УДК 930.85

ESTIMATION OF THE POSSIBILITY OF USING REVERSE ENGINEERING TECHNOLOGY FOR PIPELINES INSTALLED ON AIRCRAFT

Аглиуллина Э.А., студент гр. 1346, III курс
Научный руководитель: Аристова Н.С., доцент
Казанский национальный исследовательский технический университет имени А.Н. Туполева
г. Казань

В данной исследовательской работе рассматривается возможность использования технологии обратного проектирования трубопроводов, установленных на самолетах, для оптимизации технического обслуживания. Рассматриваются отдельные компоненты трубопроводных конструкций с целью анализа полученных результатов.

In accordance with present-day requirements set out for aircraft manufacturing industry, Kazan aircraft factory (KAZ) named after S.P. Gorbunov – Tupolev PJSC affiliate (part of UAC PJSC under the control of Rostec State Corporation) is resuming production of medium-range narrow-body Tu-214 aircraft. The development of this passenger aircraft was carried out back in the Soviet Union and not all drawings have survived to this day. However, the entire geometry of the aircraft parts, including parts of the pipelines, was preserved in the standards.

Standards are parts that are made strictly in full accordance with the plaza drawing and working drawings, and it is with the standards that finished products are compared in order to check the shape and dimensions of the part that will be installed on the aircraft. In this regard, the use of reverse engineering methods, namely scanning standards and converting them into 3D models and subsequently into drawings, would help solve several problems associated with the design of pipelines installed on an aircraft from scratch.

Reverse engineering is the process of developing any product in reverse order [1]. In other words, this is a set of technologies, hardware, software and techniques that provide the ability to obtain a 3D model as a result of 3D scanning of a real object with characteristics. It is also worth noting that reverse engineering comes down to a large extent to the process of obtaining a 3D model of a physical product; the physical object is transferred to a digital one [2]. Coordinate measuring machines (CMMs), laser scanners, computed tomography and structured white or blue light devices are used for this purpose.

It is no secret that the aviation industry requires high precision, safety and reliability of aircraft components, including piping. Reverse engineering technology is a promising approach to improve part reproducibility [3, 4]. This is especially important in the reality of serial production of one aircraft model, for example, the Tu-214.

There are 4 main types of pipelines installed on Tu-214 aircraft [5, 6, 7]:

1. Fuel pipelines designed to transfer aviation fuel from tanks to aircraft engines

2. Hydraulic lines used to convey hydraulic fluid that controls various aircraft systems.

3. Pneumatic pipelines used to transmit compressed air or gases.

4. Lubrication system piping used to transfer oil or lubricating fluid through various systems.

All types of pipes used on an airplane are united by the fact that they are all assembled and tested according to standards, which in turn can also be divided into groups. During the study of the topic, *Table 1* was compiled, which clearly shows how the standards of pipelines differ from each other and the optimal approaches to measurement were selected using the analysis method.

Tab. 1. Classification of pipe standards

Type	**1D**	**2D**	**3D**
Characteristic	Straight standard with constant/variable circular cross-section	Standard with bends or branch branches in the same plane with a constant/variable circular/non-circular cross-section	A pipe with bends or branches in more than one plane with a constant/variable circular/non-circular cross-section
Approaches to measuring standards	Contact measurement method	Contact/laser measurement method	Laser measurement method
The feasibility of using reverse engineering methods	It is only advisable in the case of a variable cross-section, since a pipeline with a constant cross-section is a primitive geometry	It is advisable in any case, since without using this method it was difficult to accurately determine the bending radius	Worthwhile in any case

The table clearly showcases that reverse engineering is advisable for almost any type of pipeline standards.

In the course of my research, I came to the conclusion that reverse engineering of piping from reference standards is an important method used in the manufacturing and design process when product specifications are missing or the product is unsuitable for use. This method makes it possible to quickly develop pipelines of complex configurations by redesigning and optimizing them in a short period and thereby reduce production costs. Reverse engineering technology is a tool that will help the aviation industry establish large-scale production of Tu-214 civil aircraft within extremely tight deadlines.

Список литературы:

1. Лукманов, О. Обратный инжиниринг // САПР и графика. – 2018. – № 1 (255). С.: 7-8.

2. Рубанова, К. А. Стратегии применения обратного инжиниринга в условиях цифровой трансформации экономики // Human Progress. – 2022. Том 9, С. 13. URL: http://progress-human.com/images/2023/Tom9_1/Rubanova.pdf. DOI 10.34709/IM.191.13. EDN AKEOLL

3. Attaran, M. The rise of 3-D printing: The advantages of additive manufacturing over traditional manufacturing // Business Horizons. – 2017. Vol. 60. No 5. P.: 677-688.

4. Mussi, E. Assessment and treatment of pectus deformities: a review of reverse engineering and 3D printing techniques / E.Mussi, M. Servi, F. Facchini, R. Furferi, Y. Volpe // Rapid Prototyping Journal. – 2022. Vol. 29. No. 1. P.: 19-32.

5. Марьин, Б. Н. Изготовление трубопроводов гидрогазовых систем летательных аппаратов / Б. Н. Марьин, В. М. Сапожников, Ю. Л. Иванов [и др.]. – М.: Машиностроение, 1998. – 400 с.

6. ОСТ 1.42378-88…ОСТ 1.42386-88. Трубы и патрубки авиационные бортовые. Классификация по группам точности. – М.: Изд-во НИАТ, 1988. – С. 39-42.

7. Марьин, Б. Н. Интенсификация формообразования деталей из трубчатых заготовок / Б. Н. Марьин, Ю. Л. Иванов, В. М. Сапожников; под ред. Б. Н. Марьина. – М.: Машиностроение, 1996. – 176 с.