AUTOMATIC CONTROL AND LOAD REGULATION OF A SOLAR-BIOMASS POWERED PROTOTYPE COMBINING A FLUIDIZED BED AND A STIRLING ENGINE FOR HOUSEHOLD COGENERATION

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A new concept system is presented for the combined production of heat and electric power. Two renewable energy sources are used, i.e., direct solar (thermodynamic solar) and biomass (indirect solar energy). Biomass combustion is conducted using a fluidized bed combustor. A second source of energy, given by the direct irradiation of the bed with a concentrated solar radiation, is integrated in the same system. A Scheffler mirror is planned to carry out sunlight irradiation of the fluidized bed in a fixed focal point. A Stirling engine, integrated in the fluidized bed, converts heat into electricity. A working prototype, referred to as MEGARIS, has been developed very recently and is presently under test.

The proposed paper is mainly devoted to automatic control and load regulation of the MEGARIS prototype. A simple dynamic mathematical model has been developed for the fluidized bed acting at the same time as solid biomass combustor, solar light receiver and heat exchanger toward the Stirling engine. For control and regulation purposes, the bed temperature has been taken as the controlled variable; the process variables acting as disturbances have been identified, e.g., the sunlight power; the main manipulated variable has been considered the solid biomass feed rate; the system parameters that are subject to uncertainty have been identified, e.g., the power dissipated through insulation. The control and regulation strategy relies on a feedback architecture. Different theoretical approaches and sophistication levels have been proposed and tested for the loop controller, i.e., PID, Fuzzy Logic and predicting model-based.

Both the dynamic model and the controller algorithms have been developed in Matlab scripts and implemented in Simulink codes.

A systematic simulation has been carried out for both the open loop and closed loop system responses to those changes that are realistically expected in the main process variables or in uncertain parameters. In parallel, the dynamical analysis of the mathematical model of the prototype has been carried out with Matcont.

The results obtained so far are very encouraging to achieve flexibility and controllability of the MEGARIS prototype.

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