Automation of composite materials products process preparation

D V Lobanov1*, M V Kuptsov1 and V Yu Skeeba2

1Chuvash State University named after I.N. Ulyanova, 15 Prospect Moskovsky, Cheboksary, 428015, Russian Federation
2Novosibirsk State Technical University, 20, Prospekt K. Marksa, Novosibirsk, 630073, Russian Federation

*shut_tm@bk.ru

Abstract. The article describes the prospects of using composite materials in industry, issues of process preparation of such materials. The ways to solve the issue of automation of process preparation of products made of modern composites are represented. Prospects for effective use of composites as structural materials are seen in increasing the degree of automation of process preparation at the stage of making reasonable technical and economic decisions on the choice of composite for mechanical engineering products instead of common materials. Besides, there is an urgent need to process a large amount of information on such materials, which is a deterrent for representatives of production department. The way out of the issue is seen in the creation of software products that will reduce the time for process preparation and will enable automated and reasonable choice of composite materials taking into account available production data and varying comparability conditions. This will not only increase the performance of the procedure of organizational and technological process preparation of products made of composite materials, but also increase the demand for products made of such materials, and will also allow up-to-date information on available products, materials and tools, their physical, mechanical and operational properties. The method of creating software products for composing and editing a database of composite materials and a software for reasonable selection of composite in the conditions of a given priority of material characteristics taken from the created database is presented. The description of the main features of the created software is represented. The modules will reduce time costs and increase the efficiency of the process preparation due to the automation, as well as allow reasonable and quick decision on the choice of rational material.

1. Introduction
The development of science and technology is not conceivable without the use of new materials, as traditional structural materials do not meet the increasing requirements for their operational properties. Composites replace traditional wide application in various fields of industry (electrical, shipbuilding, aircraft and aerospace, medicine, automotive, car building, etc.) due to high specific physical and mechanical properties. [1-7]

The range of composite materials increases every year. New species, types and brands are being invented and old ones are being improved. Information about their physical and mechanical properties is often scattered and disclosed in various sources. Selection of structural material with required properties using reference literature process is long enough and time-consuming, which reduces the
efficiency of material selection with optimal characteristics. This process is even more complicated when finding a solution for multiple parameters at the same time and their varying significance. As a result, the design engineer needs to process a large amount of information, which leads to a decrease in productivity of his work. This issue may be solved by systematization of data on physical, mechanical and operational characteristics of composites and automation of the choice of the optimal alternative with a given priority material parameters.

2. Experimental research methodology

Let us consider ways to solve this issue by:

1. Creation of software to systematize data on composite materials.
2. Creation of software for rational selection of composite materials

The database will be created on the basis of the previously accumulated knowledge base, which will contain information on physical, mechanical and operational characteristics of composite materials (strength, thermal conductivity, water absorption, maximum operating temperature, tensile strength, cost, manufacturer, etc.), from reference materials and manufacturer's catalogues. [1-7]

The structure of such a database, taking into account the data available to the user, consists of the following hierarchical chain:

- Type of composite material —> Designation of material —> Brand —> Manufacturer, cost, physical and mechanical properties.

A single classification for all types of composite materials could not be found in the literature [1-16], but in order to systematize and create a database it is necessary to group them by one of the influencing parameters. An important and significant criterion in choosing a composite as a structural composite is the type of composite material which determines most of the basic properties of the composite [8-11].

3. Results and discussion

There are a number of software products for creating and managing databases: Access, MySQL, Oracle, MongoDB. MySQL is the most suitable DBMS for performing the tasks, as the functionality allows you to work with the created database without any issues and additional knowledge, and also the ability to integrate into other software products and remote administration [8-11].

The module for working with the composite materials database is made in the Visual Studio 2019 programming environment and is shown in Figure 1. All rows of the module are directly linked and access the database.

Figure 1. “Database population module”.
In this module, the user fills in the data on composites, which he can edit, modify or delete as necessary. The influencing parameters are physical-mechanical and operational characteristics, namely: strength, thermal conductivity, water absorption, maximum operating temperature, tensile strength, compression and bending strength, cost, manufacturer, as these parameters are often used as key to production processes [8-16]. To start working in this module, enter information in the text window “View”, then the “Designation” window becomes active, where the data is entered, then the marking field and all other windows are filled. All the information that we enter is stored in the database and depends on the information entered in the View window, as it is the beginning of accessing a particular row in the future. The "Search" menu displays the following result, as shown in Figure 2:

Figure 2. "Search" Menu Dialog Box".

To get information on the selected composite material brand, the database implements the function of displaying the report as a Microsoft Word document, which is generated by clicking the “Report button”. (Figure 3)

![Composite Material Table]

| Type                | Polymer composite |
|---------------------|-------------------|
| Designation         | Testite           |
| Marking             | PTK-C             |
| Manufacturer        | RITprom           |
| Cost, rub / m²     | 500               |

**Physico-mechanical properties of the composite material**

- Density, kg / m³: 1
- Tensile strength at:
  - stretching, MPa: 147
  - compression, MPa: 149
- Bending, MPa: 149
- Operating temperature limit:
  - minimal, degrees. C: -40
  - maximum, degrees. C: 140
- Elastic modulus, GPa: 15000
- Thermal conductivity, kcal / m·mm²·C: 0.450
- Hardness, MPa: 275
- Water absorption in 24 hours, %: 1

Figure 3. “Material Report Form”.
The second stage of work is the creation of software for rational selection of composite materials, which is carried out on the basis of the methodology developed by us, which is based on the principle of identifying the indicators most relevant for specific production conditions. The algorithm of rational material selection is previously described in [8-11].

The algorithm of the program is implemented in the second program module (Figure 4). The program interface is a window with a block to select the properties of materials that are significant to justify the selection under certain conditions. In the menu, one can set or remove labels against a significant parameter to make a decision on the choice of material under varying conditions of comparability. If no clarifying limit parameters have been specified, clicking the “Calculate” button will make a selection based on the available data. The result will appear in the form of rational material and two alternatives to choose from.

![Figure 4. "Select Composite Material" Dialog Box.](image)

To clarify the data and solve the issue with restrictions, in the “Selection of rational material” window, click the “Restrictions” button which opens the dialog box (Figure 5) to fill in the maximum and minimum limits of parameters necessary for further work. After filling and pushing the “Save” button, the system is returned to the “Choice of rational material” dialog box.

![Figure 5. “Dialog Box for Limit Values”.](image)
Next, click the “Calculate” button. At the end of the calculation, the “Optimal option” window will display the material selected for all constraints, and in the “Alternative option” windows a few more options most suitable for conditions.

4. Conclusion
As a result, software products for the implementation of systematization of information about composite materials and their rational choice were created. The first module responsible for data structuring has the capability to work with the database, fill it, delete and modify data, as well as display the necessary information from it as reports. The second module, due to the method of rational choice of material, allows to evaluate and select the material depending on the specified parameters and varying conditions. These modules will reduce time costs and increase the efficiency of the process preparation due to the automation, as well as allow reasonable and quick decision on the choice of rational material.

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