УДК 629.7
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ЦИФРОВЫЕ ДВОЙНИКИ В ВЕРТОЛЕТНОЙ ОТРАСЛИ: ВИРТУАЛЬНЫЕ ТЕХНОЛОГИИ ДЛЯ ОПТИМИЗАЦИИ ЭКСПЛУАТАЦИИ И ОБСЛУЖИВАНИЯ

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DIGITAL TWINS IN THE HELICOPTER INDUSTRY: VIRTUAL TECHNOLOGIES TO OPTIMIZE OPERATIONS AND MAINTENANCE

1. Introduction:

In recent years, digital technologies have transformed the way aircraft are designed, manufactured and operated. One of the most promising trends in this area is the use of digital twins - virtual models that reflect physical objects and processes in real time. The helicopter industry, as one of the key components of aviation, faces a number of challenges related to the increasing demands for safety, efficiency and cost-effectiveness of helicopter operations.

The relevance of the problem of helicopter operation and maintenance optimisation is due to the need to reduce maintenance costs, improve reliability and flight safety, and increase equipment availability. Current methods, such as scheduled maintenance and periodic inspections, often do not take into account the actual condition of the helicopter, which can lead to unjustified costs and risks. This paper examines the introduction of digital twins to the helicopter industry as a new solution that can significantly improve operations and maintenance processes. Digital twins make it possible not only to simulate the behaviour of a helicopter under different conditions, but also to predict its technical condition based on the analysis of data collected during operation. This opens up new horizons for improving the efficiency and safety of helicopters and optimising maintenance processes.

2. Theoretical Foundations of Digital Twins:

A digital twin is a virtual model of a physical object, system or process used for analysis, monitoring and control. It includes not only geometric shape and physical

characteristics, but also data about the object's operation, behaviour and state. The main characteristics of digital twins are

The digital twin should accurately represent the physical object, including its behaviour and interaction with the environment. Also, digital twins are continuously updated using real-time data to track changes in the state of the system. Digital twins are used to analyse and predict various operational scenarios, helping to make informed decisions. They can be integrated with automation and control systems, enabling better collaboration and process optimisation. The concept of a digital twin was first introduced in 2002 when Mr Michael Griffin, working for NASA, described the need for virtual models to analyse space missions. However, digital twins have only become widespread in the last few decades due to advances in information technology and computing power. Today, digital twins are used in a wide range of industries. In manufacturing, they are used to optimise processes and improve the efficiency of production lines. In the energy industry, similar models help with grid management and load forecasting. In healthcare, digital twins of patients can be used to individualise treatment and improve outcomes. In construction, they help design and manage buildings at all stages of their lifecycle.

Creating and supporting digital twins is not possible without modern technologies. One of the key technologies is the Internet of Things (IoT), which makes it possible to collect data from sensors installed on physical objects and transmit it in real time to update the digital model. Big data plays an important role in processing and analysing large amounts of data from IoT devices. Data processing systems help to identify patterns, make predictions and make decisions based on the information collected. We should also not forget about artificial intelligence (AI), which can be used for analysis and optimisation of digital twins. AI is able to analyse data, identify anomalies and suggest solutions to improve the performance of the physical object [1].

3. Using Digital Twins in the Helicopter Industry:

Digital twins have become an integral part of modern technology in various industries, and the helicopter industry is no exception. The introduction of digital twins has significantly changed the approach to the design, manufacture, operation and maintenance of helicopters.

Digital twins allow helicopter engineers and designers to create a virtual model that accurately reproduces the physical characteristics and behaviour of a helicopter. This enables a large number of simulations and tests to be carried out during the design phase, reducing development time and costs. This technology can be used to account for different operating conditions, including changes in aerodynamics, structural loads and temperature conditions. For example, when designing a new helicopter model, specialists can virtually test different blade configurations and evaluate their impact on manoeuvrability and fuel consumption. This allows the most efficient design to be selected before production begins.

4. Examples of successful applications in manufacturing:

The Bell 525 Relentless vertical machine uses digital twins at all stages of production. This helps to increase assembly accuracy, reduce scrap and improve product quality. During production, the machine is analysed in real time, allowing potential errors to be eliminated at the assembly stage. The Airbus Helicopters factory also actively uses digital twins. They are used to simulate production processes, helping to improve logistics, reduce assembly cycle times and optimise the use of resources. These approaches have led to significant increases in productivity and helicopter quality.

5. Operation and maintenance:

Digital twins play an important role in predicting the health of helicopters during operation. Sensors installed on helicopters collect data on loads, vibrations and other operating parameters. This data is transmitted to the digital twin, where analytical calculations are performed to assess the current condition and predict when potential problems may occur. This approach helps prevent unexpected failures and improves flight safety. For example, Boeing's AH-64 Apache helicopters use digital twins to monitor the condition of their components and assemblies, allowing them to identify maintenance needs in advance.

The use of digital twins significantly optimises helicopter maintenance and repair processes. Based on data collected in real time, it is possible to develop individual maintenance programmes for each specific helicopter, taking into account its operating conditions and modes. One helicopter maintenance company uses a digital twin model to predict when components need to be replaced. This helps to avoid overspending on unnecessary maintenance and accumulates data for further analysis to improve the repair process [2].

6. Conclusion:

In this article we have reviewed the application of digital twins in the helicopter industry, highlighting key aspects related to design, production, operation and maintenance. As a result of the analysis, it is evident that the use of digital twins has a positive impact on all phases of the helicopter life cycle, contributing to improved efficiency, quality and safety.

The main conclusions of the article emphasise that digital twins enable:

1.Optimise design processes by allowing new helicopter models to be tested and simulated before they are physically produced;

2. Improve the quality of manufacturing processes and reduce production lead times;

3. Improve helicopter reliability through predictive and tailored maintenance.

The importance of digital twins for the future of the helicopter industry cannot be overstated. They are becoming the basis for creating smart, safe and cost-effective helicopters that can meet the challenges of today's world. With increasing safety and environmental requirements, the use of digital twins can provide a significant competitive advantage.

For further research and implementation of digital twin technologies in the helicopter industry, I will definitely look into deepen research into basic algorithms and machine learning technologies to more accurately analyse data collected from sensors. Also, I'm going to develop and validate standards and methodologies to support the integration of digital twins into existing manufacturing and operational processes. Moreover, I will explore opportunities for collaboration between world famous business, academia and government to create more detailed study.

Digital twins are thus opening up new horizons for the helicopter industry, and their further development will be a key factor in improving the competitiveness and sustainability of the sector as a whole.

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