Design, Manufacturing and Tests of Large Wind Turbine Rotor Blades

J. A. GÜEMES

ETSI Aeronáuticos, Universidad Politécnica de Madrid,
28040-Madrid, Spain

and

F. AVIA

Instituto de Energías Renovables,
Avenida Complutense 22, 28040-Madrid, Spain

ABSTRACT

The main requirements influencing the design of wind turbine rotor blades are discussed. The key element in achieving an economically successful WECS is the ability to manufacture the rotor blades at low cost in a configuration which will meet the severe structural requirements, produce a high level of performance and have a long life with low maintenance. A new manufacturing method has been conceived and successfully tested.

Details on the process and the ongoing qualification program are given.

1. INTRODUCTION

Starting with the oil embargo, a large number of activities has been undertaken looking for new energy sources. Wind energy conversion systems (WECS) are thought as the most effective to produce electrical energy. Every range of power has been investigated. Small machines, up to 50 kW, mainly intended for individual or isolated applications. Medium size (typically 300 kW) or large machines (more than 1000 kW), connected to utility networks, could afford approximately 3% of the overall electric energy production.
energy consumption at a cost competitive with fossil or nuclear fueled sources.

Large machines are potentially the most effective in cost terms, due to the scale effect on the cost of the components. At the present time, technology for small or medium size machines has attained its maturity, running for long periods without need for special attention. The costs of these systems are still high, needing institutional help to develop its market.

Large systems are at the demonstration stage. Contributing to the international efforts, European Communities are sponsoring several projects in this area, one of which, called AWEC-60 (Advanced Wind Energy Converter, 60 m diameter), is being developed by German and Spanish firms. This chapter deals with some of the design requirements, materials and processes considered, and the concept selected for this AWEC-60 rotor blade.

2. DESIGN REQUIREMENTS

The external blade shape is dictated by aerodynamics requirements, to achieve the maximum annual energy output, the wind variability being taken into account. Minor adjustments in external geometry are allowed, for structural or manufacturing reasons, but their effects on performances have to be carefully monitored.

Internal blade geometry has to be defined to satisfy three structural criteria:

(A) High strength to withstand the aerodynamics, gravity and inertial loads resulting from operational and extreme loading conditions. Fatigue and environmental effects have to be considered.

(B) Adequate stiffness and structural damping to avoid strong resonances. Natural frequencies must be higher than rotor speed, and non-coincident with its harmonics, in order to avoid dynamic load amplification.

(C) Aeroelastic stability requirements. Rotary wings are prone to flap-lap and torsional modes of instability. Gravity centers in each section must be located properly, and high torsional stiffness is required. For this reason the concept of a structural D spar is usually preferred over the two halves of a monocoque structure.

For quality and cost requirements, this chapter mainly concerns materials and process selection. Early designs had tried metallic structures,