

Conceptual Design of a Tandem Joined Wing UAV

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Background. The box wing has excellent flight and structural characteristics. Advantages of the box wing [1]:

1. The model is stable.
2. Reduction of frontal (in particular, inductive) resistance to 20 %.
3. Vortices formed at the ends are minimized.
4. Smaller wingspan.
5. High strength of the box structure.
6. Minimum drag for a given wingspan and weight.

Due to these advantages, the idea of a tandem box wing is in demand not only in the field of UAVs, but also in the promising development of civil aircraft. That's why I chose this design for my project.

Aim. The purpose of my research was to design a lightweight multi-purpose unmanned aerial vehicle with a tandem wing.

Methods. Optimal geometric characteristics of the wing have been selected. A summary of weights has been made. Pegasus must be balanced with its center of mass 220 mm along the X-axis relative to the origin (Figure 1). NACA-1112 profile was selected. Wingspan is 720 mm.

Then, the estimated aerodynamic [2] and speed characteristics of Pegasus were calculated (Table 1).

Table 1. The main characteristics of Pegasus-4M

Parameter	Formula and value
Estimated speed (m/s)	$V = 20$
High-speed pressure (Pa)	$q = \rho V^2 / 2 = 220$
Specific wing load (kg/m ²)	$p_0 = m_0 / S = 8.6$
Lifting force coefficient	$C_{ya} = (g/q)p_0 = 9.81/220 \cdot 8.6 = 3/8$
Wing extension	$\lambda = 5$
Narrowing	$\eta = 1.2$
Total wing area (m ²)	$S = m_0/p_0 = 1.8/8.6 = 0.208$
Wingspan (m)	$l = \sqrt{\lambda S} = 0.72$

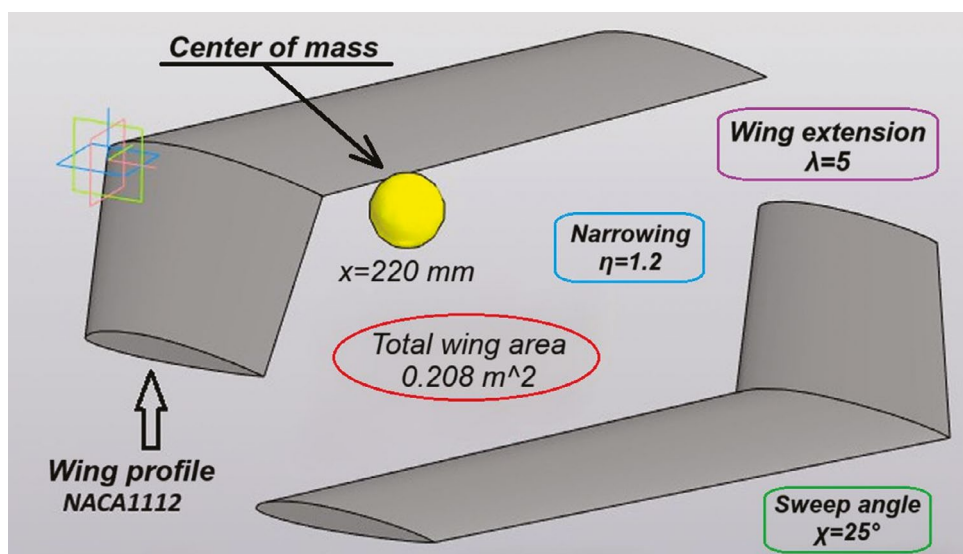


Fig. 1. The scheme of the wings



Fig. 2. UAV “Pegasus-4M”

Next, the configuration of the first version of Pegasus was created: where the wings and body were completely made of expanded polystyrene with a density of 40 kg/m^3 . At the same time, the weight of the device with all the avionics was 627 grams, with a necessary balance of — 220 millimeters along the leading edge of the upper wing chord. The 1360 g load is located in the area of the center of gravity.

Then, to create a mass-dimensional layout which, in the future, could be flown around, it was decided to print the fuselage entirely on a 3D printer. The design of the fuselage compartments has been developed for printing. This ensures their strength and optimal location of equipment. The wings are made of expanded polystyrene. A special adhesive tape is used to reinforce the surface, which partially performs the function of the skin.

Results: The Pegasus-4M can be equipped with one or two video cameras in the forward fuselage. According to preliminary calculations, the payload mass of this drone is almost twice its own mass, which opens up the possibility of its wide use for various purposes: from surveying the area to the prompt delivery of cargo to its destination by dumping methods from the compartment, for example. This is how Pegasus looks like (Figure 2).

Conclusions: To conclude, I would like to say that further I am planning to increase the overall dimensions of the product, calculate and manufacture this UAV from composite materials, refine the tail in the form of a keel to facilitate gliding during flight, and place equipment on board for research.

Keywords: unmanned aerial vehicle; conceptual design; tandem wing, box structure; 3D printer.

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