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Multipurpose Unmanned Aerial Vehicle Design

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Abstract

The work contains the analysis of the design methodology of an unmanned aerial vehicle (UAV), which is able to carry out environmental monitoring, define the location of various objects and targets with high accuracy, map the seats of fire and areas of environmental contamination, fulfil patrolling functions to solve the tasks of the National Armed Forces and police, carry out meteorological research, etc. The original UAV design is provided with special compartments to carry useful load (engine, batteries, surveillance camera, control elements, etc). The UAV has a combined control system intended for the control in an automatic mode including the application of GPS system.

KEY WORDS: *unmanned aerial vehicle (UAV), UAV design, peculiarities of UAV construction, UAV control system*

1. Introduction

The advantages of an unmanned aerial vehicle (UAV) for the implementation of surveillance and reconnaissance air tasks are obvious. These tasks may include, for instance, ecological monitoring, control of agricultural lands and woodlands condition, introduction of video surveillance and determination of the position of mobile and non-mobile objects, desired route patrolling, etc.

Except the possibility to control it in an off-line mode (unmanned), the main UAV development requirements are its compactness (small size), multifunctionality, and ecological safety [1].

In order to control the UAV in the off-line mode it should be equipped, for instance, with a special radio control system combined with a GPS module.

UAV multifunctionality is meant for the implementation of such tasks because it should carry such useful load as a telecamera, equipment for digital communication and a GPS receiver. Moreover, the obtained information should be transmitted in an online mode as well as recorded onto an electronic media. Outside visibility zone the UAV should pass to an automatic flight mode with GPS system monitoring.

These restrictions make the task of designing as well as the creation of the actual construction of "micro" class UAV especially difficult (with construction weight up to 5 kg).

Another significant problem is to ensure the "ecological safety" of the UAV construction. First of all, this aspect provides for not using the actuator as an internal combustion of the engine. This would make it possible to avoid the emission of harmful combustion residue as well as release from noise, which appear in the process of engine operation. In this relation, for instance, the use of the actuator as a collector-free electric engine is a perspective direction.

In addition the designed UAV should be characterizes by high-tech construction, safety, high flight technical and performance criteria.

The design and creation of the UAV corresponding to the specified requirements is an actual and at the same time complex scientifically-practical task.

2. Basic Requirements to UAV Design

The principal task of this research was a creation of an UAV construction corresponding to the following principal requirements:

- possibility of implementing environment monitoring;
- implementation of the functions of strategic and nature conservation objects protection;
- possibility of determining the exact location of the target;
- possibility of detection and mapping of seats of fire and contaminated environmental zones;
- implementation of patrolling functions to solve the tasks of national armed forces and police;
- implementation of meteorological research, etc.

In addition, in the process of designing, a number of specific requirements is also taken into account, they include:

- performance (the UAV ability to take-off and land in the conditions of runaway absence, the simplicity of maintenance and repair, etc.);
- ecological safety requirements (non-contaminated environment, minimum noise level, etc.);

- effective steerability requirements (possibility of controlling the UAV both in manual and automatic mode using modern navigation systems and communication facilities).

3. Peculiarities of UAV Construction

The aerodynamic diagram of the UAV represents a low-wing aircraft with a normal stabilizer and control (Fig. 1). The UAV construction is peculiar thanks to its design philosophy including the construction of center wing section made in accordance with a longeron diagram with a partially stressed skin. The UAV construction is provided with special useful load compartments (engine, batteries, surveillance camera, control elements, etc.). Outer wings are of V-shaped profile, which ensures a transverse stability of the UAV.

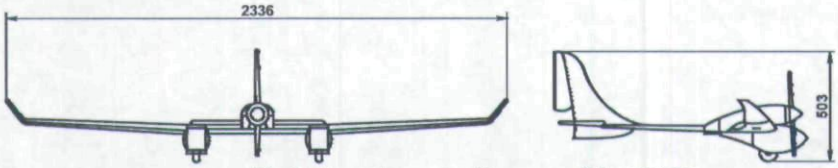

Fig.1. Aerodynamic diagram of the UAV

The UAV tail-end is a beam conjugate with a longeron (Fig. 2).

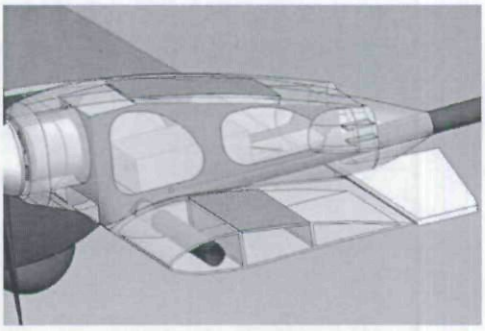

Fig. 2. Beam connection with a longeron

An electric power unit corresponding to the ecological requirements and characterized by high reliability and operational safety is used as an actuator.

The glider construction provides for the installation of surveillance video cameras meant for the UAV control and navigation as well as transmission of image data both to the operator and other services for the recording of surveillance and visual information in the process of monitoring.

In streamed nacelles, which are under centre wing section (Fig.3), in addition to the surveillance camera there are also situated autopilot construction elements as well as a landing gear. Such construction gives opportunity to place the surveillance camera far from the engine and avoid unwanted vibration exerting a negative influence upon the quality of the picture being transferred.

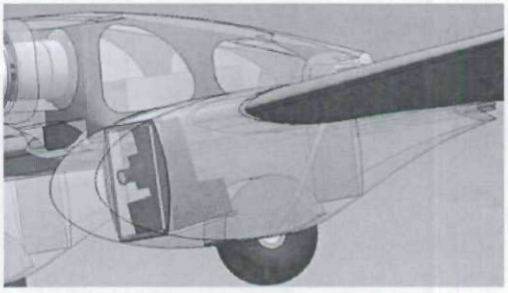

Fig. 3. General view of a suspended nacelle

A separate video camera is placed into each nacelle. One of the cameras is used for the UAV control and navigation. The picture from the camera is transferred directly to the operator controlling the UAV. The second camera is meant for surveillance and recording of visual information during the monitoring.

Different combinations of polystyrene materials, composite materials on the basis of resin, superlight balsa elements were used to make the UAV. Basic bearing structures are made of extra strong carboxylic tubular members.

The design of basic elements and UAV constructions in general was implemented in *SolidWorks* program (Fig. 4).

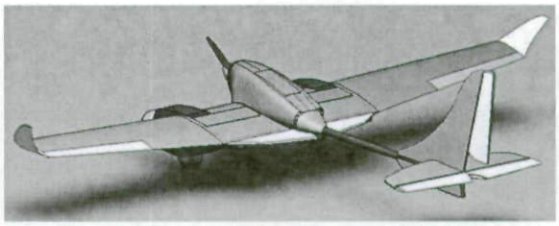

Fig. 4. View to computer model of UAV

Parts and units are designed taking into consideration the workability of UAV assembly. With a high degree of accuracy there are solved the tasks of centring and chosen the optimal diagrams of basic elements and UAV units arrangement. The possibility of computer-aided design made it possible to create the optimal constructions of basic elements and the constructions in general taking into account the aerodynamic properties as well as durability and weight.

4. UAV Control System

The UAV has a combined control system covering three flight zones (Fig. 5). Within zone 1, there is implemented a radio control of take-off/landing mode and the UAV flight inside visibility zone. The UAV control within zone 2 is implemented by an autopilot according to GPS system with the possibility of flight characteristics change in a real-time mode and flight process control using video cameras. The operator controlling the UAV has the opportunity to set flight modes on the basis of a preliminarily compiled computer program as well.

The enciphered data of the drawn Flight Plan is downloaded to autopilot database. At the same time there is an opportunity of UAV flight realization according to a guided route as well as the opportunity of making some necessary partial corrections to the plan or a complete change of flight parameters. For example, it is possible to interrupt the flight of the UAV at any journey leg, return it to the home position or to direct it according to another route. Within zone 3, the UAV control is implemented by means of autopilot according to programmed flight plan. Moreover, the control of UAV mode is implemented by means of the video camera using new generation 3G mobile communication systems. In addition to the on-line control of flight modes the system gives opportunity to transmit visual data to several independent users not connected with a ground system of UAV control.

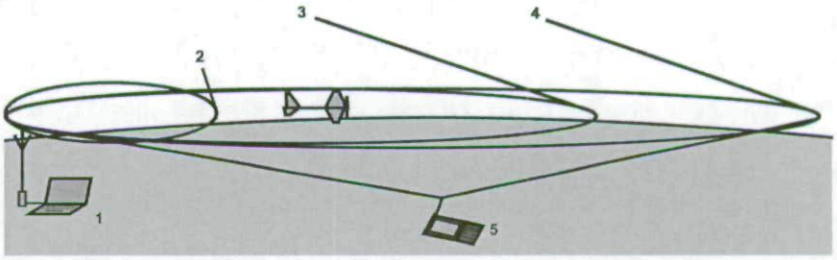

Fig. 5. Schematic diagram of UAV control: 1 – ground control system (basic station); 2 – radio control coverage inside visibility zone; 3 – autopilot coverage; 4 – mobile communication coverage for information transmission; 5 – mobile communication device

Module systems of the UAV flight control make it possible to strictly maintain the altitude and selected flight course, to efficiently correct the UAV spatial orientation taking into account wind force and drift angle.

5. Conclusions

In the UAV construction there are used different innovative materials – a combination of polystyrene materials, composite materials on the basis of resins, superlight materials on the basis of balsa. The basic bearing structures of the UAV are made of extra strong carboxylic tubular members. The centre wing section has a partially stressed skin, which gives opportunity to increase the strength and rigidity of the UAV construction in general and reduce the weight of basic load-bearing elements.

The designed UAV is characterized by the following key features:

- construction weight – up to 5 kg;
- flight duration – up to 1 hour;
- flight altitude – up to 1 km;
- useful load – up to 1.5 kg;
- actuator type – electric.

References

1. **Urbahs A., Petrovs V., Savkovs K., Jakovlevs A., Bulanovs V.** Unmanned aerial vehicle design. Transport and Engineering., ISSN 1407 – 7345. – Riga, 2008, Nr.26, p. 7-11.