DEVELOPMENT OF FLEXIBLE AIRCRAFT WING WITH CORRUGAGED CORE MADE BY 4D PRINTING OF COMPOSITES

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ABSTRACT

This paper presents a method to manufacture corrugated core without the need to make a mold having the shape of the corrugation. The method is called 4D printing of composites. The corrugated core is used to support the upper and lower skins of a flexible aircraft wing. The flexible core allows the wing to be able to morph during flight. This morphing capability allows for complex flight path maneuver. A prototype was made and tested. Experiments show that the flexible wing can support loads up to 50 lb/ft^2., with a morphing angle of up to 20^o.

1 INTRODUCTION

It has always been human desire to have the capacity of flight of birds or insects such as flies, mosquitos etc. These species have flexible wings that enable them to have quick flight maneuver. Most commercial aircrafts have fixed wings and they use moveable flaps to control take-off and landing. Efforts to develop aircrafts with flexible wings have been going on for several decades [1]. There are numerous ways to change the shape of the wing. Among these is the concept of Active Compliant Trailing Edge (ACTE) [2]. In this concept, the trailing edge of the wing is made flexible (figure 1). This is done by having stringers to support the skins. The trailing edge is moved by a motor and cable mechanism located on the inside of the wing.

The flexibility of the trailing edge can be done using a corrugated core rather than stringers (figure 2). The corrugated core can provide flexibility in the chord direction, and stiffness along the span direction. In order to make the corrugated core, normally, a mold with corrugated geometry needs to be made. Composite prepregs are then laid on the surface of the mold. The composite is then cured and cooled to room temperature. A new concept for the manufacturing of composite structures with complex geometry has been introduced [3]. This is called 4D printing of composites. Using this concept, there is no need for the mold with complex geometry. Instead, only a flat mold is required. The concept utilizes the anisotropic characteristics of the different layers at different fiber orientations in the laminate to create the change of configuration from flat to curved. Using this concept, many composite structures have been developed. This includes the development of composite leaf springs [4]. These springs have spring constants similar to those made of metal, and they can withstand fatigue loading to more 1 million cycles without failure. In another development, wing skin stiffeners having the shape of the omega were also developed [5]. This paper presents the development of the corrugated core for the flexible wing using the same concept.

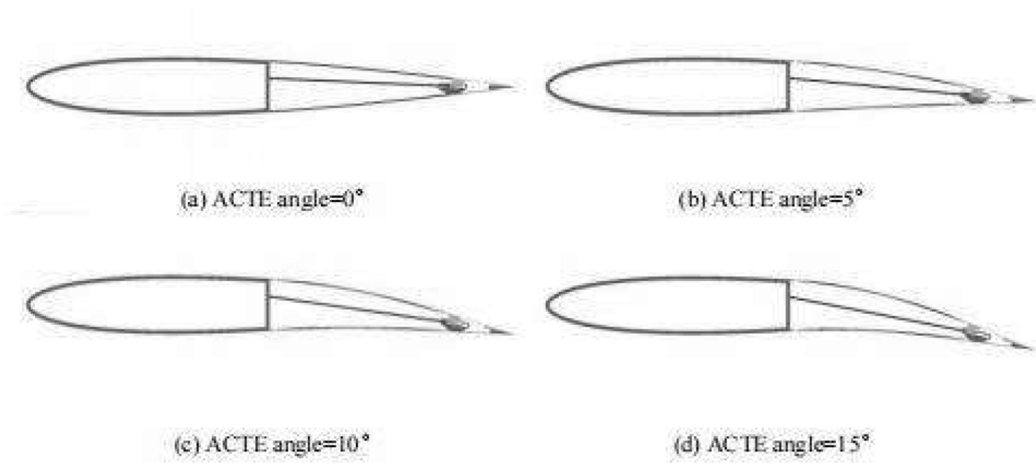

Figure 1: Schematic showing the concept of Active Compliant Trailing Edge wing [1]

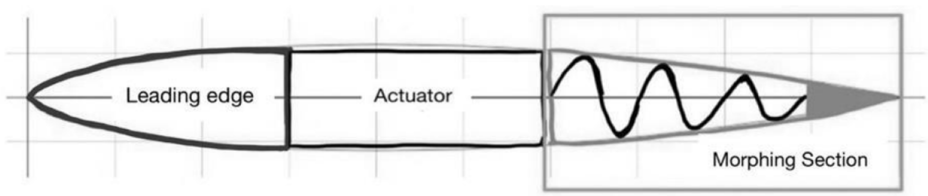

Figure 2: Flexible trailing edge using corrugated core

2 DEVELOMENT OF THE SAMPLES

Due to the size limitation of the autoclave at the Concordia Center for Composites, samples with a maximum length of 1 m was developed. The corrugated core is supposed to fit within the envelope of the last third of the wing. Figure 3 shows the configuration of the corrugation.

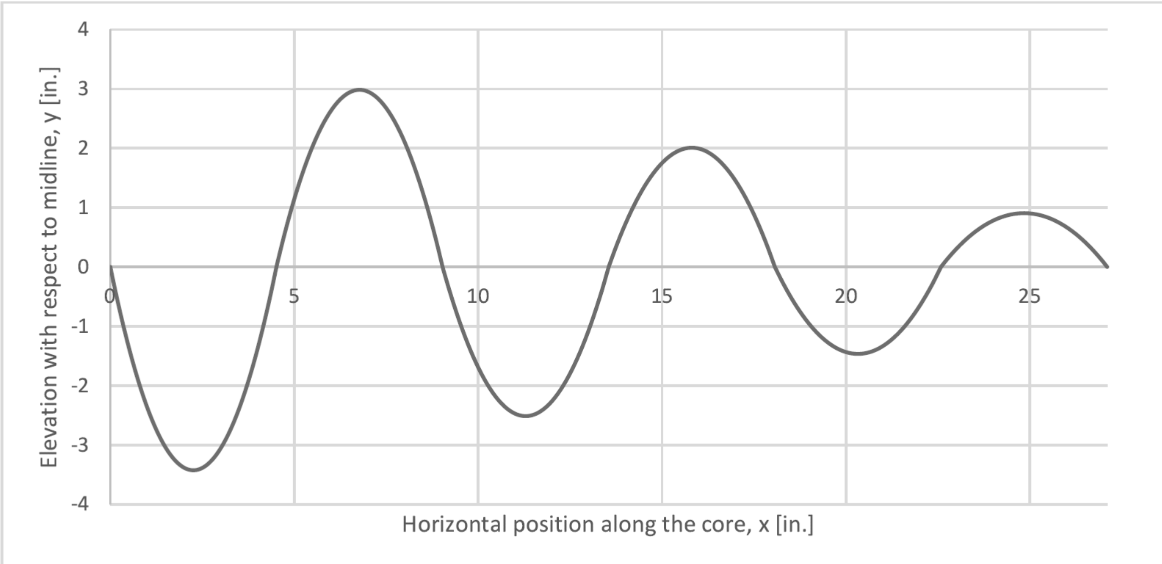

Figure 3: Configuration of the corrugation.

In order to obtain the configuration in figure 3, unsymmetric laminates with the sequence as shown in figure 4 were laid up on a flat mandrel. The core as made was bonded to upper and lower skins to make up the flexible wing, as

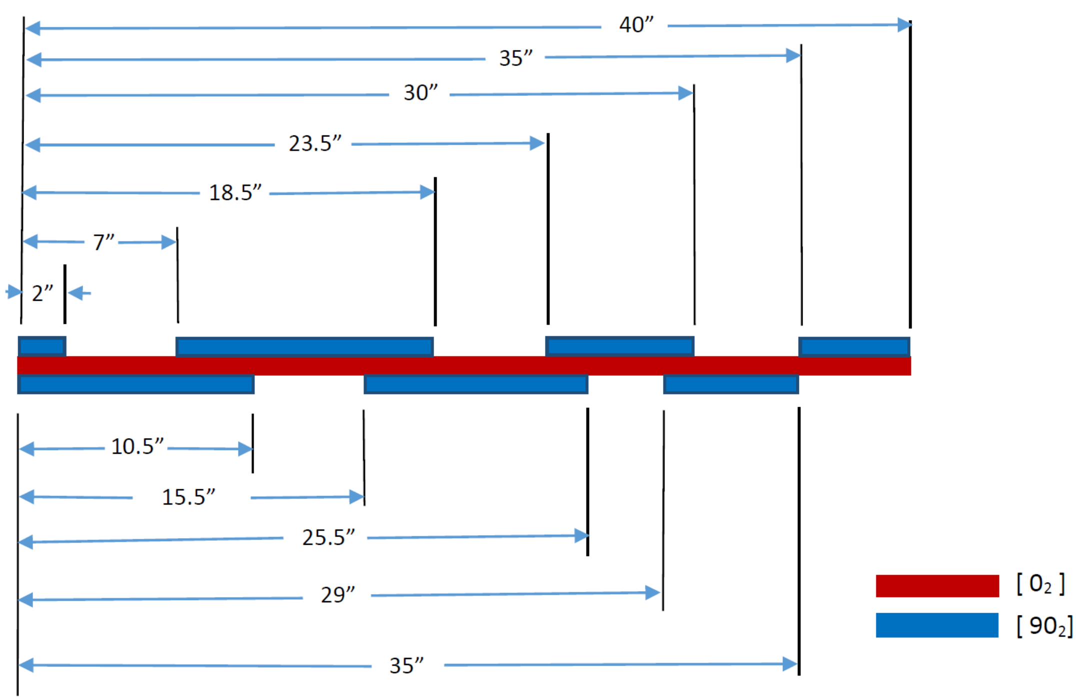

Figure 4: Unsymmetric laminate was used.

Figure 5: Sample of a flexible trailing edge made using 4D printing of composites

shown in figure 5. This sample was tested in cantilever mode. Figure 6 shows the deformed configuration as compared to the initial configuration of the wing. The angle of deflection was measured to be 20^o and the maximum load that was supported was 50 lb/ft^2 [6].

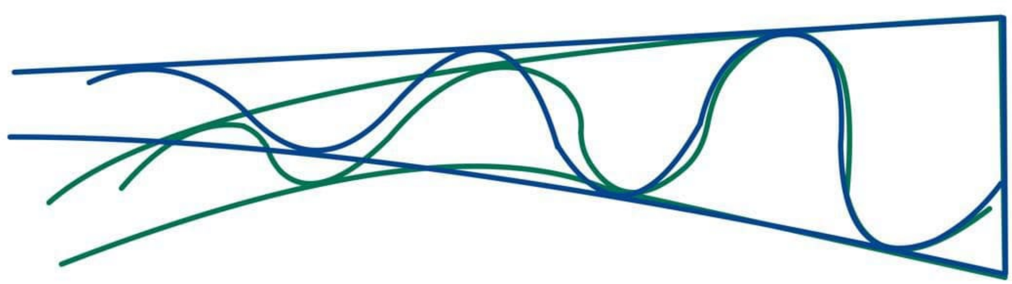

Figure 6: Deformed configuration of the wing, as compared to the initial configuration.

3. CONCLUSION

In this paper, it was shown that it is possible to use the concept of 4D printing of composites to make composite corrugated core which forms part of a flexible aircraft wing. The corrugated core was made without the need for a mold having corrugated shape. The flexible wing can morph up to 20^o, and can support loads of up to 50 lbs/ft^2.

4. ACKNOWLEDGEMENT

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