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OPTIMAL DESIGN OF UNMANNED AERIAL VEHICLES USING PARAMETRIC CAX SYSTEMS

Стаття присвячена постановці задачі вибору CAx систем для оптимального проектування безпілотних літальних апаратів. Розглянуто задачі кожного етапу проектування БЛА та визначено засоби, які дають змогу забезпечити оптимальне проектування, враховуючи емпіричний досвід.

Ключові стова: БЛА, безпілотні літальні апарати, МЕМС, мікроелектромехінічні системи, CAx, оптимальне проектування.

The article is devoted to solution of the optimal design tasks of Unmanned Aerial Vehicles at different stages. The tasks for all UAV's design stages are considered and CAx tools for optimal design are proposed based on empirical experience.

Keywords: UAV, Unmanned Aerial Vehicles, MEMS, Micro Electro-Mechanical Systems, optimal design.

I. Introduction

The development of modern control technique that uses autonomous GPS (Global Positioning System) and progress in the miniaturization of mechatronic systems (e.g. propulsion systems, servomechanisms) and MEMS technologies (Micro Electro-Mechanical Systems), materials science (composite technologies) and electronics allowed to build specialized Unmanned Aerial Vehicles (UAV) designed under a specific purpose and application.

It should be noted that UAV's design, manufacturing and service are, like the "big" aviation, an interdisciplinary subject, binding many areas of modern science for the development, implementation and operation of a concrete technical object or system of such objects.

Choosing the right form of UAV is the overarching objective of the design process. For this task are design methods using optimization procedures.

II. Application of CAx Systems in UAV Design Process

Nowadays advantages of CAx systems usages are unquestionable. In aviation branch are using both high level CAD/CAM/CAE integrated systems (e.g. CATIA) as well as CAx systems based on more popular and much cheaper middle level CAD software.

Present CAx systems called „middle level" (for example: SolidWorks, SolidEdge, TFlex, Alibre Design, BricsCAD) are based on the main parametric solid-surface geometry modeller and work in 3 environments: „Part", „Assembly" and „Drawing".

There are many areas of CAx application in multidisciplinary UAV design process [1]:

- conceptual phase 3D model;
- mass properties modelling (e.g.: selection of materials and technologies, CG, moments of inertia);
- modular design;
- KBE (Knowledge Based Engineering) design;
- CFD/FEM Structural, Thermal, Modal analyses;
- mission-based optimisation;
- real prototypes making using Rapid Prototyping (RP);
- flow visualization, wind tunnel testing using RP objects;

- experimental structural validation (CAD model using to fast machining of real component on CNC machine or for example mould preparation for composite elements performing);
- assembly integration studies (both virtual as and real – RP or CNC making)
- Reverse Engineering techniques using for various UAV component (3D scanning, point cloud objects processing);
- fast cooperation by presentation UAV conception in any phase of project using standard and special (e.g.: Adobe 3D PDF, eDrawing, 3DVIA Composer) file format, the Internet publication, Virtual Reality, etc.

Generally, the above applications of CAx systems allow time and costs saving while implementing of the new UAV product.

III. Fundamentals of Optimal UAV Design

In the design process of any technical object mostly known for what purpose and how to design an object, i.e. a set of guidelines adopted in characterizing the task (e.g. patrol missions) and a list describing the projected size of the object. The first group of data is known from the beginning of the design process, the second - is formed in the course of the design process. The area of possible changes in the size sought, stating in essence a set of possible variants of UAV, in the tasks of optimal design is usually described by a certain mathematical model.

In the physical sense such a model describes the need to meet a specific aim (task), the physical properties of the options under consideration UAV (e.g. range, ceiling, flight time, speed, detection, instrumentation) designed based on a certain level of technical (technology, equipment, construction) and UAV function. In the algorithmic sense, such a model represents a certain amount of equations and inequalities, implying the interdependence of primary and sought greatness.

The set according to the mathematical model, in principle, has a number of solutions sought for greatness. Each of the solutions corresponds to a particular form of UAV. The large number of acceptable alternatives UAV, according to a mathematical model and to the basic problem of optimal design, namely to find the best form of UAV in the sense adopted the criterion of efficiency.

Efficiency criteria, as follows from general principles for their construction [2-4], in some form of compile some effect (utility) of the effort needed to achieve it.

In the category of tasks a positive effect (social, economic or defensive nature) is due to the implementation of a particular purpose. Achieving this goal is of course related to material inputs, energy and other measures necessary for the establishment and operation of the proposed UAV. Therefore, according to the tasks of design criterion should always be to collate the required characteristics and some properties adequately reflect the effects of UAV and outlays (e.g.: effect - to patrol a certain area, the inputs: fuel consumption costs) [5-8].

IV. Conclusion

The design process using CAx tools is a basic approach aimed to obtain better UAV product. Advanced part-assembly geometrical modelling methods, parallel with proper aerodynamic, structure, modal and other analyses loop should give robust and efficient base for manufacturing of real UAV prototype. Modern and fast manufacturing technologies can be used to receive components for reality simulations, for example wind tunnel or mechanical tests. Designers should strive for integration works in common environment. Nowadays flexible CAx systems, based on popular parametric CAD modeler, permit to carry out of many tasks in design process (e.g. use of CFD and structural, modal FEA at the earliest stages of design).

Nowadays parametric CAD tools are used to develop specialized tools for the design of geometric features including the functionality and the need to meet the mission of UAV. A literature review of that, mainly for this purpose, a so-called strategies conceptual design [9-11], using design methods based on the knowledge base KBE (Knowledge Based Design). In many cases special multidisciplinary optimization engine was developed to design the vehicle, taking into account altitude, range, efficiency, payload, propulsion, aerodynamic characteristics, etc. [12 - 17].

The most important feature of the CAD model should be its flexibility to be able to represent a large number of proposed options. Parameterized main dimensions and characteristics in the environment of the parametric CAD system would provide a flexible geometrical model, which can be modified on the basis of computational and experimental studies.

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