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RESEARCH ARTICLE

ALGORITHM OF ELEMENTS OPTION OF CONTROL SYSTEM OF FLEXIBLE MANUFACTURE SYSTEM

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ABSTRACT

One of important and priority directions providing economic development of Azerbaijan is automation of manufacture enterprises and their passing to intellectualization of control system. In this connection, creation of algorithm for option of elements of the sensor system of automated control of the flexible manufacture systems (FMS) is considered. On the basis of the generalized parameters of the automated functions of control system of FMS the block-scheme of stage-by-stage option of control computers and providing of efficiency of their work is proffered.

INTRODUCTION

Implementation of the requirements in accordance with the specific of the designed manufacture, application of the newest facilities of hardware of control system, applications of flexible programmatic control of the flexible manufacture systems is an important problem at automation of option and designing elements of control system of FMS. It was set by research of the stages of designing control system of FMS, that of realization of the problems of option of its standard and non-standard elements on the initial stages efficiency and productivity of designing process depend in a great deal (Troitsk *et al.,* 2005). In this connection, let's define the area of the applied technical equipments of management and control of the informatively-control system of FMS, managing computer technique. In depend on the functional setting and character of the decided problems the informatively-control system of FMS is conditionally divided by the subsystems of external information. The subsystems of such information provide registration of the actual state of separate standard and non-standard elements of FMS at every instant and realization of the required parameters of motion. They include sensory, executive devices and technical control systems providing jigging of manipulation objects, implementation and control of technological operations of standard and non-standard elements of FMS accordingly.

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Investigational problems in area of creation of instruments of the computed designing control system of FMS on the stages of designing (Norenkov, 2004; Dembovski, 2004) not sufficiently embrace the problems of mathematical solution of option, determination of optimal coordinate positions and reliability of functioning sensitivity elements, sensory, executive mechanisms of the system; development of data ware on the base of searching models and knowledge of logical character; creation of functional diagram of automation on the base of the modernized system of hardware; problems of creation of instruments of simulation of control system of FMS.

Solution

One of directions of decision of the problem on creation of control system of FMS is introduction of the systems of sensitivity and intellectualization of control in technological equipments and industrial robots of production, able to take into account obtained information about an environment, both in the process of planning and in the process of execution. The system of sensitivity perceives by means of present in its composition sensors of state information about status of external area, processes them. As a result signals of influences which acting on one of entrances of control system are produced, that in turn produces corresponding signals on technological units and industrial robots of FMS areas. Substantial influence on option of one or another type of sensors, on reliability of channels of information transferring, watts-ins and structural implementation of technical units of

FMS renders the environment of functioning what are characterized by physical properties of F_{s_i} ($i = \overline{1,m}$), geometrical parameters G_{p_i} ($i = \overline{1,n}$) and parameters of manipulation objects O_{m_i} ($i = \overline{1,m}$).

Option of sensors for controlling influence of active elements of FMS depending on the initial parameters of environment of functioning I^{ef_i}, the initial geometrical sizes of I^{gs_i}, the initials parameters of manipulation object of I^{mo_i} provides at executing the following condition:

$$D_i \Rightarrow \begin{cases} \forall D_{fs} \in \{ \exists I^{ef-i}, F_{s\_i} \}; \\ \forall D_{gp} \in \{ \exists I^{gs-i}, G_{p\_i} \}; \\ \forall D_{pom} \in \{ \exists I^{mo-i}, O_{m\_i} \}. \end{cases} \quad \text{.....(1)}$$

where $D_i \in \{D_{fs\_i}, D_{gp\_i}, D_{pom\_i}\}$ – great number of types of sensors that get out in accordance with physical properties, geometrical parameters and parameters of manipulation objects of FMS; F_{s_i} – normative data of luminosity, temperature, explosiveness, radio-activity, presence of hindrances, vibration and shots, humidity; G_{p_i}–possible composes sizes of equipment, industrial robots, conveyers and manufacture modules on the functional setting, sizes of working zones of active elements of islands of FMS, form of working zones, form of technical units, obstacle; O_{m_i}– standard sizes of series of the produced wares, form of the manipulated object, mass of manipulation object on the islands of FMS; material of output products, method of transporting a manipulation object; degrees of mobility of manipulation robot, that moves manipulation object, number of classes of output products.

Geometrical parameters of the working areas of FMS which are used at option of its scheme of composes allow to build a structural scheme of optimal relocation of sensors in technological equipments, robots, conveyers, and others technical units of FMS. Thus the built scheme of sensors placing on the active elements and accordingly in the islands of FMS provides reliable informative connection with executive mechanisms set on the same equipments and controlling computers.

In depend on the applied composes scheme of manufacture islands of FMS and their scheme of automation (Mammadov 2004; Mammadov and Huseynov, 2011) are determined requirement to its exactness of positioning. The total error of positioning must provide the required exactness of setting a manipulation object on technological equipments. The error of setting an object in technical units consists of two constituents: errors of lack of coincidence of center of form of detail with a certain center in an equipment and error of orientation on a corner in relation to some axis.

Descriptions of objects of manipulation in the technological route of FMS renders influence on type selection and structure of the systems of sensitivity, construction of executive device and function of industrial robots in the manufacture module. Descriptions of object of manipulation determine the type of working zone of active elements of FMS.

At option of sensors of technological parameters and other units of selection of information for the manufacture terms of FMS it is necessary to take into account some factors of metrology and regime character: permissible error; measuring limits with the assured exactness; influence of physical parameters of the controlled and surrounding environment on normal work of sensor; distance on that the information distinguished by a sensor can be passed; measured maximum values and other parameters of environment.

By basic description of sensor that must be taken into account at its selection are static and dynamic errors. The static error of sensor is characteristic for positioning manipulators on automation transport system executing the functions of jigging of purveyance and grippers of industrial robot which keen and off-loading objects. For determination of static error calculation formula is used (Mammadov and Huseynov, 2003):

$$\Delta x_s = x_{n1} - \kappa_f , \quad \text{.....(2)}$$

where x_{n1} – testimony of a sensor characterizing value of output signal at jigging of purveyance; $\kappa_f = const$ is a truth value of measured (coordinates of x, y, z of permanent position of jigging) on the entrance of sensor, characterizing presence of manipulation object on a positioning manipulator.

Accordingly the initial coordinates of jigging of presence of manipulation object on the positioning manipulator of automation transport system of FMS are determined as follows:

$$\begin{aligned} x &= 0 , \\ y &= R_{\text{int } IR} = r_0 \cos \alpha_0 , \\ z &= h_{\text{int } IR} = r_0 \sin \alpha_0 , \end{aligned} \quad \text{.....(3)}$$

where $R_{int\ IR}$, h_{intIR} – accordingly on a radius and height initial position of gripper of hand of industrial robot depending on initial arctic coordinates r_0, α_0.

For determination of error of sensor in the dynamic mode a calculation formula is used:

$$\Delta x_s = x_{n2} - \kappa_s , \quad \text{.....(4)}$$

where x_{n2} – testimony of sensor characterizing value of output signal at the linear and angular moving; $\kappa_s = vario$ - truth value of measure (coordinates of x_i, y_i, z_i positions of moving) on the entrance of sensor characterizing presence of purveyance at the changes of positions of purveyance in the working zone of maintenance of industrial robot.

Accordingly the initial coordinates of jigging presence of manipulation object at its linear and angular moving are determined as follows:

At the linear moving accordingly along the axis of x, y, z::

1) the rectilinear moving is executed along the axis of *z*, and other coordinates remain unchanging:

$$x_1 = 0,\quad y_1 = 0,\quad z_1 = \Delta z = r_1 \sin\alpha_1 - r_0 \sin\alpha_0. \qquad \text{.....(5)}$$

where r_1, α_1 - arctic coordinates corresponding to position after the rectilinearly moving gripper of hand of industrial robot upwards along the axis of *z*; $j = p/2$ is a corner of turn of hand of industrial robot about axis of *z*.

At the angular moving about axis of *z*:

2) The angular moving is executed around axis of *z*, and other coordinates remain unchanging:

$$x_3 = \cos\varphi - \sin\varphi,\quad y_3 = \sin\varphi + \cos\varphi,\quad z_3 = 0, \qquad \text{.....(6)}$$

Dependence of output signals of sensor of measuring linear and angular moving of *xn2* on the value of entry parameter of $\kappa_d \in \{z_i, \pi/2\}$ is determined by means of the system of equations:

$$x_{n2z} = a + в(r_1 \sin\alpha_1 - r_0 \sin\alpha_0), \qquad \text{..... (7)}$$

$$x_{n2\varphi} = a + 2в\left(\pi - \arccos\frac{1}{\sqrt{2}} - \arcsin\frac{1}{\sqrt{2}}\right),$$

where *a, в* - coefficients regressions that are determined by drafting of the systems of equations by means of least-squares method.

Taking to account that an industrial robot in the productive module of FMS executes the great number of moving on the degrees of mobility, then here is a necessity of determination of total static and dynamic error of measuring.

Using expressions (4), (5) and (6) it is possible to define the general total error of measuring the mechanical moving:

$$\Delta = \begin{cases} n_x\left(x_{n2\varphi} - (\cos\varphi - \sin\varphi)\right) + x_{n1} - r_0\cos\alpha_0 \\ n_y\left(x_{n2\varphi} - (\sin\varphi + \cos\varphi)\right) + x_{n1} - r_0\cos\alpha_0 \\ n_z\left(x_{n2z} - (r_1\sin\alpha_1 - r_0\sin\alpha_0)\right) + 2(x_{n1} - r_0\sin\alpha_0). \end{cases} \qquad \text{..... (8)}$$

where n_x, n_y, n_z – accordingly number of moving along axis of *x*, *y*, *z*.

Taking into account change of the measurable rectilinear and angular moving of capture of hand of industrial robot on the entrance of sensor and output signals of sensor, a sensitiveness is determined accordingly on static and dynamic to the errors:

The sensitiveness on a static error:

$$S_{abs\ y} = \frac{x_{n1} - x_{n1-1}}{r_0 \cos\alpha_0 - \kappa_{f-1}}; \qquad \text{.....(9)}$$

$$S_{abs\ z} = \frac{x_{n1} - x_{n1-1}}{r_0 \sin\alpha_0 - \kappa_{f-1}}$$

Sensitiveness on dynamic errors:

along the axis of *z*

$$S_{abd\ z} = \frac{x_{n2z} - x_{n2-1}}{n_z(r_1 \sin\alpha_1 - r_0 \sin\alpha_0) - \kappa_{\partial-1}}; \qquad \text{... (10)}$$

around the axis of *z*

$$S_{abd\ \varphi x} = \frac{x_{n2\varphi} - x_{n2-1}}{n_\varphi(\cos\varphi - \sin\varphi) - \kappa_{\partial-1}}, \qquad \text{.....(11)}$$

$$S_{abd\ \varphi y} = \frac{x_{n2\varphi} - x_{n2-1}}{n_\varphi(\sin\varphi + \cos\varphi) - \kappa_{\partial-1}},$$

where n_φ - number of rotations of hand of industrial robot round coordinate axis; κ_c - κ_{c-1} – change of initial coordinate of jigging of a manipulation object on a positioning manipulator; κ_d - κ_{d-1} – change of moving a manipulation object in the working zone of the manufacture module.

Quality of work of control system of FMS is determined by the generalized indexes of controlling computer: by mean time of decision of tasks (AV computer speed); by time of calculation and forming output data; by authenticity of the given out data; by time of work of out of data devices.

AV controlling computer speed is determined as (Mammadov *et al.,* 2007):

$$V_{UK} = \frac{1}{\sum_{k=1}^{n} P_k t_k} \qquad \text{.....(12)}$$

where P_k – frequency of appearance k^{th} -machine operation at the decision of task control of FMS, that depends on the number of executable operations its active elements; t_k - duration of κ^{th} - machine operation of control computer, depending on the type of operations of robot in every island of FMS.

The problem of option of device of technological information processing is characterized also mean time of decision of management task, authenticity of the given out data and probability of decision of tasks in the set time without refuses in-process control computer. Thus for option of models and number of control computers basic data are used $I_k \in \{I_{k1} \wedge I_{k2} \wedge I_{k3} \wedge I_{k4}\}$, where I_{k1} – descriptions of the decided tasks; I_{k2} – requirement to time of decision and reliability of work of control computer; I_{k3} – the series-produce models of computers that can be used; I_{k4} – technical and operating descriptions of computers.

In this methodology the option of control computer is envisaged on the basis of implementation of calculations on the next stages:

1) Preparation of basic data for the choice of number of control computers;
2) Preparation of basic data for the choice of communication system with an object;
3) Determination of necessary number of computer;
4) Option of communication system with an object;
5) Verification of requirements of reliability;
6) Verification of computer efficiency.

An offer block-scheme of stage-by-stage decision of problem of option of control computer for automation scheme of FMS is presented on a Figure 1.

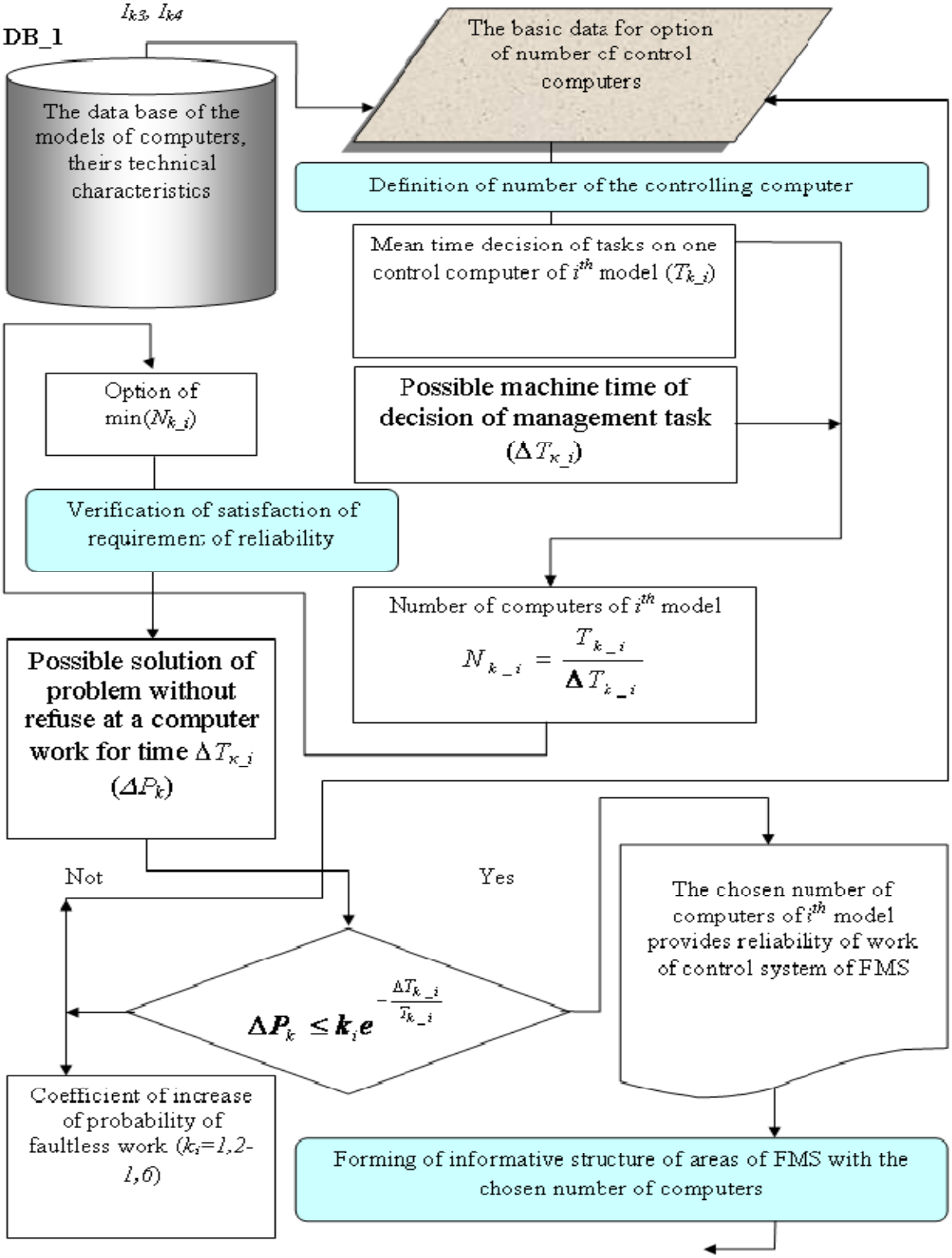

Figure 1. Block-scheme of stage-by-stage option of control computer of FMS

Conclusion

Accordingly the solved problems in the article the following results are got:

- The algorithm of sensors option for controlling influence on active elements of FMS depend on the initials parameters of the area of working, the initials geometrical sizes and the initials parameters of a manipulation object is proffered;
- It is solved the problem of controlling computer option of FMS and proffered block-scheme of stage-by-stage providing automation functions of the system.

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