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AERODYNAMIC ANALYSIS AND OPTIMATION OF 2D AIRFOIL SHAPES REPRESENTED BY NURBS FORMULATION

Wanghyun Kim[1], Jong-Soo Choi[2] and Byoungsoo Kim*[3]

[1] Chungnam National University, Graduate School, wanghyun88@nate.com
[2] Chungnam National University, Dept. of Aerospace Eng., jchoi@cnu.ac.kr
[3] Chungnam National University, Dept. of Aerospace Eng., kbskbs@cnu.ac.kr

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In this paper, geometrical representation of 2D airfoils with NURBS curve and using this representation for flow analysis by using CFD approach is studied.

To represent a 2D airfoil shape a NURBS curve formula is used as shown below[1)]

$$P(s) = \frac{\sum_{i=0}^{n} N_{i,p}(s)\omega_i P_i}{\sum_{i=0}^{n} N_{i,p}(s)\omega_i}$$

The problem of approximating an airfoil data $A(t)$ with a NURBS curve is can be stated as follows: Find the set of control points P_i and weights ω_i such that $\|P(s) - A(t)\|$ is minimized in a suitable norm[2)].

To approximate a given airfoil data L_2 norm of both the mean and the maximum error between the approximation curve and target curve is optimized as the reference recommends[2)]. The mean error is calculated by summing the distance d_i of a set of points along the target curve and their projections on the approximation curve, and the maximum error by finding the largest value of those distances.

$$\varepsilon_{mean} = \frac{1}{n}\sum_{i=1}^{n} d_i$$
$$\varepsilon_{\max} = Max(d_i)$$

With the definitions above optimization problem to minimize the cost function is solved, where the combination of mean error and maximum error is used as follows

$$F(X) = 2\varepsilon_{mean} + \varepsilon_{\max}$$

In this study the airfoil is approximated with 6th degree non-uniform B-spline blending function with 13 control points as shown in Fig. 1.

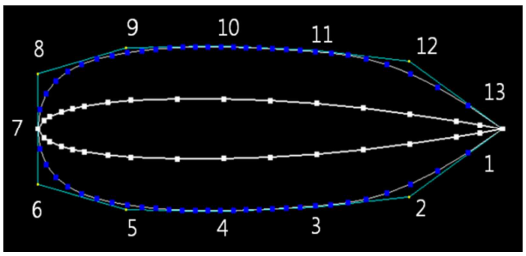

Fig. 1. NURBS curve with 13 control points

Grid generation about this NURBS representation and flow calculation by using CFD method including Euler solution and RANS calculation will be performed and the shape optimation for aerodynamic performance will be also performed.

Comparison with available data including experimentation and other calculations will also be given.

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