Available online at www.sciencedirect.com
ScienceDirect
Renewable Energy 32 (2007) 95–104
RENEWABLE ENERGY
www.elsevier.com/locate/renene

Efficient meshing of a wind turbine blade using force adaptive mesh sizing functions

Alireza Maheri*, Siamak Noroozi, Chris A. Toomer, John Vinney

Faculty of CEMS, Frenchay Campus, University of the West of England, Coldharbour Lane, Bristol BS16 1QY, UK

Received 4 May 2005; accepted 14 December 2005
Available online 13 February 2006

Abstract

This paper describes mesh sizing functions for discretization of a wind turbine blade as a shell structure. Two different functions, one along the blade span and the other chord-wise, are presented. The effect of the magnitude of the aerodynamic force has been considered in a span-wise mesh sizing function to obtain a force-adaptive mesh generator, applicable when the blade needs to be analysed as a part of an aero-structure problem. The direction of the aerodynamic force has been considered in the chord-wise mesh sizing function to improve the mesh efficiency. Results show a large improvement in the rate of convergence when the direction of the external force contributes towards the chord-wise mesh size.

Keywords: Wind turbine blade; Adaptive mesh; Shells

1. Introduction

Generally, a complete meshing procedure includes three steps: first the domain is discretized, based on its geometry and the physics of the problem; then the problem is solved; finally refinement occurs based on an error analysis. The last two steps will be repeated (the inner loop in Fig. 1), until the final convergence is achieved. In most mesh generation methods the domain is discretized based on its geometry alone and the physics of the problem is not usually involved in any direct sense. As a result of error analysis, regions that need more refinement are identified and local refinements take place. The

*Corresponding author. Tel.: +44 117 3282643; fax: +44 117 3283800.
E-mail address: Ali2.Maheri@uwe.ac.uk (A. Maheri).

0960-1481/$ - see front matter
doi:10.1016/j.renene.2005.12.005

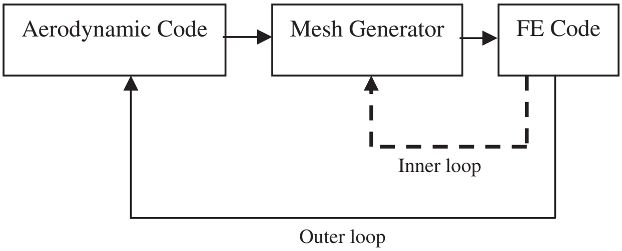

Fig. 1. Aero-structure coupling.

physics of the problem impacts indirectly on the mesh size through the error analysis procedure [1–3].

The issue of efficiently generating and refining a mesh is important in order to save computational cost, but it becomes vital when the structure is involved in an aero-elasticity problem which is iterative in nature. In these problems a FE code is linked to an aerodynamic code and needs to run many times (the outer loop in Fig. 1). Using a poor mesh with redundant elements, due to over-refinement or locating elements improperly, can be very time consuming. On the other hand, if the domain has been initially discretized only based on its geometry, to refine it efficiently without any over-refinement a complete error analysis over the entire domain is necessary.

In the case of a wind turbine blade made of a composite material with bending–torsional coupling, which is subjected to a real run-time load, there is a coupling between the external load and the angle of twist of the blade. As the aerodynamic load is applied on the blade, it starts to twist and as a result the aerodynamic load will change. In other words, in each iteration the physics of the problem varies and therefore there is no guarantee that the mesh that has been used to give a converged solution in the first iteration, gives a correct solution in the next one. To be assured of having converged solutions, one option is carrying out a complete meshing procedure by running an inner-loop iteration between FE code and mesh generator in every single iteration of the outer loop. This is very time consuming and impractical. The second option is to impose the effect of incorporating physical parameters, here the aerodynamic force, into the mesh sizing function. In doing this, the mesh becomes adaptive to the new physical conditions and the inner-loop iteration can be omitted.

A tapered pre-twisted horizontal axis wind turbine (HAWT) blade has a relatively complicated geometry and therefore semi-automatic meshing is much faster than automatic meshing and also can be more efficient if the physics of the problem contributes to the mesh sizing. By linking a force adaptive mesh generator between the aerodynamic code and the FE solver, nodal forces automatically will settle to new values in each iteration.

2. Blade domain discretization

Normally, no concentrated load is applied on a wind turbine blade. Geometry and material discontinuities, as two other sources of stress concentration, take place along lines rather than at points. Therefore, in FEA of a wind turbine blade, no point refinement is necessary (Fig. 2). Because of this we can apply strip refining rather than a point refining