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Optimizing Output Power of a Variable Speed Synchronous Generator by Controlling Excitation and Load Restistance

Michael George Edds, *University of Massachusetts - Amherst*

Publication Date
1980

Abstract
Since 1973 the University of Massachusetts Energy Alternatives Program has been involved in a project, the UMASS Wind Furnace (WF-1) which is directed at supplying the heating needs of households in northern climates. This project had as its inception an attempt to design and build fiberglass rotor blades. Since then the combined efforts of students and faculty from many engineering departments have produced a facility whose purpose is the study of wind and solar energy for useful purposes. The current Wind Furnace Model (WF-1) utilized a wind-driven electromechanical system to generate electrical energy. This energy is then dissipated through resistance heaters and either stored thermally or delivered directly to the house. It is the theory and design of the electrical power system that is the primary topic of this report. In 1974 during the design stage o f the Wind Furnace, I volunteered to work on the electrical power system for this wind turbine generator (KTG). Basically this involved describing how the generator was to be used to provide heat to the house and how it would interface with the rest of the KTG. As a beginning I was given a plot of output power as a function of wind speed representing the desired WTG performance. This preliminary curve, Figure 1, was based on the best estimates available a t that time o f the performance o f the blades and mechanical transmission coupled to a crude model of the generator, based on the manufacturer's data sheets (see Appendix A). The curve in Figure 1 shows the output power as a cubic function at wind speed, with rated conditions o f 25.32 Kw at 26.1 mph. The final cubic curve, Figure 2, has as rated conditions an output of 25 Kw a t 26.1 mph, and 1800 rpm at the generator. The low end of the generator's speed range, 400 rpm, was set by the cut-in wind velocity of approximately 6 mph. It was my opinion then that a better generator model was needed in order to arrive at a method of controlling the generator for the desired output. That concern has led to this thesis.

Pages
159