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CST气动外形参数化方法研究

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A Study on CST Aerodynamic Shape Parameterization Method

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摘要 类别形状函数变换(CST)方法是通过类别函数和形状函数来表示几何外形的新型气动外形参数化方法。通过考察参数化过程线性系统的条件数以及对翼型的表示误差,研究了Bernstein多项式阶数(BPO)对CST方法单值性和精度的影响,并将CST方法与B样条法、Hicks-Henne法和参数化翼型(PARSEC)法的参数数量和表示精度进行了对比。使用基于CST参数化方法的远场组元(FCE)激波阻力优化方法对超声速机翼进行外形优化,优化后的机翼其激波阻力降低达61%。研究结果表明:CST方法具有参数少,精度高的优点;为保证表示精度,同时避免病态参数化过程,应使用4阶以上、10阶以下的Bernstein多项式定义形状函数。

关键词： 类别形状函数变换 线性系统 参数化 多项式 减阻 外形优化

Abstract: Class-shape-transformation (CST) is a new shape parameterization method which represents the geometries of aircraft shapes with a class function and a shape function. Based on the condition numbers of linear systems and the representation residuals in the parameterization process, a study is performed on the influence of the bernstein polynomial order (BPO) on the numerical uniqueness and the precision of the CST method. Comparisons of parameter number and representation precision between the CST method and B-spline, Hicks-Henne and parametric section(PARSEC) methods are represented in this paper, as well as a supersonic wing shape optimization case using the far-field composite-element (FCE) wave drag optimization method which yields a 61% reduction of wave drag. It is suggested that the CST parameterization is chara-cterized by high precision and low parameter number. In order to achieve sufficient precision and avoid ill-conditioned parameterization, the shape function should be defined by bernstein polynomials of at least 4th order, but no more than 10th order.

Keywords: class-shape-transformation linear system parameterization polynomial drag reduction shape optimization

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