

Software solution designing of «The analysis system of workability of industrial product» during the production startup of aeronautical products

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Abstract

The approach to solve the problem of the automated analysis of aeronautical equipment products (AE) is considered in the present article. The analysis is made with due regard for technology recommendations of their designing and manufacturing as the case of the sheet semifinished parts realized in the discussed software solution.

Keywords: Design automation, Technology recommendation, Workability of industrial product.

Introduction

The use of the software complex in the automated design systems (CAD) is especially efficient at early stages of designing, when the information about the object of the designing has an undefined and ambiguous nature. The design imperfection and errors are hardly recoverable at the next stages and their recovery is usually connected with essential labour costs. The general structure of the developed software solution (SS) «The analysis system of workability of industrial product (WIP)» shown in Fig. 1 [1, 4].

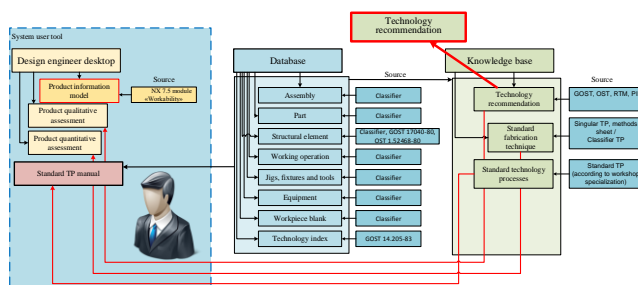


Fig.1. «WIP analysis systems» Structure

In the present article some fundamental stages of the formalization of the technology recommendation (TR) in the knowledge base (KB) of a personal computer (PC) are only

considered. The knowledge base is necessary data in the analysis of the product design of the aeronautical engineering during the product qualitative assessment implementation.

The solution

CAD systems as well as design systems of technological processes are an integral part of process engineering systems of up-to-date machine-building enterprises. However, nowadays the domestic development systems of technological processes available at the software market are problem-oriented editing programs making it possible to form technological documentation, as a rule. The level of design automation in such systems is very low. In practice, all decisions related to the design of the technological process structure are made by a technologist. One of the main reasons for the low level of automation of technology solution acceptance is an extremely low level of process engineering formalization.

One of the principle tasks during the designing of product manufacturing route is the one of the choice of the necessary amount of working operations (WO) depending on the structure of the manufactured product. As a rule, in the choice process the technologist has to study group, standard and singular operating procedures as well as to know legal requirements for the given type of the processed parts. This condition allows to formally introduce the task of the TR choice as the one of searching for the data collection relating to the analyzed product. At the initial stages of the problem solving one can abstract away from the TR choice patterns, accepted in mechanical engineering. The patterns can be introduced as constraints at the subsequent stages [1].

In the design process some functional solutions can be found. They are submitted and documented as a certain structure. The structure can be materialized with the help of specified regulations. The regulations serving for product manufacturing are made in the way that all functional requirements to the manufactured product should be implemented. In this sense the design process presupposes not

only getting all necessary product drawings but also the development of its manufacturing technology processes (TP). The aim of designing is the development and forming of the product functions by means of geometrical, technological and organizational information processing; the preproduction ensures the technological realization of converting the primary part into the product.

For the reason that a number of tasks providing workability of industrial product (WIP) (qualitative assessment, in particular) is difficult to formalize, it is reasonable to have a good look at the possibility of application constructing computer-aided subsystem of providing WIP examiner elements.

In this article the possibility of formalization of the standard technology recommendations of a manufacturer. The structural chart of any TR is given in Figure 2.

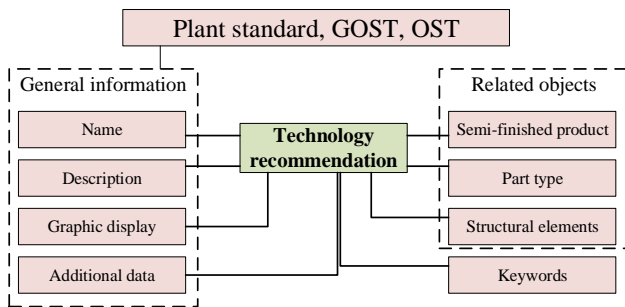


Fig.2. Standard technology recommendation structure

To formalize TR in the knowledge base of the system it is necessary to generate a demand to the knowledge base to create a set. As a result the system forms a subset to save technology recommendation:

$$TR = \{TR_1, \dots, TR_n\}, TR_i \in T (i = 1, \dots, n),$$

$$\forall TR_i (F_j (TR_i) \equiv F_j) \wedge (F_{j+1} (TR_i) \equiv F_{j+1}) \wedge (D^t (TR_i) \equiv D^t),$$

$$(j = 1, \dots, m)$$

Where TR_1, \dots, TR_n are elements of the chosen set, being a subset of T set of every TR in the system knowledge base; n is a number of elements of TR set, satisfying the input data.

As soon as the cycle of TR set forming is finished, for every TR the technology index values are defined. When the designer carries out product fabricability qualitative assessment, the makeup of total (integral) weight of every TR takes place in the results of the expert rating of TR according to inequivalent fabricability assessment tools:

$$\forall TR_i R(TR) = \sum_{j=1}^h r_{ij} \cdot b_j, (i = 1, \dots, n; j = 1, \dots, h),$$

Where b_j is the weight, defining the importance of the j -th assessment criterion ($0 < b_j < 1; j = 1, \dots, h$); r_{ij} is the weight of the i -th TR according to the j -th assessment criterion.

Exploiting the mechanism of the fabricability qualitative assessment the formula, analogous to the previous one, is used, in which r_{ij} has a little bit different sense:

$$r_{ij} = \begin{cases} \frac{k_j}{k_j^{633}}, & \text{if } k_j \text{ has dimensionality} \\ k_j, & \text{if } k_j \text{ is dimensionless} \end{cases}$$

Where k_j is the value of the j -th processability index of the structural element (SE); k_j^{633} is the basic value of the j -th processability index of the whole product.

The values of k_j can be calculated at this stage of the design in less detail, using the mathematical patterns, built on the ground of the evaluator awareness in the subject field.

Having performed accounting of the values of every TR from the T set, the ordering of this set according to decreasing of the concept of «the most manufacturable TR» (T_T) takes place.

For the case of the qualitative assessment there is [3]:

$$\exists TR_i \in TR: R(TR_i) = \max_{i=1} R(TR_i) \rightarrow TR_i = T_T,$$

i.e. The TR with the maximal value of the integral weight is the most manufacturable one.

For the case of the quantitative assessment there is:

$$\exists TR_i \in TR: R(TR_i) = \min_{i=1} R(TR_i) \rightarrow TR_i = T_T.$$

The rest set members are put in order by the data:

$$\forall TR_{T_i}: R(TR_{T_i}) > R(TR_{T_{i+1}}), (i = 1, \dots, n).$$

For the ease of the assessment of the obtained results the TR weight can be proportionally worked out to the weight of the most manufacturable one. Therefore, the weight of the most manufacturable TR is 1, the weight of the rest solutions in the bracket of (0;1) is for the case of the qualitative assessment and (1; ∞) is for the quantitative assessment.

1. Thus, the TR in the knowledge base can be introduced by the following tuple:

$$T = \{T_i, \dots, T_n\}.$$

Meanwhile,

$$\forall T_i \in T_k,$$

Where T_k is the subject field of the TR.

$$T_i = \{ID^T, F^{K3}(T_i), SE(T_i), C(T_i), R(T_i)\},$$

Where ID^T is a storage identification number in the knowledge base of the TR.

The structural elements (SE):

$$SE = \{ID^{SE}, D, O\},$$

Where ID^{SE} is a storage identification number in the knowledge base of the SE;

O is a working operation of SE manufacturing:

$$O = \{ID^O, D^t, O\},$$

Where ID^O is a storage identification number in the knowledge base of the working operation of SE manufacturing.

The rules of technology recommendation choosing are as follows:

$$C = \{C_1, \dots, C_n\} \neq \emptyset,$$

In this connection,

$$\forall C_i \in C: C_i = \{if, then, otherwise\}.$$

Hence, evaluating the product by its quality the initial data are a product information model [2], to which the standard technology recommendations are directly related:

$$S = \bigcup_{i=1}^m T_i,$$

where T_i is a standard technology recommendation.

Such an approach is favourable to solve the problems of the detection of the non-technology combination of the structural members of the structural system, as, in this case, the designer

gains an access to the analyzed product selecting an appropriate tree node.

The output data array is the tuple of the following type:

$$M_1 = \{F^{SE}(T_T), D(T_T), D^t(T_T)\}.$$

After having ordered the selected set, the information about the set members and the results of their estimation are typed in the designer's dialog box. The designer selects a certain solution, after which the data transmission into the product development environment and TP happens. Some possible changing of the members according to the TR in the product solid design is realized (the «product image» is freshened).

In the module of the «formulae analyzer and rules of TR selecting» some rules of selecting as well as the ones of ranking TRs according to the rank of relevance are introduced [2]. While ranking every object alternative associates with a natural number. As this takes place, the most preferable alternative gets rank 1, however, the least preferable one gets rank N, i.e. the alternative recommendations should be ordered by rank increase. The solution of such a problem can be implemented in the terms of the fuzzy-set theory.

Forming the input data to evaluate the product processibility has been carried out on the ground of the lists of the formalized assessment manufacturability criteria of sheet, profile and monolithic items obtained from operating departments.

In the software realization the discussed approach is implemented in PC as «The analysis system of workability of industrial product (WIP)», the interface overview is shown in Figure 3.

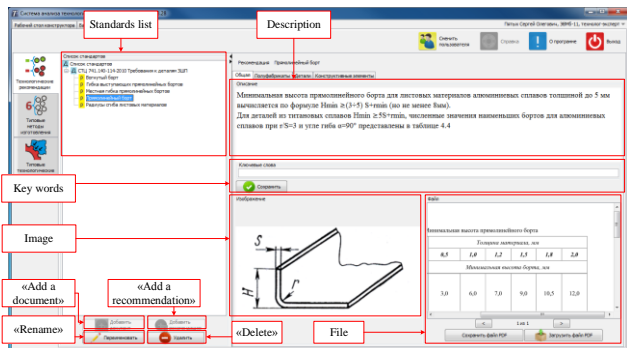


Fig.3. The interface of «technology recommendations» module

For the user, in this case, for the designer planning a product or technologist accomplishing technological control, the following information is given available [3]:

- 1) General information:
 - Name-the element necessary for the identification in the data base;
 - Description-the textual description of the TR (2-3 sentences);
 - Graphic image-for the better perception by the user;
 - Supplementary data-the *.pdf file containing some additional information, as tabular data, for example.
- 2) Dependent objects are marked by the user with the help of check marks:

- semifinished product-the list of the semifinished products available at the plant;
 - part type-manufactured parts range, presented in the form of a structured classifier;
 - Structural element-the list of all SEs being part of the structure of standard parts, with the menu describing the current SE;
- 3) Key words-the present element is essential for the search for a formalized TR carrying out a complex analysis of the product processibility, in particular, realizing technology control of composition and correctness of product electronic model construction.

Conclusion

Thus, the developed module, «Technology recommendations», lets the expert technologist formalize technological guides (TG), OST, GOST and some other regulations in the data base, available at the plant, used during product technological control at the stage of process engineering. The technologist gets the tool, in which he can conversationally select the application area of TR (semifinished material types, part types, SE types). The developed and structured data base in PC makes it possible to realize technological check of the product design in a semiautomated mode. The use of PC in designing products at early stages lets the designer check geometrical parameters of the product taking into consideration available plant manufacturing capability.

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