Scientific and technic report -stage 4
The integrating of the control system into the HIL structure of the biorefinery type plant

Abstract

Stage 4 of the project No. 269/2014 – BIOCON (*The implementation of the control system on the HIL structure of the biorefinery type plant*) had two main objectives: 1). finalizing the biorefinery, both in terms of hardware and software, to be functional for the experiments in the activities 4.2 – 4.5; 2). the experimental control strategy proposed in the previous stages of the project. To fulfil the two objectives six activities have been done, as follows: Activity A4.1 – *The implementation in the basic software of the control laws designed in stages II and III,* Activity A4.2 – *Conducting experiments for the identification and experimental validation of the model of photosynthetic growth of microalgae in the photobioreactor, a process controlled with the process computer;* Activity A 4.3 – *The analysis of experimental data in the case of the process of photosynthetic growth of microalgae in photobioreactor;* Activity A4.4 – *Conducting experiments for experimental validation of the biorefinery plant, controlled with the process computer, according to the HIL structure (Hardware in the Loop) adopted in the project;* Activity 4.5 – *The analysis of the experimental data in the case of the biorefinery plant;* Activity 4.6 – *The dissemination activity of the results*.

Activity 4.1: the control system software of the biorefinery has been finalized. The pH control, average irradiance and biomass concentration loops were integrated in the general Simulink model. It was also included the mathematical model of anaerobic digester. This model is loaded in the dSpace board and functions autonomously, in real time, in connexion with the controlled process. The report contains the extended Simulink biorefinery plant, according to the HIL structure adopted in the present project.

Activity 4.2: there were carried out three experiments of microalgae growth in the photobioreactor. A series of preparing operations were performed, such as: the selection of the type of microalgae used in experiments, the positioning of the gas diffuser for the most efficient homogenization of the photobioreactor content, the determination of the correlation between turbidity and the biomass concentration etc. The first experiment was a batch experiment carried out with the aim to bring the concentration of the microalgae culture to a value high enough for continuous operation, and the other two served mainly for the calibration of turbidity sensor based on some laboratory analyses (the determination of the biomass concentration using the method of the dry matter measurement) and for the identification of a mathematical model of the photobioreactor for the design of the control laws.

Activity 4.3: consisted in: 1. The analysis of the efficiency of the filtering of the process signals. The process is strongly affected by noise (especially high frequency noise), the most affected being the turbidity signal. Initially, the team has opted for an order 4 filter to which it was subsequently serially connected with an order one filter. The resulted filter reduces significantly the noise but introduces a delay of tens of minutes in the measurement of the biomass; 2. The identification of a linear mathematical model of the photobioreactor for the design of the control laws.

Activity 4.4: three experiments were performed for the control of the biorefinery plant. Prior to the three experiments, the controls of the three loops (pH, average irradiance and biomass concentration) were installed and adjusted. In the first experiment, there were performed the controls of the pH to values between 6-6.5, values considered optimum and recommended by the technical literature, of the average irradiance and of the biomass concentration to the optimal reference in accordance with the conclusions from RST stage 3. In the second experiment, it was analysed the influence of the anaerobic digester on the photobioreactor. The third experiment targeted the control of the biomass concentration with a type Mamdani fuzzy controller.

Activity 4.5: the results of the experiments have been analysed. There are presented results regarding the pH control, the average irradiance and the biomass concentration at the optimal reference. What needs to be observed as being one of the original contribution of the project, is the achievement of the simultaneous functioning of the three control loops (pH, average irradiance and biomass concentration), loops which influence one another, given that the anaerobic digester ‘disturbs’ the functioning of the photobioreactor.

Activity 4.6: there were published 12 articles in the proceedings of major scientific events of the field, two of them being delivered at the IFAC Congress, from Toulouse, France.

In conclusion, all the activities in stage 4 of the project have been 100% fulfilled, the results being obtained in experimental regime on an plant designed by the team of the project, plant that proved to be reliable, efficient and that permitted the acquisition of high level original scientific results.