

Conceptual Design of an Airfoil with Temperature-Responsive Polymer

Mohammed Niyasdeen Nejaamtheen

Abstract—The accelerated growth in aircraft industries desire effectual schemes, programs, innovative designs of advanced systems and facilities to accomplish the augmenting need for home-free air transportation. In this paper, a contemporary conceptual design of a cambered airfoil has been proposed in order to providing augmented effective lift force relative to the airplane, and to eliminating drawbacks and limitations of an airfoil in a commercial airplane by using a kind of smart materials. This invention of an unsymmetrical airfoil structure utilizes the amplified air momentum around the airfoil and increased camber length to providing improved aircraft performance and assist to enhancing the reliability of the aircraft components. Moreover, this conjectured design helps to reducing airplane weight and total drag.

Keywords—Collector electrode, corona electrode, Temperature-responsive polymer and ultra-faams microchip.

I. INTRODUCTION

THE Smart materials are designed such that have one or more intrinsic properties which can be significantly modified in a predictable and contained fashion by external stimuli to change the way the materials functions in response to the environmental stimulus [1], [2]. With the advancement and evolution of technologies, many innovative cutting-edge modernized materials find their applications in aerospace and aviation industries. Smart material is a promising and ensured example that deserves a wide focus, from research and analysis to practical applications. Literature review crystal clearly reveals that unlike chemical adhesives and composite materials which are highly flammable, less predictable, complex damageable, brittle, and very difficult to inspect [3], smart materials are highly reliable, power consumption, no moving parts, and provide new capabilities [4]. This conceptual innovative design has many benefits over existing cambered airfoils. The potential capabilities that smart materials offer are allowing this new technology to be considered for use in state-of-the-art applications. For example, smart materials are mainly applied in medical sciences, electrical, aerospace and mechanical engineering and also can open new applications in civil engineering specifically in seismic protection of buildings [5], [6]. “Smart carpet” piezoelectric helps in building/installation security and in military applications, smart sensors and smart nanobots are used [7]. Smart polymers and smart ceramics are used in

medical applications [8].

Cambered smart airfoils are highly effective for supporting the airplane’s Degrees Of Freedom (DOF), by providing phase transformations which will produce shape changes when this material, called smart materials subjected to a thermal field. This arrangement possesses the obvious advantage that the smart materials deforms to its ‘martensitic’ condition with low temperature, and automatically regains its original shape in its ‘austenite’ condition when heated (high temperature). Smart airfoils typically require low bandwidth and low frequencies with a high hysteresis for a limited temperature range operations. Further, these unsymmetrical airfoils are suitable for producing large forces with high energy density and material strength. Different conventional airfoils utilized for different operations such as passengers, fighters, interceptors, transports, and bombers are inefficient in that they require a new innovative design to replace all the conventional airfoils with a single effective design. In general, prior cambered airfoils require thick cambers which have been found to be inherently inefficient. There have been some new proposals to use conventional airfoil designs in practical applications. However, the conventional prior design, are inefficient from a special standpoint and are considerably complex.

The present invention fulfills these needs and provides other related advantages. Though many studies were carried out on existing cambered airfoil structures [9]-[12], there are no viable airfoil structures found in the open literature to obtain higher overall reliability in aerospace applications. Note that most of the earlier investigators were focused on improvising the existing composite technology. Therefore in this paper, a new conceptual design of an airfoil has been proposed with an advanced material technology.

II. CONCEPTUAL DESIGN

The present invention resides in an improved unsymmetrical airfoil structure for producing additional lift force, improves the reliability of the airframe components. In its most basic form, the unsymmetrical airfoil of the present invention utilizes airfoil which is made up of a Temperature-responsive polymer, kind of smart materials; undergo changes in structure upon external thermal stimuli. This type of structural deformation changes the actual dimension of the camber which generally provides an increased surface area, further produce augmented lift force with increased reliability.

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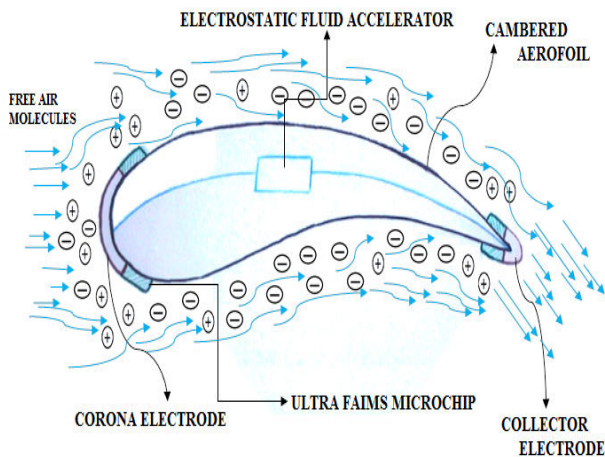


Fig. 1 A side-view of an airplane wing with free air molecules and ions

With the help of Electrostatic Fluid Accelerator, corona electrode (Cathode) is fixed at the leading edge of the smart airfoil which ionize the incoming free stream air particles when high intensity flux applied whereas collector electrode (Anode) is fixed at the trailing edge of the smart airfoil which attract the (-) ions when high intensity flux applied. Fig. 1 is a fragmented perspective view of an airplane wing called as an unsymmetrical airfoil structure embodying the invention, illustrating the use of cathode, anode, ultra-faims microchips, and electrostatic fluid accelerator. The high intensity electric field required for the electrostatic fluid accelerator is produced by a small thermoelectric generator which is placed inside the aircraft body, near to the engine section, converts heat from the engine combustion chamber directly to electric current, known as thermoelectric current by the phenomenon called "Seebeck effect", it is a phenomenon of e.m.f in a thermocouple when its two junction are at different temperatures [9].

III. WORKING PRINCIPLE

The ionized gas molecules at the leading edge generally contains maximum of (-) ions and a minimum of (+) ions, move towards the collector electrode at the trailing edge accordingly due to the unsymmetrical airfoil structure. The anode at the trailing edge attracts the large amount of (-) ions with a small repulsion of (+) ions conclusively increase the momentum of the charged ions towards the trailing edge. While travelling the charged ions starts colliding with neutral air molecules on the way. During these collisions, momentum of the ionized gas particles gets transferred to the neutral air molecules around the airfoil, resulting in the increased momentum of air molecules moving towards the tip of the trailing edge. This increased momentum of the air molecules produce augmented lift force.

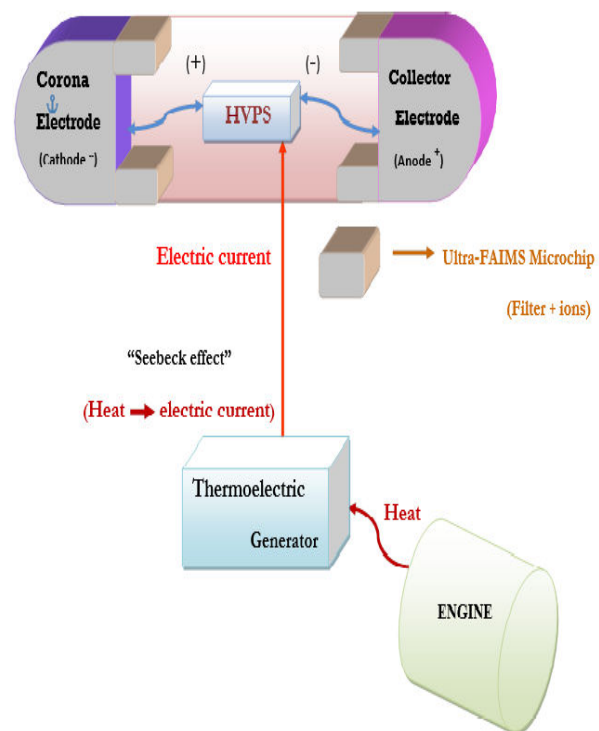


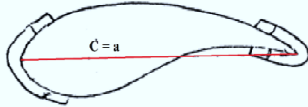
Fig. 2 is a pictorial representation of an unsymmetrical airfoil with miniature thermo-electric generator

Moreover, repulsion of (+) ions by the anode causes small flow disturbance, producing turbulence around the airfoil which can be reduced by using Ultra-faims microchip. This microchip, placed just beside to the electrodes in the leading edge and trailing edge, filters (+) ions, as soon as the air gets ionized at the leading edge. Fig. 2 is an enlarged pictorial representational diagram of an unsymmetrical airfoil structure with miniature-sized thermo-electric generator and engine, showing, the actual work-flow of the smart airfoil with clear indication of the process which is taking place in order to produce augmented lift force.

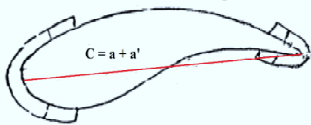
Reference will now be made to the unsymmetrical airfoil structure illustrated in Fig. 1 with the Fig. 3 which gives the comparative study of varying camber dimensions with respect to external thermal stimuli. Initially, the surface temperature of an airfoil (T) = A , the camber length (C) is assumed as ' a '. When temperature increases, $T = A$ became $A+A'$, simultaneously C also varies as $a+a'$, this structural variation increases the momentum around an airfoil with respect to the initial condition. Further increases in surface temperature $A+A'+A''$, increases the camber length as $a+a'+a''$, further increases the momentum of an airfoil. Moreover, the disclosed structure produces very compact and efficient systems which are light in weight and which yet have high power efficiency. Reduced turbulence helps the air molecules to flow laminar to the trailing edge. Increased smoothness of the air molecular flow will further increases the momentum of air molecules around the airfoil which simultaneously increase the lift force.

For increasing the air molecules over the airfoil, *thrust vectors* can be used in order to provide Upper Surface Blowing (USB).

1. $T = A$



2. $T = A + A'$



3. $T = A + A' + A''$

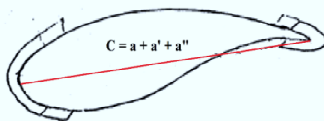


Fig. 3 Varying camber dimension with respect to external thermal stimuli

The engine's exhaust flow can be vectored to flow across the upper wing surface to provide USB to augment lift. Fig. 4 is a diagrammatic representation of the thrust vectors, where the engine's exhaust flow can be vectored to flow across the upper wing surface to provide USB in order to increase the neutral air molecules over the smart airfoil [10].

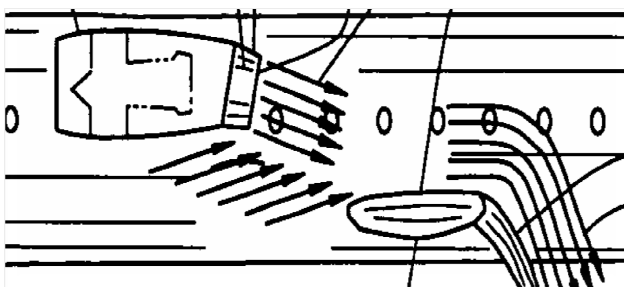


Fig. 4 A thrust vector with USB [10]

One additional advantage of electrostatic fluid accelerator is that it acts as a cooler, heat generated by electronic devices and circuitry inside the airplane must be dissipated to improve reliability and prevent premature failure.

IV. CONCLUSION

In a preferred form, the primary additional lift produced by circumferentially surrounded air momentum of an airfoil, helps to increase the performance of an airplane. The secondary lift force produced by the structural deformation, helps to improve reliability of the structure. Accordingly, there has been a need for a novel cambered smart airfoil structure which replaces a multiple moving parted cambered airfoil with a single active element to produce a compact and spatially efficient structure which is light weight and obtain high power efficiency. In the present invention, various modifications may be made without departing from the spirit and scope to fully use up the technology in aerospace industries.

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