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DEVELOPMENT OF A PLC BASED DATA ACQUISITION AND CONTROL SYSTEM FOR BIOMASS GASIFIERS

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Abstract
In this research, a PLC controlled data acquisition and control system has been developed which can be installed on different types of gasifiers to monitor the gasification processes. The developed system is a modular system and equipped with analog and digital input / output expansion modules. The developed system was tested in the research by used downdraft type gasifier. With the developed prototype data acquisition and control system, the process variables can be saved to USB memory in adjusted periods and monitored on a HMI panel during gasification processes. The system has been tested successfully in experimental studies and the obtained graphs of temperature, pressure, flow rate and mass change are presented in the text.

Keywords: automation, biomass, data acquisition, gasification reactor, plc.

INTRODUCTION

In recent years, researchers focused on the possibility of generating biomass electricity with small-scale gasifiers. The way to produce synthesis gas economically and efficiently by biomass with a small scale gasifier is to effectively monitoring and controlling the gasification processes. From this point, it is important that the developed gasifiers are equipped with suitable and economical automation systems.

Erlich and Fransson [1] studied on a downdraft gasifier. The temperature distribution in the reactor was measured by type N thermocouples. There were four thermocouples in central positions and two measuring wall temperatures. In the highest temperature region the measuring tolerance of the thermocouple was in the range of ±10 ˚C [2] but due to the process dynamics the temperature here fluctuates heavily. The temperatures presented within this study were given as average or in intervals where the fluctuation was large.

Pedroso et al. [3] designed and constructed that a bottom feed gasifier. The reactor produced wood gas continuously for 6h and worked stably during all the experiments. The data acquisition system was data logger based. Sensor data were collected by data logger.

Weiland et al. [4] defined that for safe process control and automation, a PLC (Programmable Logic Controller) based control system was used, and relevant process values were stored in a database for post processing of the results from the experiments.

Because of the cost efficiency and safe automation and process control, in this study a PLC based universal control system was developed for biomass gasifiers.

EXPOSITION

In this study, a PLC-controlled data acquisition and control system was developed to monitor and to control the gasification processes by mounting on small scale gasifiers. The system was equipped with analog and digital input/output modules suitable for structurally expanding. This expandable structure allows the developed control system to be used in gasifiers of different sizes, which require a greater number of channels or to collect more data from the different points of the developed gasifier.

In the developed system, Enda ELC-186R was used as the processor module. It has eight digital inputs and six relay outputs. Some expansion modules were directly connected to this processor module to get analog sensor signals:

GXM-40U temperature analog input modules were used for temperature measurements. This module is compatible with J, K, B, C, E, N, R, S, T type thermocouples, PT 100, PT 1000 and RTDs. In the study, K-type thermocouples were used. Its temperature range is -250 □C to 1250 □C.

A GXM-40A analog input expansion module was used for converting analog signals to digital values for inputs. Then PLC could use these signals for control purposes. It has four channels and each of the channels can be configured as current or voltage input independently. Its analog input range is 0-10 VDC, 0-20 mA and 4-20 mA optionally.

A GXM-10L load cell module was used for connection of load cells. ESIT BB100 type load cells measured the weight of loaded biomass feedstock.

Enda EOP 41-70ETE model HMI provided a visual representation of the status of the gasification process, data logging and machine control in real time to operators. It was equipped with a USB host port. Through this port, USB flash memory was connected to perform uploading, downloading, project operation and storage of related data. HMI was connected to PLC via RS232. Visual program for HMI was developed in user-friendly programming software ENDA _V2.0. During gasification process, HMI screen display was shown in Figure 1.

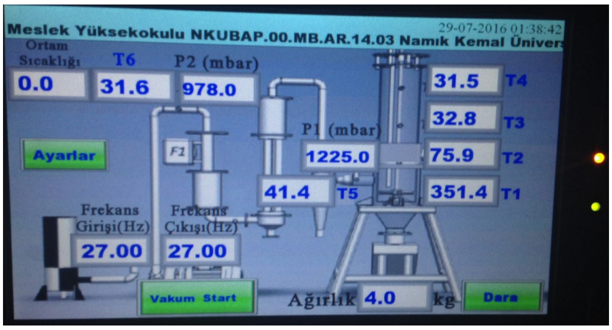

Fig. 1. Main screen of the program downloaded to HMI

The gas flow in the system was provided by a cycle-controlled vacuum fan. GREENCO 2RB 210-7AH16 model vacuum blower was used for this purpose. In the system, the frequency control of the vacuum fan motor was carried out with Siemens Sinamics G110 inverter. The inverter installed in the automation cabinet was controlled via HMI.

Generated syngas was measured by an orifice plate which has 18 mm of orifice diameter and differential pressure gauge.

In the developed system, pressure measurement was made from the two points at the outlet of the reactor and before the blower. Measurements were made with two Keller brand 4-40mA analogue output pressure sensors connected to the GXM-40A analog input module. The measured pressure information was sent instantaneously to the HMI panel and recorded in a minute intervals.

PLC program of the system was written in EndaSoft PLC editor software. It supports ladder logic programming. Program tasks of the PLC were written using ladder logic programming. Program was downloaded to PLC device via ethernet port. Hardware configuration of the PLC system and the channels of GXM-40U were shown in Figure 2.

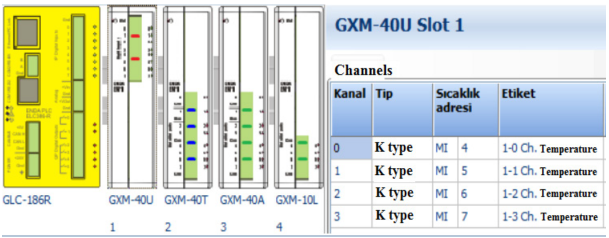

***Fig. 2.** Hardware configuration of PLC*

General view of the gasifier and hardware of the data acquisition and control system designed in the study was shown in Figure 3.


***Fig. 3.** General view of gasifier and control unit*

System was tested with rice stalk pellets gasification. The data were successfully recorded on the USB flash memory connected to HMI until the end of the gasification period. The recorded data were processed in MS Excel program.

Temperature measurements at six different points from the beginning of the gasification process in the reactor were recorded as a one sample per minute (Figure 4).

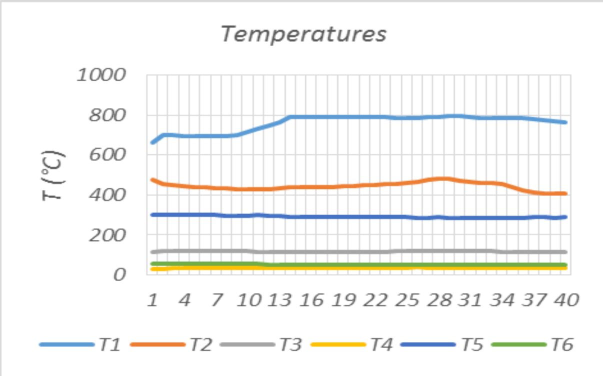

Fig. 4. *Temperature curves recorded during gasification*

Pressure (Figure 5) and weight data (Figure 6) were successfully acquired.

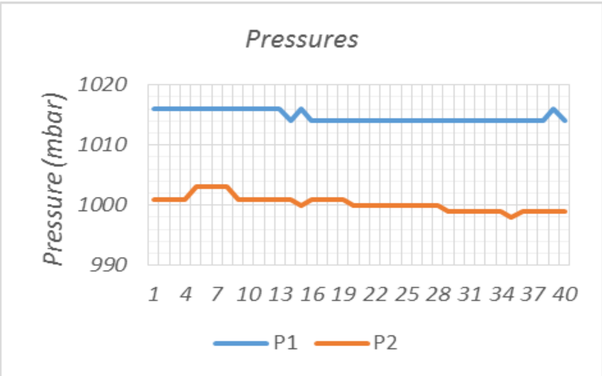

Fig. 5. *Pressure curves recorded during gasification*

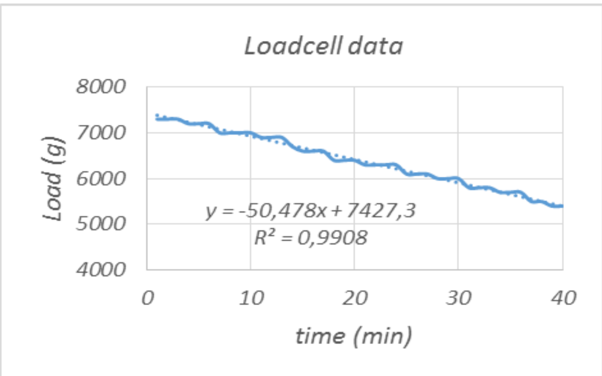

Fig. 6. *Weight change rate curve obtained by weight measurement*

Mass flow rate data were successfully acquired (Figure 7).

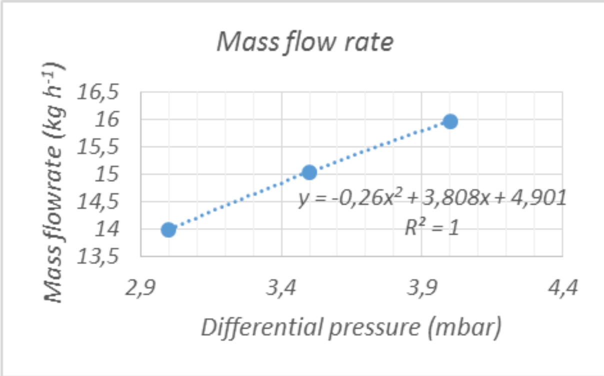

Fig. 7. *Differential pressure-mass flowrate curve*

CONCLUSION

It has been observed that the PLC based automation system designed in the research has successfully performed the expected data acquisition and control processes.

Equivalence ratio dictates the performance of the gasifier. The quality of gas obtained from a gasifier strongly depends on it. It must be kept between 0.2 and 0.4 by adjusting the amount of air supplied to the system. This was achieved by the vacuum fan in the system. It was adjusted by changing the drive frequency that controlled the fan motor via the HMI control panel.

The designed electronic measuring system was mounted on the gasifier, and operating conditions and parameters of biomass gasification experiments were successfully recorded.

ACKNOWLEDGE

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