Static and frequency analysis of the inner frame of the rotary platform of the fuel tank test bench

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Abstract. In the course of the work the search for design solution of optimal variant of internal frame of the rotary platform of the stand intended for testing the aircraft tank in accordance with paragraph 965 (d) of Aviation Regulations AP-29A was carried out, frequency and static analysis was carried out using the method of finite element modeling, the results of calculations are given.

1. Introduction
The creation of a modern helicopter is a complex technical task that requires modern approaches to the processes of development, testing, certification and further operation.

These requirements are fully relayed to the on-board system complex and the accident-proof fuel system (APFS), in particular.

The key task of an accident-resistant fuel system is to ensure safe operation of the helicopter over the entire operational range, including taking into account emergency situations.

One of the main elements of an accident-resistant fuel system is a soft fuel tank (SFT).

The SFT designed for an accident-resistant fuel system must meet a large number of design requirements to ensure, in conjunction with other APFS units, that no fuel is spilled, even if the helicopter falls.

For example, according to the requirements of AP-29, section 29.952, the fuel tanks of modern helicopters should be designed to prevent fuel leakage when falling from a height of 15.24 meters without initial acceleration on a rigid non-deformable surface, the tanks should be filled with 80% water, the deviation at the time of impact from the horizontal surface should not exceed ±10°. At the same time, at the moment of testing, the tanks should be in a container that repeats the design of the rotary-wing machine [1-3].

Another requirement is that in order to pass type certification, it is necessary to fulfill some of the requirements, which include testing of fuel tanks.

Each fully assembled tank, together with its mounting units, must be subjected to vibration tests in a configuration that simulates the actual installation on a rotary-wing machine [4,5].

The main task in the design is to provide the required indicators of quality and reliability in conditions close to operating conditions. Some such indicators can be obtained during the operation of the product. However, in this way it is not always possible to measure all the parameters of the object required to assess their quality. The most complete information can be obtained by conducting tests at all stages of the life cycle - during design, production and operation.
In other words, the object can be placed in real operating conditions, which most often increases the cost of the research process, or simulate operating conditions and place a sample of the product in them. Typically, the latter method is used because it allows you to get the maximum number of indicators of interest, and is most often less expensive.

At the same time, it is necessary to understand that taking into account the modern level of development of computer technologies, the most effective is the combination of methods of mathematical modeling and field tests.

Work to create a complex of mathematical modeling tools in conjunction with a test facility for crash-resistant fuel system of helicopter is carried out with the financial support of the Ministry of Science and Higher Education of the Russian Federation as part of the implementation of the RF Government Decree of 09.04.2010 No. 218 (as amended on 21.07.2016), agreement No. 075-11-2019-043 of November 30, 2019.

This development will be used, among other things, to confirm such point of the rules 965 (d) AP-29 mathematical model in conjunction with the test facility. It allows to simulate the behavior of the fuel tank during the flight (pitch, roll, impact of vibration from the rotors of engines and propeller) [6-8].

When creating this complex, you need to solve a large number of complex technical problems.

In the modern world it is impossible to imagine design without using computer models, which greatly simplifies and cheapens the process of creating a real design that meets the requirements. One of the most common methods is finite element modeling [9]. It allows to optimize the process of obtaining the necessary data; by changing the parameters of the product, select the most optimal ones.

The article presents the results of static and frequency analysis of the internal frame of the rotary platform on which the test object is installed [10].

2. Research subject description

The test facility for fuel tank testing consists of a swivel platform with an inner frame on which the test object is mounted. The platform is fixed on a fixed base through an axis of rotation. The general view of the unit is shown in the figure 1.

![Figure 1. General view of the stand.](image)

The rotating platform has been designed so that the test object can be mounted on it both along the rotation axis and across, thus simulating pitch and roll during the flight.

The object of investigation is an internal frame designed to simulate vibration from the rotors of motors and the main screw. The main requirements to the design are the possibility to install a tank with
overall dimensions not exceeding 6 meters in length, 2.8 meters in width and weighing up to 4000 kg. The eigenfrequency value of the internal frame should be greater than the frequency of the external excitation force [11, 12].

A vibration load with a frequency of 20 to 33.3 Hz is applied to the frame. The inner frame is a truss construction consisting of steel profiles of I-beam and square cross sections on which the test object is installed.

Fermented design allows obtaining minimum deflections as a result of external load, and also has sufficient rigidity for installation of the test object weighing up to 4 tons.

Figure 2 shows the model of the inner frame. Orange color shows the profiles of the I-beam section, gray profiles of the square section.

![Figure 2. Internal frame model.](image)

3. Finite element model
The method of finite element modeling was used for static calculation and eigenfrequency analysis. This method makes it possible to determine the strength characteristics of interest with sufficient accuracy, as well as to optimize the process of selecting a profile that would meet the strength criteria.

Figure 3 shows the calculation scheme. In points “T” is implemented swivel fixation. The arrows show the load from the test object.

![Figure 3. Platform Calculation Scheme.](image)

The calculation model consists of beam elements. Section type and dimensions are specified in element properties.

4. Results
Figure 4 shows the movements from the applied load, figure 5 shows the maximum normal stresses.
As a result of static analysis, the maximum deflection was 0.15 mm, the maximum normal voltage was 2.5 kgf/mm². The obtained values meet the strength criteria [13].

The obtained results allowed to choose the optimal profiles and sections used in frame creation.

Since the platform is subjected to vibration loading, the analysis of platform eigenfrequencies was also carried out. As a result, the first eigenfrequency in the load direction was determined, which was 123 Hz. The form of vibrations corresponding to this frequency is shown in the figure 6.

5. Conclusion
With the help of numerical methods for solving strength problems, namely, the method of finite element modeling, the frame of the rotary platform of the test bench was calculated. As a result of the performed analysis, the optimal frame design was chosen, which meets the requirements of specifications, strength criteria, and minimum eigenfrequency values. The data obtained are used for further design.

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