Generation the efficient measuring instruments kit in the computer – aided preproduction planning’s system for multiproduct machine manufactory

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Abstract. Today it is necessary to change the existing nature of the organization of production in connection with the current trend of transition to the intellectualization of technological preparation of production. Therefore, the actual and fundamentally new today is the creation of a system that will allow you to plan the production process in an automated mode. It is possible to implement on the basis of the development of many variants of technological processes of mechanical processing of the manufactured products. To choose the optimal technological process from the developed, for the current production situation it is necessary to apply a set of control and measuring procedures proposed by the authors. From the subtasks of the complex of control and measuring procedures in One automated system of design of technological processes of machining is the formation of a rational set of measuring instruments, and the solution of this problem is a prospect for the introduction of digitalization of production.

Modern manufactory should be competitive on the world stage, so is important to follow the trends to reduce the time for the planning and design of production and ensure high quality of manufactured products. Following these trends and obtaining a high economic effect in the manufacturing plant promotes the use of multiproduct manufacture. Manufacturing system in machine – building plant should be flexible and has a possibility to create procedure specification based on present-day manufacturing equipment. Innovative solution for quality improvement is computer – aided planning system. Authors develop a modern computer – aided planning’s system for design procedures specification (CAPS – PS) (figure 1) and it allows planning procedures process automatically.

Specificity of this CAPS – PS is creation interposes communication between planning process of procedure’s specification and stage of product machining. Use of CAPS – PS is aimed at ensuring strict requirements for accuracy and quality of production in manufacturing systems for high – precision products. Consequently, computer – aided planning system for design procedure specification contributes technological advancement high-precision products and it is essential in progressive manufacturing industry. In this regard, the question of ensuring high quality measuring – and – control procedures in order to achieve the dimensional parameters necessary quality of the manufactured parts becomes relevant. For find the solution of quality question authors proposed a method for selection an efficient measuring instruments kit at computer – aided planning system for
design procedure specification that contribute to improving planning process of control quality manufacturing part’s dimensional parameters.

![Diagram](image)

**Figure 1.** Computer-aided planning system for design procedure specification.

Improving quality measuring – and – control procedures at pre – production engineering is critical technology the ones. This problem is consecrated in many scientific papers [1–4]. Conducted analysis at literature data about selection an efficient measuring instruments kit at manufacturing system in machine – building plant detected dependence it selection on the characteristic of the control objects and measuring – control instruments and also the requirements for the procedure specification. It is also showed that the function of measuring – and – control procedures consist in the exclusion defected products based on analysis manufacturing part acceptant sketch and procedures specification. During development subsystem organization measuring – and – control procedures for required quality manufacturing production proposed take into an account an effectiveness criterion, namely, degree of merit manufacturing products. The disadvantage of this approach is heavy expenses for using precision quality diagnostic equipment, and according to this employment of high skilled specialists.

Consequently, necessary using an efficient approach for optimal selection of diagnostic equipment in current work situation of manufacturing system in machine – building plant.

The purpose of the article is automatically selection the effective measuring – and – control instruments kit by computer – aided planning system for design procedure specification. To achieve this purpose, it is necessary to solve a few tasks:
- Database creation of measuring – and control instruments and target detail’s surfaces;
- Generation all variants of measuring – and – control instruments in current work situation of manufacturing system in machine-building plant;
- Measuring – and – control instruments kit selection automatically.
Development selection measuring – and – control instruments automation subsystem is part of computer – aided planning system for design procedure specification and it takes necessary information about models of procedures specification from prevision step of CAPS – PS [5].

Solving problem of selection efficient measuring – and – control instrument’s kit divide by three series of actions to be taken by a computer:
- Generation all variants of measuring – and – control instruments in kits;
- Sift ineffective variants of measuring – and– control instruments at kits;
- Choosing an efficient kit of measuring – and – control instruments for details quality testing in current work situation of manufacturing system in machine – building plant.

For generation all variants of measuring – and – control instruments in kits at planning manufactory system authors used the theory of sets. For basic data to generation is used:
1) Plurality of potential control surfaces combination from CPPS – PS database;
2) CPPS –  PS database plurality of potential measuring – and – control instruments that are in manufacturing system of machine – building plant.

Measuring – and – control instruments kits generated in manufacturing system of machine – building plant. Condition of likeness manufacturing part’s dimensional parameters \( \{S_t\} \) and diagnostic equipment’s \( \{v_t\} \) technical features \( \{w_i\} \) technical features \( \{v_i\} \) should be held:

\[
K = \{S_t\} \cap \{w_i\} \cap \{v_i\}
\]  

\(K_i(w_1, w_2, ... w_i), K_j(w_1, w_2, ... w_j), K_n(w_1, w_2, ... w_n)\) – kits with their own measuring-and-control instruments set; \(w_i, w_j, w_n\) – technical features of measuring-and-control instruments set, \(i=1...u, u\) – property of technical features kit \(K_i, j=1...q, q\) – property of technical features kit \(K_j, n=1...z, z\) – property of technical features kit \(K_n\).

**Figure 2.** Measuring – and – control instruments choosing characterization for control quality manufacturing part’s dimensional parameters.
Generation of measuring – and – control instruments at kit based on condition that each of instrument of population K has own characteristic \( w_i \), which is obey of measuring – and – control procedures or fail to meets the measuring – and – control procedures requirements \( w'_i \):

\[
K_{i,j,n} (w'_1, w'_2, ..., w'_{i,j,n}) = K - K_{i,j,n} (w'_1, w'_2, ..., w'_{i,j,n})
\]

(2)

On the second stage sift variants of measuring – and – control instruments at kits from \( K \). Sort out based on test on homogeneity. Test on homogeneity (3) use for choose typical size of measuring – and – control instruments which can used on more measuring – and – control procedures as possible [6]:

\[
\sum_{i,j,n=1}^{u,q,z} k_{i,j,n} (w'_1, w'_2, ..., w'_{i,j,n}) \neq 0,
\]

(3)

\[
\sum_{i,j,n=1}^{u,q,z} k_{i,j,n} (w'_1, w'_2, ..., w'_{i,j,n}) \rightarrow \min
\]

\[ \sum_{i,j,n=1}^{u,q,z} k_{i,j,n} (w'_1, w'_2, ..., w'_{i,j,n}) \neq 0 \] - the condition that one instrument should be in the kit and be used for measuring surfaces of manufacturing’s parts; \( k_i (w_1, w_2, ... w_i), k_j (w_1, w_2, ... w_j), k_n (w_1, w_2, ... w_n) \) – each of instruments from kits K (\( K_i, K_j, K_n \)) with its own set of measuring – and – control instruments; \( w_1, w_2, w_n \) – technical features of measuring – and – control instruments in the kit, \( i=1...u, u \) – property of technical features kit \( K_i \), \( k_1, k_2, ..., k_i \); \( j=1...q, q \) – property of technical features kit \( K_j \), \( k_1, k_2, ..., k_j \); \( n=1...z, z \) – property of technical features kit \( K_n \), \( k_1, k_2, ..., k_n \).

Then procedure of generation an efficient measuring – and – control instrument’s kit is realized for those which keep from the second stage. For it could use genetic algorithm [7, 8].

Each of formed kits \( K'' (K''_i, K''_j, ..., K''_n) \) has set of measuring – and – control instruments \( K''(k_1, ..., k_z) \) with technical features, and from it choosing that measuring – and – control instruments which has minimum time for measuring – and – control procedures:

\[
T_k = \sum t_k \rightarrow \min
\]

\[
P(K'') = \sum k_m \cdot w_k \rightarrow \max
\]

\[
\sum_{m=1}^{z} k_m \cdot t_k \leq T_k
\]

\[
k_m \in \{0,1\}, m=1,z
\]

(4)

\ [

P(K'') \] an efficient measuring – and – control instrument’s kit in current work situation of manufacturing system in machine – building plant; \( k_m \) – the instrument of kit which keeps from stage of sift variants of measuring – and – control instruments, \( m=1, 2, ... z \); \( z \) – property of measuring – and – control instruments at this stage; \( \{w_k\} \) – technical features of measuring – and – control instruments in the kit; \( t_k \) – control time of each measuring – and – control instruments.

The conclusion of this research pepper is procedure of generation measuring – and – control instrument’s kit formalized for control operations during design procedure specification at pre-production engineering. This fact promotes a quality of manufacturing’s parts and costs reduction of it.

Development potential of this scientist work is creation of universal method of generation efficient measuring – and – control instrument’s kit for manufacturing production and allows to solution
creative computing as selection an effective set of process equipment and tooling for pre – production engineering perspective lean production.

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