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Using of wavy morphing wing for flow and flight control

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Abstract
The present work is devoted to investigation of new type of power surface with possibilities of flow adaptation and movement control founded on wavy wing effect.

1. Introduction

Aviation science doesn't stand still Nowadays progress in materials science and electronic systems has provided avalanche of interest to untraditional aircraft constructions. The morphing aircraft concepts is one of the newest trend of the aircraft industry [1]. Special type power surface creation is in the basis of morphing aircraft construction. The surface has capable to change a shape and a boundary structure with depending of flight conditions The flow conducting and aerodynamic forces control is two main direction of the morphing conception based on different purpose [2-5]. In rare cases, there is an universal morphing constructions but they have extremely complex structure.

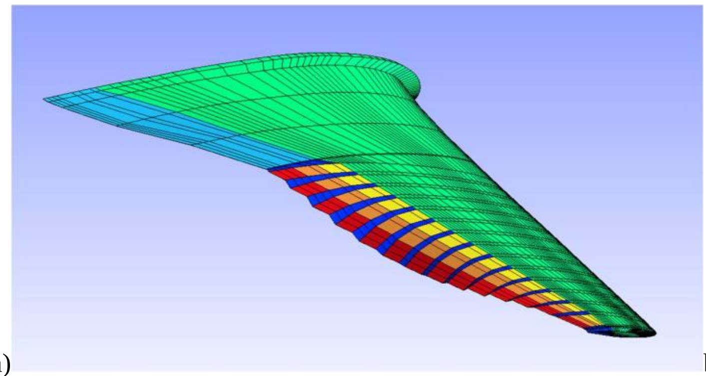

a)

b)

Figure 1: Morphing concepts a) BATS project by NASA b) Fool-span flaps NASA

The universal morphing power surface based on the wavy wing effect was researched in this work. As known, the "wavy wing" effect is very useful for low Reynolds number aircraft. [6-9, 12].
The variophorm section wing (VSW). The device is system of sectored skeleton base and elastic skin (Fig.2) The power surfaces sectors is independent and hermetic with pressure gradient changing system controlled through special valves. With appearing of pressure gradient in a section the surface part is deformed It leads to pressure gradient changing on surface and redistribution of aerodynamic forces. That is condition of movement evolution for any aircraft.

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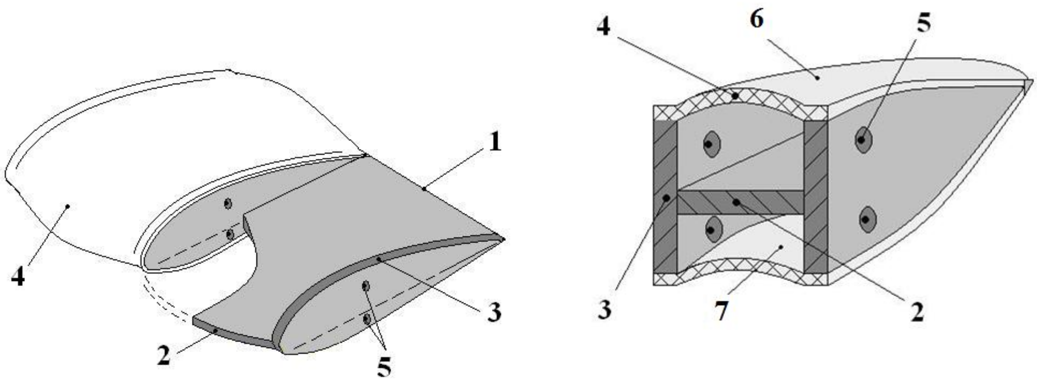

Figure 2: 1 - primary structure; 2 - longitudinal frame set; 3 - transverse frame set; 4 - elastic skin; 5 - pressure gradient channel; 10 - hump; 11 - groove. (patent №2412864 (RU))

At same time the longitudinal hump appearing create transverse pressure gradient and a vortex structures are localized between neighboring humps. This is effect of wavy wing which increase the critical angle of attack and destroy a hysteresis of aerodynamic characteristics. [9-11]

2. Experimental setup

The classic techniques of the aerodynamic experiment is unsuitable for this type constructions because the surface instability can to lead to destroy of thermoanemometer sensor for example. The special acoustic scanner was used for receiving boundary layer characteristics. (Fig.3) It was system of sensitive microphone with flexible waveguide settled on automatic coordinate machine. The waveguide flexibility has allowed to save the scanner and elastic skin structure of the WSV wing.

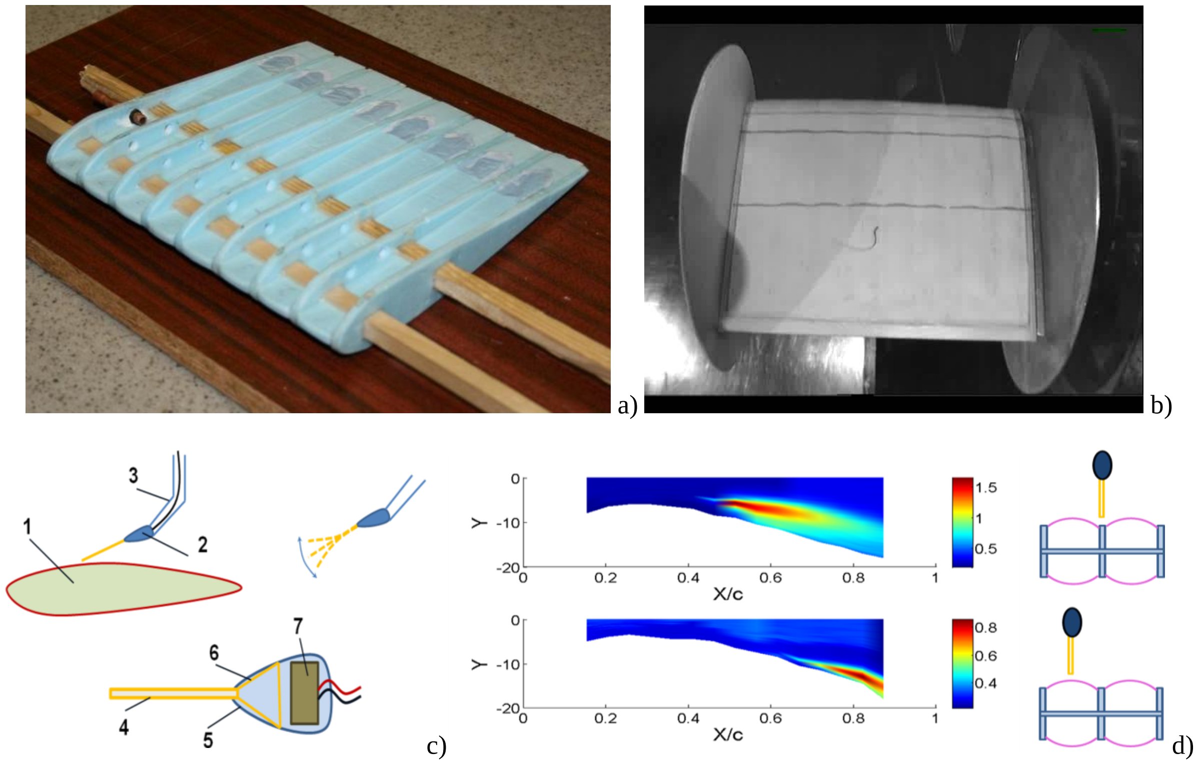

Figure 3: a) model structure; b) model in wind tunnel c) 1-model 2 - acoustic scanner; 3 - pylon; 4 - flexible waveguide;

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5 - scanner case ; 6 - acoustic bell ; 7 - microphone. Right: acoustic disturbance distribution (mV).

The laminar-turbulent transition is started in the groove as shown in our early works[11-13]. With comparing the results of the acoustical measurements and the thermoanemometer data on the classic flat wing [14], the following was obtained: The scanner shows that maximum of the pulsations is in the origin of laminar boundary layer separation area. At same time the measurements of the thermoanemometer show that the pulsations maximum are localized on end of transition area. For our opinion, this is coupled with sensibility limit of the scanner microphone. In any case this technique allows to get localization of the separated area and it must improve for new aerodynamic investigations.
Ultimately the new type of the morphing wing was developed it is variophorm section wing improved (VSWI) which allow to increase the range of change of aerodynamic characteristics. The main distinguishing VSWI from VSW is the appearing of flexible part of rib in skeleton base (Fig.4) which allow to change of the pressure gradient much more effective.

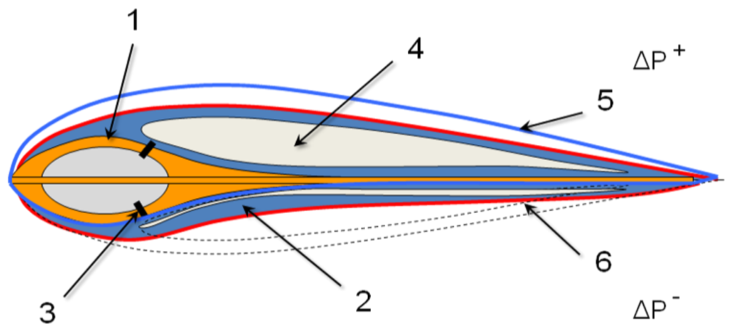

Figure 4: 1 - rigid rib part; 2 - flexible formative rib part; 3 - control valves;
4 - form-building space; 5 - elastic skin; 6 - skin contour in rib area.

The approximate estimate of VSWI efficiency is represented on the Pic. 5. In this picture graphics of the lift coefficient for usual profile, profile with flap, average on section profile of the VSW and VSWI are submitted. They was obtained from two dimensional simulation on X-foil [15].

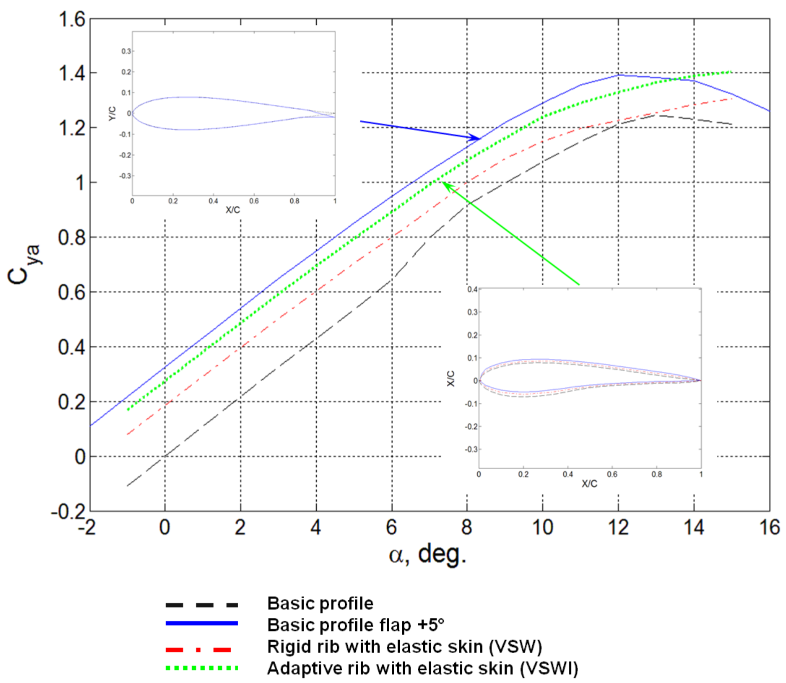

Figure 5: Estimated efficiency of VSW and VSWI concepts Re 1.5x10^5.

As we can see from the figure this type of morphing concepts allows to change the diapason of the aerodynamic characteristics as like as the flap deviation to 5 degree.

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Conclusions:

The system of the variophorm section power surface (VSW and VSWI) is effective technique to flow and flight control in generally.
Investigation of the morphing wing needs new methods of the aerodynamic experiments.

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