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Vehicle Electrification

On Water, in Air and Space

Springer

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ISSN 2191-530X ISSN 2191-5318 (electronic)
SpringerBriefs in Applied Sciences and Technology
ISBN 978-3-030-81739-8 ISBN 978-3-030-81740-4 (eBook)
https://doi.org/10.1007/978-3-030-81740-4

Preface

The challenge of vehicular electrification has recently become an extremely important engineering task. This is primarily due to the well-known benefits of electric traction drives. The most significant component in the solution of this problem is the development of highly efficient and fault-tolerant electric propulsion systems that will be the optimal choice for the vehicles, working under specified operating conditions.

The aim of this book is to provide a comprehensive assessment and presentation of various feasible applications of an electric propulsion system, considering their weight, volume, reliability, and fault tolerance. The results of this feasibility analysis can be used today or in the near future for the development of electric propulsion system for the ships, planes, helicopters, and spacecrafts. To solve the above task, we applied new theoretical approaches, including combined random process methods, the *Lz*-transform technique for multi-state systems, and statistical data processing.

The authors anticipate that the book will be attractive for researchers, practical engineers, and industrial managers in addressing issues related to design and operation of safety-critical traction electric drives. In addition, it will be a helpful textbook for undergraduate and graduate courses in several departments including electrical engineering, industrial engineering, mechanical engineering, and applied mathematics. The book is self-contained and does not require the reader to use other books or papers.

It should be noted that it is impossible to describe all the achievements in the field in a single book. Naturally, some interesting results remained outside of the book's scope. In such cases, the authors provide the readers with the corresponding references.

There are four chapters in this book.

Chapter 1 presents the comprehensive analysis of interrelation between the components reliability features, such as failure rates and repair rates, of a diesel-electric propulsion system of Arctic LNG carrier for the year-round Arctic navigation along the Northern Sea Route, and economic indicators of operational efficiency of icebreaking gas carrier. Arctic navigation imposes specific strict requirements to

propulsion systems of the gas tanker, related to the comprehensive reliability and safety. The tasks of implementing year-round navigation along the Northern Sea Route make it even more relevant to ensure reliable and sustainable operations in heavy ice conditions of the eastern sector of the Russian Arctic with the support of atomic icebreakers. The reliability analysis was carried out based on Markov models for multi-state systems.

Chapter 2 is devoted to the feasibility analysis for full-electric aircraft in terms of a conversion design. The advancement of energy storage technologies has given the potential to fully electrify future transport systems. The means of electrifying aircraft are to reduce carbon emission and increase efficiency in air transport. This chapter studies the feasibility of developing an all-electric short to midrange aircraft. The study investigates the possibility of replacing the aircraft's conventional system with an all-electric drive train. Using the current conventional aircraft model, different types of electrical systems are compared to examine their advantages and limitations. The parameters of the turboprop-powered regional airliner De Havilland Canada Dash 8 (DH8D) and the average flight are used to analyze the feasibility of completing a desired range. Additionally, a reliability analysis is conducted for both the conventional and the electrified versions of aircraft, including different electrified topologies.

Chapter 3 is concerned with the investigation of the actual feasibility and prospects of creating an innovative type of electrical helicopter's propulsion system based on battery electric storage, fuel cell electric energy source, ultracapacitors, and a superconducting electric motor for the conventional Airbus helicopter EC135 with two gas turbine engines and a speed reducer. The chapter discusses the advantages and technological problems, which are associated with the thoroughgoing transformation of the conventional propulsion system of helicopter with two turbine engines to the novel electric traction drive topologies. The feasibility evaluation of helicopter's electric propulsion is provided based on the comprehensive analysis, its weight, volume, efficiency, and reliability features.

Chapter 4 focuses on the analysis of the ways to realize the project of electric rockets carrying out flights from Earth's orbit toward planets of the Solar System. The designs, which make it possible to assemble the rocket from individual modules by docking, have been developed. For the jet movement implementation, the electric engine, which belongs to the class of magnetoplasma electric rocket engines, is developed. It has the superconducting exciting winding, the current in which it is directed along the engine axis. That increases the efficiency of the engine significantly. To reduce the flight time, a new technology has been developed which makes it possible to melt ice on the surface of satellites of the planets of the Solar System (Europe, Titan, Oberon, Triton) and using electrolysis to produce hydrogen for tank containers refueling with working substance. A study of the proposed electric propulsion systems

was carried out, which allows to optimize the basic parameters of electric engines and onboard electric energy supply systems.

Munich, Germany — Igor Bolvashenkov
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