Organizational approaches to composite repair of products with deterioration

Alla Brom 1, Ivan Sidelnikov 2
1,2 Bauman Moscow State Technical University, Moscow, Russia Federation
E-mail: 1allabrom@bmstu.ru, 2sid@bmstu.ru

Abstract. In the article, the authors examined in detail how the return flow of products from consumers (operators) is formed. The authors emphasize which parameters need to be analyzed, in particular, pay attention to the analysis of the correlation between operating time and operating conditions. The article provides an algorithm for performing composite repairs.

1. Introduction
Composite materials are increasingly being used in the manufacture of aerospace equipment, automotive technology and land transport, marine equipment and many other industries. One of the key features of using composite materials is that damage made from these components is not always visible to the naked eye and non-destructive testing methods must be used to assess the degree of damage. Thus, composite repair can reduce the need for expensive composite materials by restoring the technical resource of products with a large operating time or defects formed during operation.

For rational planning of material and technical supply, it is necessary to take into account the volume of the return flow of elements made of composite materials, as well as the time periods when the delivery of elements with a restored resource will be carried out.

2. Research Method
To solve this problem, it is necessary to analyze the value of the parameters of the return flow from the sites of the operation of the equipment, using the module "processing and analysis of the parameters of the return flow". Figure 1 shows the return flow with characteristics describing the state of the technical resource of the return flow.

Figure 1. Formation of the block for analyzing the parameters of the return flow

The organizational chart reflects the return flow of composite elements that have exhausted their technical resource. Parameter $t_{\text{actual operating time}}$ - the actual operating time of elements is the most significant for determining the actual state of the technical resource of the product. Depending on the actual operating time in the module in which the parameters of the return flow elements are evaluated, the failure rate $\lambda(t)$ at a given time is determined, and the presence of a multidimensional correlation dependence $\eta$ is established for each element. Thus, the collection, processing and analysis of information necessary for planning production processes for restoring the technical resource of products from composite materials is carried out [1].
The next step is to study the relationship between two organizational processes: the module "planning production processes for the restoration of technical resources" and the module "processing and analysis of parameters of the return flow".

![Figure 2. Organizational link between recovery processes and parameter analysis](image)

After processing the information flow and calculating the parameters of the return flow elements, the data on the failure rate is transmitted for planning production processes. Based on these data, the time of restoration of the technical resource $t_{\text{restoration of repair}}$ is determined, as well as the fraction of elements to be restored $\mu$. All this is necessary to adjust the planned volume of purchases of expensive composite materials in the system of material and technical supply.

However, before determining the recovery time of a technical resource, it is necessary to investigate the composite repair scheme and its specifics [2].

The first step is to carry out damage assessments. The key problem is that small damage can in fact amount to significant damage. Mechanical damage to the fiber of a composite material can manifest itself as a dent in the reinforced composite surface, but the underlying damage can be more significant. Thus, a key question arises about making a decision either to repair an element (restore a technical resource) or to dispose of it [3]. Primarily, the decision depends on the amount of necessary repairs required to restore the original structure of the composite, and, as a consequence, on the costs required for its implementation.

### 3. Results

When assessing the damage, the type of repair required is also determined - either easy repairs or complex ones. Easy repairs do not affect the structural integrity of the component. In complex repairs, in the case of significant damage, it is often necessary to replace the structural characteristics of the component. In composite repairs of any complexity, one of the key criteria is to study the operating conditions of the repaired composite, and the selected repair scheme meets the design requirements for the structure. Another important problem when carrying out composite repairs is the need to use special equipment, which should be reflected in the determination of the corresponding costs.

After carrying out a composite repair, it is imperative to check the quality using non-destructive tests. Of greatest interest is the study of the boundary between the repaired area and the original part of the part. At the moment, the most popular are ultrasonic and X-ray control methods [4, 5].

Thus, the composite repair can be represented as a flowchart (Figure 4).

![Figure 3. Organizational chart of planning production processes for resource recovery](image)
From the module "planning production processes for the restoration of a technical resource" for planning material and technical supply, data \( \nu \) is used - the volume of elements with a restored resource, it is for this volume that the volume of purchases of expensive composite elements for material and technical supply is adjusted at time \( t_{post} \). For each supply planning period, there will be their own volumes of elements with a restored technical resource \([7, 8]\). Thus, the total need for material and technical supply will be calculated according to the ratio:

\[
n(t_{post}) = N - \nu
\]

A diagram of the relationship of modules and information flows between them can be presented in the following summary form in Figure 5 \([9, 10]\).

4. Conclusion

Thus, using the proposed organizational solutions for processing the return flows of composite elements and carrying out composite repairs, it is possible to provide more rational planning of production processes, improve the supply activities of the enterprise and reduce the corresponding costs to ensure the operation of technical products.
Figure 5. Organizational diagram of the organization of material and technical supply, taking into account the restoration of technical resources

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