or it is equivalent that the function would accept maximum value.

$$\sum_{x,y}[k(x,y) - c(x,y)\tau(x,y)] \quad (3)$$

$$\sum_{x,y} c(x,y)\tau(x,y) \quad (4)$$

So, if to designate through ...(x) (unknown) time of the implementation of the event x, then sho[illegible]imize the function (4) dependent on the [illegible]g inequalities

$$\tau(x,y) + \tau(x) - \tau \text{[illegible]} \quad (5)$$

$$-\tau(s) + \tau(t) \le T, \quad (6)$$

(7)

(8)

After that, the cost of the project (CT) which corresponds to the given value T in (6) is determined by the formula:

$$C(T)\sum_{x,y} k(x,y) - \max \sum_{x,y} c(x,y)\tau(x,y),$$

where maximum is taken over all ...(x, y), ...(x) at stated limitations.

Let us suppose that these limitations are admissible and no doubt, it will be right at large T. Indeed, for function ...(x, y) that satisfies conditions (7) and (8) the limitations are admissible in the event that T is less than ... - the longest chain from s and t. The proof of this relies on the fact that the network of the project does not contain any directed cycles.

Neusipa[illegible] K.A., Zabelskiy A.I. Some aspects of theory of [illegible]ation and prediction. M., 2000.

Twiss B. [illegible]gement of scientific and technical innovations. M., 1989.

Received for publication on 24.06.2009