

REVIEW

of the dissertation work of Sun Yifang on the Topic

"Scientific Grounds to Provide Lifetime of Regional Passenger Airplane Wing Structural Members", submitted for the degree of Doctor of Philosophy

in the field of knowledge 13 Mechanical Engineering and
in the specialty 134 Aviation and Rocket and Space Technology.

Relevance of the dissertation topic

This dissertation's research is highly relevant to aircraft engineering, especially in regional aircraft design. Here are the key points showing its relevance:

Meeting Market and Safety Needs: The growing global air transport market increases the demand for regional aircraft. Ensuring aircraft structural safety and durability is crucial. Research on the fitting joint between the center and outer wing sections, a critical load - bearing area, directly contributes to enhancing regional aircraft's structural strength, fatigue life, and overall safety, meeting market demands while complying with safety standards.

Solving Design Challenges: Designing the center - outer wing section fitting joint is complex. Different docking methods affect the aircraft's service life and assembly. The wing root area has high requirements in multiple aspects. This research's methods for strength design, fatigue life extension, and structure analysis help overcome these design challenges.

Design and Analysis Innovations: The dissertation presents new methods for fitting joint design and analysis. An effective solution for modeling - stage joint design and static strength calculation, based on force - transmission - discreteness - induced stress, offers a new way to optimize joints. The indirect method for calculating stress - strain state is more efficient than traditional direct methods, improving aircraft design accuracy and efficiency, and reducing development time and costs.

Experimental and Practical Value: The research experimentally verifies methods like the effects of extruded grooves on wing panels and double - shear joints. These methods, such as using extruded arc/annular grooves and anti - fretting paste, have practical applications in Chinese aircraft design and the education of the National Aerospace University "Kharkiv Aviation Institute", demonstrating its relevance to real - world aircraft manufacturing and education.

Aviation Industry Contribution: Studying international regional aircraft fitting

joint designs provides valuable references for manufacturers. The proposed flexible compensation design and other findings can improve domestic aviation product competitiveness. The research also promotes advanced technology and design concept application and trains professionals through educational implementation, contributing to the aviation industry's development.

Evaluate the validity, reliability and novelty of the scientific results of the dissertation

The scientific propositions, conclusions and recommendations defended are fully justified by analytical methods. They are the result of analysis, generalization and statistical processing based on the results obtained by the thesis candidate. A large amount of information is presented in the form of mathematical expressions, plots, charts and tables to illustrate and supplement the scientific content of the thesis.

Make full use of proven theoretical research methods, comprehensive modeling, numerical methods and comparison with verifiable open source results.

The scientific novelty of the research results of the thesis is as follows:

1. For the first time, an effective solution for the design and static strength calculation of the fitting joint in the modeling stage is proposed. The method and its application are introduced by taking the preliminary analysis and design calculation of the flange connection design of the center wing section of a regional aircraft as an example.

2. For the first time, an indirect method for calculating the stress-strain state of the fitting joint between the center wing section and the outer wing section of a regional aircraft is proposed. The indirect method obtains the stress-strain state of the fitting joint through two finite element calculations. The results are consistent with those calculated by direct method.

3. The influence of the depth and angle of the extruded arc groove on the fatigue life of the wing panel is studied in detail by experimental and new finite element simulation methods. The results show that the extruded arc groove can improve the fatigue life of the wing panel and the optimal extruded arc groove depth and angle are obtained.

4. For the first time, the extruded annular groove is proposed to extend the fatigue life of the wing panel with functional holes, and it is verified by experiments.

5. For the first time, a method of the extruded annular grooves in combination

with anti-fretting paste to extend the fatigue life of the double shear joint of the wing panel is proposed. The study shows that the combination of the extruded annular grooves and anti-fretting paste can improve the fatigue life of the double shear joint of the wing panel.

Therefore, the scientific task proposed in the thesis was successfully completed, and the applicant fully mastered the methodology of scientific activities.

Evaluation of the content, completeness and compliance with academic integrity of the dissertation

The content of the paper work of the applicant Sun Yifang fully complies with the 134 Higher Education Standards for Aerospace Engineering and the research areas of the Aerospace Engineering Education Program.

The applicant's research results show that the paper has a good scientific level and methodological value of the work carried out. The author's research results address the questions raised in the paper and show the theoretical and practical significance of this research.

After reviewing the similarity report based on the results of the paper text matching check, we can conclude that Sun Yifang's paper is the result of the applicant's independent research and does not contain falsification, compilation, fabrication, plagiarism or borrowing elements. The ideas, results and texts of other authors cited are appropriately cited from relevant sources.

The language and style of presenting results

The dissertation is written in English. It is coherent, well-structured, easy to understand, and written in technical language using scientific terminology. The text of the paper is of sufficient length and is illustrated with figures and tables. The paper consists of an abstract, introduction, five chapters, a general conclusion, a list of sources used, and an appendix.

Chapter 1: This chapter focuses on the crucial wing root connection in regional aircraft. It begins by introducing various typical fitting joint types, including those with multiple single joints and comb - shaped profiles. Analyses of the B777, A320, and B787's fitting joints follow, highlighting their pros and cons. Design methods are then presented, covering load transfer, root rib layout, connection interfaces, and flexible compensation. The chapter concludes with key findings on root rib influence

and connection design principles.

Chapter 2: Using a comb - shaped frame fitting joint as an example, the chapter details the fitting joint design. It defines initial calculation data such as component dimensions and material properties. A calculation method based on force - transmission discreteness is proposed, along with specific steps. A calculation example is provided, and the results show the design's basic rationality and areas for improvement.

Chapter 3: This chapter develops an indirect method to calculate the stress - strain state of the fitting joint. It segments and simplifies the 3D model in CATIA and conducts two finite - element calculations in ANSYS Workbench. Comparing with the direct method, the indirect method proves to be feasible with less calculation effort and higher speed. The analysis also shows that the fitting joint meets the strength design requirements.

Chapter 4: Targeting the issue of reduced fatigue life in wing panels with functional holes, this chapter explores the impact of extruded arc grooves. Through experiments and finite - element simulations, it discovers that these grooves can extend fatigue life. The depth and angle of the grooves significantly affect fatigue life, and optimal values are identified. The findings have practical engineering applications.

Chapter 5: The chapter proposes using extruded annular grooves to extend the fatigue life of wing panel double - shear joints. Experimental studies on the effect of these grooves on wing panels with functional holes show an inverted "V" - shaped relationship between groove depth and fatigue life, with the maximum at 0.26 mm. The grooves and anti - fretting paste are found to improve the fatigue life of double - shear joints.

General Conclusion: This section summarizes the research results. It includes research on international regional aircraft fitting joint designs, new design and calculation methods, the influence of various factors on wing structure fatigue life, and the practical application of these findings in engineering and education.

The dissertation was prepared in accordance with the Order of the Ministry of Education and Science of Ukraine dated January 12, 2017 No. 40 "On approval of the requirements for the thesis design".

Dissertation results published

By the time of his graduation in 2025, Sun Yifang had published 8 scientific

papers, including: 4 articles in Ukrainian specialized scientific journals, 3 articles in Scopus - indexed publications (Q1 - Q3), 1 technical report presented at a scientific and technical conference. All results presented in the papers were obtained independently by Sun Yifang. These publications reflect his rigorous engagement with the research topic and his contributions to advancing methodologies in aerospace structural design and fatigue life optimization.

The applicant's scientific publications contain a description of the scientific research conducted as part of the thesis research, the nature of the problem, the analysis of the research methods and results, and the substantiated conclusions. No violations of the principles of academic integrity were found in the applicant's scientific publications, and the conclusions are original.

Therefore, the scientific results described in the thesis are fully covered in the applicant's scientific publications.

Disadvantage and Overall assessment

The following comments can be made regarding the dissertation:

1. The review of literature sources contains almost no publications by European and American specialists, almost all references are to Chinese works.

2. An extremely large right limit of the range "fatigue life can be increased by 2.35 – 32.9 times" is written. It is necessary to explain in more detail why such a range.

3. The first section is not a review it contains only 19 references to literature and the conclusions do not state the problems in the form in which they are written in the introduction.

4. Some numbers from the conclusions of the 4th chapter should be placed in the formulation of novelty.

I believe that the comments made are not decisive, do not reduce the overall scientific novelty and practical significance of the results, do not affect the positive assessment of the dissertation and can be corrected in further research.

Conclusion

I believe that the dissertation work of the candidate for the degree of Doctor of Philosophy, Sun Yifang, "*Scientific Grounds to Provide Lifetime of Regional Passenger Airplane Wing Structural Members*" was completed at a high scientific

level, without violating the principles of academic integrity, and is a complete scientific research, the theoretical and practical results of which solve scientific problems of great significance for 13 mechanical engineering. The dissertation work in terms of relevance, practical value and scientific novelty fully complies with the requirements of the current legislation of Ukraine, as provided for in Articles 6-9 of the Act "On the Procedure for Awarding the Degree of Doctor of Philosophy to Institutions of Higher Education and Scientific Institutions and Cancellation of the Decision of the One-time Specialized Academic Committee on the Award of the Degree of Doctor of Philosophy", approved by Resolution of the Cabinet of Ministers of Ukraine No. 44 of January 12, 2022.

The dissertation work should be recognized as meeting the requirements, and Sun Yifang as worthy of the degree of Doctor of Philosophy in the field of knowledge 13 Mechanical Engineering and in the specialty 134 Aviation and Rocket and Space Technology.

Reviewer:

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