Aerodynamic Optimization Design of Airfoil Based on Directly Manipulated FFD Technique

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Abstract:

Due to the disadvantage of the conventional FFD (Free Form Deform) technique that it lacks the capability of directly manipulation, the approach of applying DFFD （directly manipulated FFD）technique into aerodynamic shape design has been proposed in this paper. Instead of the manipulation of control points to deform the objective geometry in FFD method which is not direct and intuitive, the DFFD method is used by solving the displacements of all of the FFD control points simultaneously with some specified geometric points' movements, which are as geometric constraints in the process of deformation, so that the deformation of the objective geometry could be directly manipulated. These geometric points are called Pilot Points to determine the deformation at the specified locations on the objective geometry. Sometimes the designers have to achieve some local and detailed deformation of the objective geometry. In FFD approach it could be accomplished by increasing the number of control points to form a higher order FFD control frame. However it would result in a large number of design variables, for that the design variables in FFD approach are the displacements of the FFD control points. DFFD method could accomplish a relatively small number of design variables together with high order FFD control frame, because in DFFD method the design variables for the geometric parameterization are the displacements of the pilot points instead of the FFD control points. Thus designers could have a better capability to accomplish local detailed geometric deformation by using more FFD control points with no increment in design variables. Besides, because of the capability of directly manipulation, some practical engineering geometric constraints could be coupled within the parameterization process by DFFD method, such as the thickness at the location of front beam or back beam of an airfoil.

The study cases in this paper have shown that applying this method as a geometric parameterization method in aerodynamic optimization design of airfoil aiming at drag reduction is of good result. And the geometric constraints could be coupled within the parameterization process to guarantee the geometric characteristics like the airfoil thickness at the location of front beam and back beam.

The following two figures are for illustration and comparison of the deformation process and result of FFD and DFFD approach.

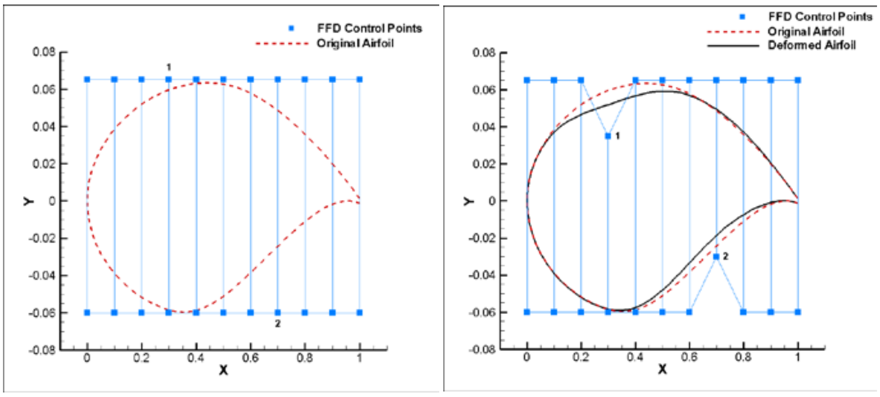

Fig 1. Deformation Process Using FFD Method with the Displacements of 2 Control Points as Design Variables

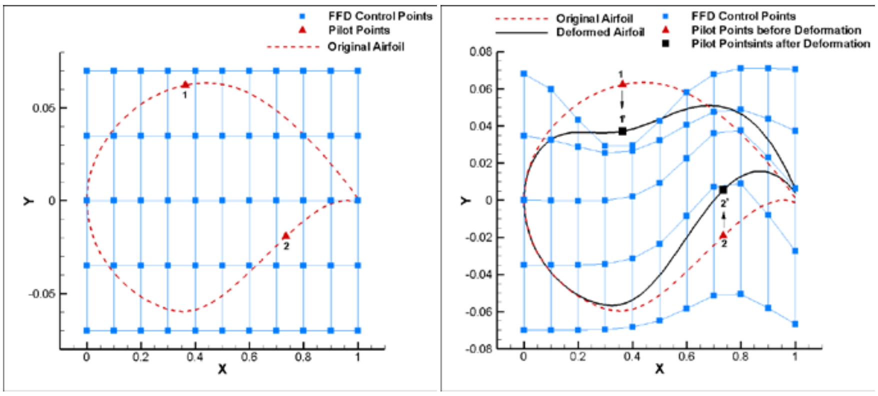

Fig 2. Deformation Process Using DFFD Method with the Displacements of 2 Pilot Points as Design Variables, with More Control Points Compared with that Using FFD Method

Key words

Aerodynamic Optimization Design; Geometric Parameterization; Directly Manipulated FFD; Airfoil; Geometric Constraints