In this paper the initial layout of a 2 MW composite wind turbine blade is designed first. The new airfoils families are selected to design a 2 MW wind turbine blade. The finite element parametric model for the blade is established. Based on the modified Blade Element Momentum theory, a new one-way fluid-structure interaction method is introduced. A procedure combining finite element analysis and particle swarm algorithm to optimize composite structures of the wind turbine blade is developed. The procedure proposed not only allows thickness variation but also permits the spar cap location variation over the structure. The results show that, compared to the initial blade, the mass of the optimized blades is reduced and especially for the scheme II (the location of blade spar cap is seen as one of the variables) which exhibit more mass saving. This present study has important significance for the structural design and optimization of wind turbine blades. © 2012.