Innovative Management of Design Concepts Research and International Cooperation on EU Programs for creating Hybrid Electric Aircraft & Airship

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Abstract. Fast and expanded implementation of the most relevant innovative developments is becoming a fundamental trend in the strategy of breakthrough economic development of advanced countries. However, today finding and implementing any original idea or a new scientific discovery or technological solution requires more and more tool costs. It is necessary to use highly valuable experience of smart specialists and provide considerable financial support for foreign economic cooperation and targeted scientific interaction on an international level. MAI was included in two international consortiums for the new European programs INEA 2020-2023 to create new promising environmental models of Hybrid Electric Propulsion systems for FUTPRINT50 and IMOTHEP regional passenger aircraft projects.

1. Introduction

The science of the future, in many ways, will consist of finding the right management strategy of "foresight" and the potential synergistic effect of international scientific cooperation of "big minds and talents" with the combination of achievements in various innovative programs aimed at improving the most relevant today "green" technologies. These technologies can play an important role in the development of environmental "low-noise and low-toxic" land and air transport systems for smart cities as well as mobile comfortable communications between them.

Undoubtedly, it is important to have a "fully effective and experienced leader", as it was at the time with the authority of S. Korolev, A. Tupolev, S. Ilyushin, and others. Recently, the role of a successful generator of current ideas and a creative manager can be seen in Elon Musk’s breakthrough approaches and projects – from the development of mass-scale concepts of the Tesla E-mobile family, the creation of mega factories for the production of Li-Ion batteries of normal and high power that increase the range of mileage on a single charge, the production of embedded solar "roof" panels to cover small houses, urban high-rise buildings and skyscrapers, to the underground network of tunnel urban roads, pipeline high-speed modular express trains between cities, the idea of regular Intercontinental rocket-plane air systems and reusable rocket stages for space launches with the distribution of services of global satellite Internet networks.

2. Developing an innovative scientific environment for managing current international research

In recent years MAI, as a national research University, has been building an integrated 10-year perspective concept for the development of joint scientific cooperation, both with leading domestic industrial aerospace corporations and organizations, and with foreign advanced research centers and universities. MAI is involved in solving urgent technical tasks for real projects. In particular, MAI was included in two international consortia for the new European programs INEA for 2020-2023 to create new promising environmental models of hybrid power plant electric systems for regional passenger aircraft projects - FUTPRINT50 for 50 passengers and IMOTHEP for 100 comfortable seats [1, 2].

MAI's participation in international scientific projects such as RAMBLE together with TSAGI, CIAM and GosNIIAS is already a natural "scientific corporate environment" that accumulates the most advanced scientific developments of
scientists and research staff of the aviation institute, known for its achievements, uses the existing scientific and practical groundwork, effective management style in external economic activities and the patent basis for effective innovative developments.

Innovative management approaches and processes for creating a Hybrid Electric Aircraft, its Propulsion Systems and Electrical Components/Wire Lines include an interconnected complex of stages of conducting research on problematic issues, reflecting the levels of research:

1. Selecting and optimizing options for design concepts of aircraft for urban airports with short and ultra-short takeoff and landing (STOL/USTOL) and steep climb and descent at high angles of attack without the occurrence of disruptive negative aerodynamic effects of the wing,

2. Analyzing and developing optimal hybrid electric propulsion (HEP) systems using compact units and a rational layout on the wing or fuselage with a short length of power cables, their thermal protection systems and control of effective energy consumption and recovery in all flight modes,

3. Evaluating and synthesizing innovative solutions for HEP components: high-speed sliding bearings of aggregates and electric motors (by the number of the rotor’s rotations), cryogenic cooling systems and storage of liquid energy carriers (nitrogen, neon, helium, hydrogen) with high-temperature superconductivity systems (HTS), battery platforms (lithium and graphene) and energy storage devices, including the new Film Solar Energy Panels (FSEP).

3. The Main Air Transport problems and priority International Partnership Research

It is necessary to highlight a number of current innovative research areas in MAI in cooperation with other research centers and firms, which served as the basis for implementing conceptual approaches to solving major air transport problems and are protected by patents for devices:

- cryogenic various cooling systems and high-speed suspensions with gas sliding bearings of rotary engine systems that do not require lubrication, which proved to be better than Japanese technologies [3] and found application in research for vehicle aggregates at Stuttgart University (Germany), as reported in presentations at the international scientific conference MAI Aero&Space Week 2019 by Dr. Michael Klusachek [4] and the international EU INEA Innovation Forum 2020, January, Brussele by Prof. Yury Ravikovich [5];

- creation and modification of the Computer-Aided Design (CAD) systems for the study of various aircraft concepts (classic scheme, rombue-shaped, disk-shaped, integrated circuits and ‘duck’ circuits) [6], creation of disk-shaped Aerostatic Light Aircraft (ALA) "Thermoplane" MAI [7] with a Hybrid Electric Power plant (two sides Electric Motors) with the largest Composite Material power torus in a diameter of 40 m with modification to the Solar Film Cover System (SFCS) in cooperation with SOLARSTRATOS Swiss Aircraft Company [8] and the creation of a fully electric mobile platform E- Motion System (EMS) for Full Flight Simulation (FFS) of the SSI-100 aircraft in collaboration with THALES T&S (France), L-3 Link (UK) and SJI (Italy) [9].

4. Design Analysis of the Optimal Hybrid Electric Propulsion Cryocooling System for New Aircraft and Disc Airship with High Temperature Superconductor Components

Development of the technical appearance and calculation of the Technical characteristics of the HTSP cooling component system for electric vehicles hybrid propulsion of the new aircraft and disc airship by MAI projections and may use to the R&D cooperation with EC FUTPRINT50 INEA Program. Design Diagram of the Optimal Cryogenic Refrigerator Cooling System on the basis of the reverse Brayton cycle with the use of turbomachines:

- the generalized Diagram of the use of cryogenic systems from cooling capacity and temperature level;

- the math Model of created using thermodynamic models of individual circuit elements, taking into account the efficiency of each element, hydraulic losses in the paths of all system elements:
  * Calculation of hydraulic losses in the channel element
  * Calculation of heat exchangers of the regenerative type
  * Turbocharger calculation
  * Turboexpander calculation;
The Experiments of research two-stage neon electric compressor and turboexpander with Testing of the cryogenic cooling system LAB E-System Demonstrator as may see Figure 1, 2 and 3.

**Fig.1.** Research road map of the E-Components of High Speed sliding bearings study

**Fig.2.** Real examples of the E-Components of High Speed turbo tests
Cryo-maintenance system for high-temperatures superconductors of electric generators and electric motors

Fig.3. Demonstrator of the Cryogenic cooling system for HTS E-Generators and E-Motors

5. Development of the CAD Systems for Conceptual Design Synthesis of any Hybrid Electric Aircraft & Airship

Any Aerodynamic Optimal Structure and Weight Level Analysis of the Modern Aircraft, as show in Figure 4, are based on the main Complex CAD Data. Let's consider the identification of the layout Limiting Space and Weight Level around/inside Aircraft, its decomposition according to the characteristic features and the identification of a critical factor for the Aircraft innovation project.
Fig. 4. Modern CAD Version of Optimal Aerodynamic Concept projection

If we consider the whole issue, from the point of view of the 3D Volume-Weight-Noise Configuration, the optimal solution will be an Aircraft for which the external contour was obtained as a result of positioning of individual aggregates taking into account the criticality of the layout both with respect to the three axes coordinates and in three planes, and for any arbitrary radius-vector, starting from the center of mass of the Aircraft and kvasy-center of Weight area of the Optimal Engine positions.

A characteristic feature of a layout with "hard" dimensional constraints is the possibility of carrying out spatial coupling of many units in the first iteration, which allows us to build the layout from a certain virtual center. It is convenient to choose the origin of the associated coordinate system, which coincides with the real center of mass of the Aircraft. Therefore, the layout problem is reduced to the location and interconnection of units in the layout space due to infrastructure constraints caused by the condition of bringing the real center of mass (RCM) to the virtual mass center (VMC) and providing characteristic features for Aircraft Design MAI SW, as shown in Figure 5, that satisfy infrastructure requirements as well as others, for example, Aerodynamic and Weight efficiency [6, 7].

Fig. 5. Infrastructure restrictions of the Geometric Aircraft shape

The passenger compartment of the Aircraft (comp-digital first iteration) was adopted as a base. The second comp-digital iteration is the wing and fuselage. Third iteration is the wing, fuselage and tail. And the fourth comp-digital
iteration is the whole composition of the aircraft aggregates, which corresponds to the complete washable surface (taking into account the engine nacelles).

The Aerodynamics of ALA Shaped Discs were used for Innovation Projection in MAI. It’s the MAI Light-then-Air (LTA) Disc Shaped THERMOPLANE (Figure 6) unique and patented Project or other version as the E-Aircraft Projects with the new Laminar Flow Control and Solar Nano Film Upper Surface System for more Electrical Aircraft & Skyships PAX & Cargo Transportation for Low Cost and High Comfort Flight Operation as High Ecology Air Transport Aircraft & Airship conceptions to Future Mobility Development [10-12].

![Figure 6. The Industrial Demonstrator of the Disc Shaped Thermoplane MAI Project for test research](image)

The LTA are intended for long time flights, so High Aerodynamic Quality is a high priority in the formation of the washable surface. It is best to use them for light coverage of soft Solar Nano Film Battery Panels with E-Recuperate Efficiency. The higher it is, the lower the resistance and the greater the bearing capacity. The Drop Shape of the fuselage structure and the washable surface of the Integrate or Disc Aircraft, made according to a higher efficiency Integral E-Formation with minimum negative influence and consequences for the environment, confirm test results of the Swiss SOLARSTRATOS E-Aircraft and E-Airship Projections as show in Figure 7.

![Fig. 7. The SOLARSTRATOS E-Aircraft and SOLAR E-Airship projections](image)

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