

## THE METHODOLOGY OF GRADE OF GASIFICATION REACTOR EFFECTIVITY

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### **Abstract**

*Ecology problems are addressed in all areas of engineering. Gasification is widely used methodology, which allows to power vehicles and fuel generators via alternative fuel. The more it seems important to address the issues of gasification in the group of scientists dealing with machines. In article authors present results of methodology in effectivity of gasification graduation. The base of experiment is the complimentary reactor, which was made for gasification of different materials. Gases that are achieved on the output of the system are used to supply combustion engines. In article, expect mentioned methodology, authors present reactor build and measurement (including complimentary software) system, mounted on system. The new energy supplies are still discovered. At the same time, researchers on good know substances are in progress. In article, authors are presented one of the methods of gasification reactor effectivity. Authors' reactor has a burning chamber, and outlet circuit. Presented methodology was relayed on E-E system with software part. System is contained a few thermocouples with multiplexing ADC card for acquisition of data. All parts are presented in an article. An article is a result of progressing grant in DEMONSTRATOR+ program (no. WND-DEM-1-527/001).*

**Keywords:** *gasification, reactor, process effectivity*

### **1. The conception of gasification reactor**

Schematic diagram of attaching thermocouples shown in the following drawing paper (Fig. 1). Descriptions of thermocouples are incremented according to the distance of the combustion chamber (TI to TIV) [1]. The thermocouples are connected to the measuring inputs (A0-A3) Analog to Digital data acquisition system from National Instruments 9215 through conditioning amplifier (Fig. 2).

Data acquisition system (Fig. 2) consists of an amplifier card conditioning and A/D (NI9215). Data logging was used standalone program "thermo", designed and compiled in LabView2014. The sensors are connected to the amplifier by means of screw connections, different lengths, and the compensation is made in a software. The output of the amplifier is connected to the measuring card using coaxial cable, terminated with a BNC. NI9215 is connected to the computer via USB (2.0).

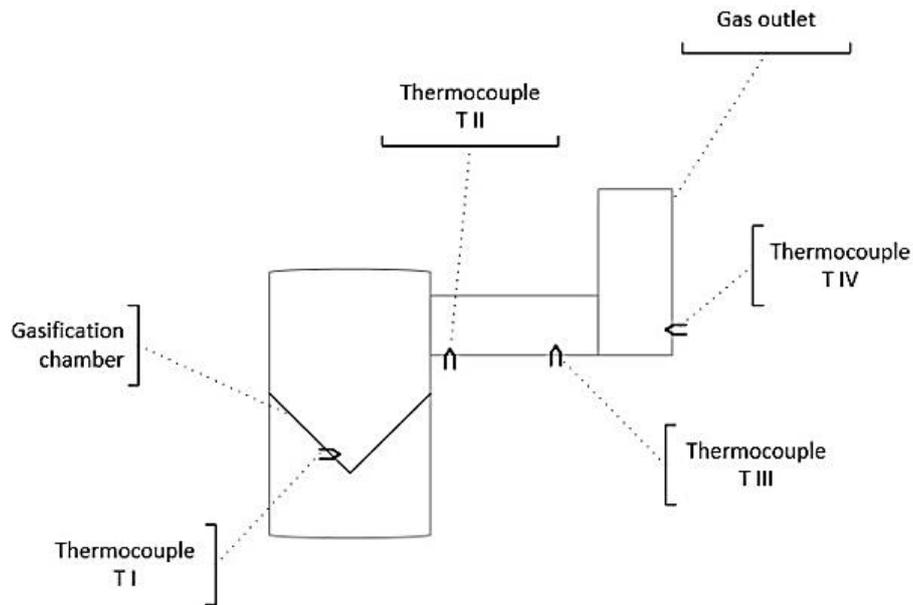


Fig. 1. Schematic diagram placement of thermocouples

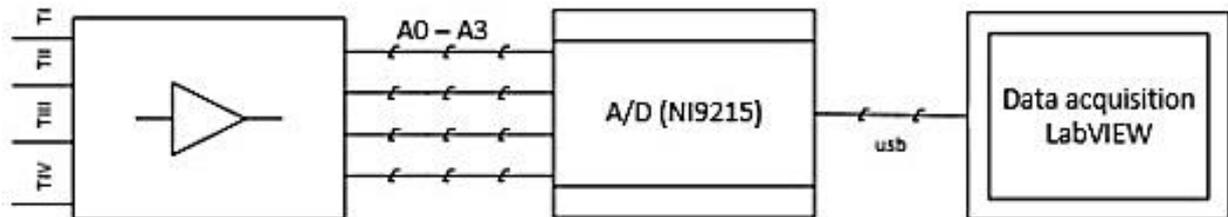


Fig. 2. Block diagram of the measuring circuit

The following figures are physically mounted sensors in these places.



Fig. 3. Photos of the mounted sensors; TI left in the combustion chamber (shown pellets ready for gasification) to the right exhaust gas with TIV

## 2. Sensors and system characteristic

For the purposes of measurement used thermocouple type K (NiCr-Ni) [2], TI was mounted in the production process in the combustion chamber. Physical structure of installed sensors is shown in Fig. 4.

Voltage characteristics of the used thermocouple measurement of the selected area, is shown in Fig. 5.

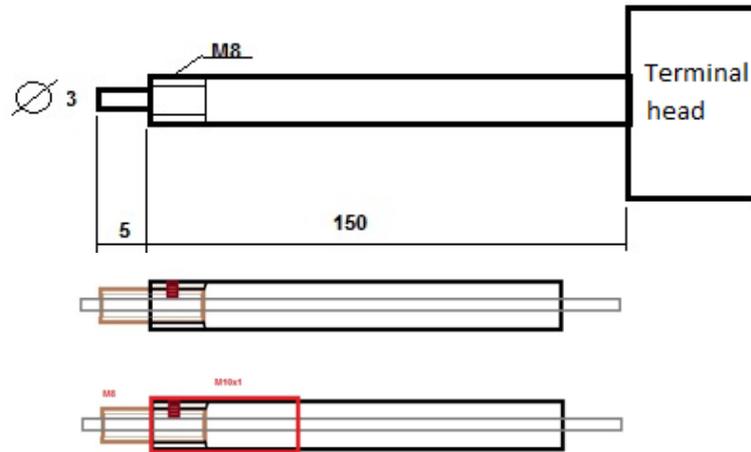


Fig. 4. Throw the whole sensor system (first figure from the top) and the construction of the connector

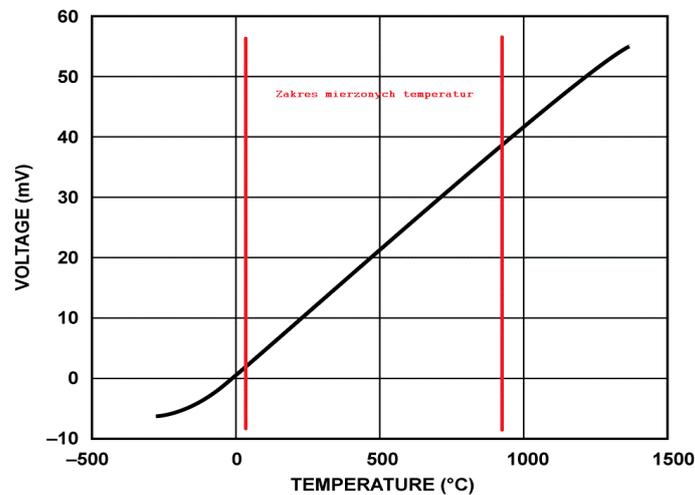


Fig. 5. The operating characteristics of the sensor to the preferred operating range

The processing system A / D uses NI card, card 9215th model is characterized by a switchable (between channels) sampling (in this case, the process of switching frequency of 4 Hz was so that it was possible to measure the temperature of 1 sec.) [3]. Posted card version with BNC connectors (Fig. 6) and the system allows communication with the software part of the acquisition, through USB (2.0).



Fig. 6. Measurement ADC card NI9215 communication with the system via USB

Basic parameters of the card:

1. The measuring range of  $\pm 10$  V;
2. 4 multiplexed channels;

3. Max. sampling rate of 100 kS/s/ch;
4. 16-bit resolution;
5. Protection 60 V DC (with respect to the ground);
6. The method of connection BNC connector.

To visualize the results of measurements used visual programming environment LabVIEW (the latest version 2014). It contains 13 tools to optimize the efficiency of programming, enhanced training materials on-line application LabVIEW RIO and new tools in the LabVIEW Tools Network services, such as business Bergmans LabSocket Mechatronics System LLC. This software allows remote access to LabVIEW applications through a Web browser, without the need to install any additional plug-ins or software that runs on the client side.

Figure 7 shows the wiring diagram of the program with explanations. DAQassist is the block for communication with the corresponding measurement chart. Set the measurement of each channel every 1 sec. and automatic measurement range. Since the output signals are not directly equivalent temperature (input voltage mode), so the next step, it was necessary to use a multiplier (120) and a summing circuit for temperature compensation (-2). In the next block identifies specific system calls, joining compensation connection cable (shown with a value of 0). For each channel measurement, system attached as a virtual thermometer, and indicator values. After reconnecting all channel data is introduced in a Write to Measurement File, to allow a record to a file. The whole program is performed in a loop which allows (also) be stopped.

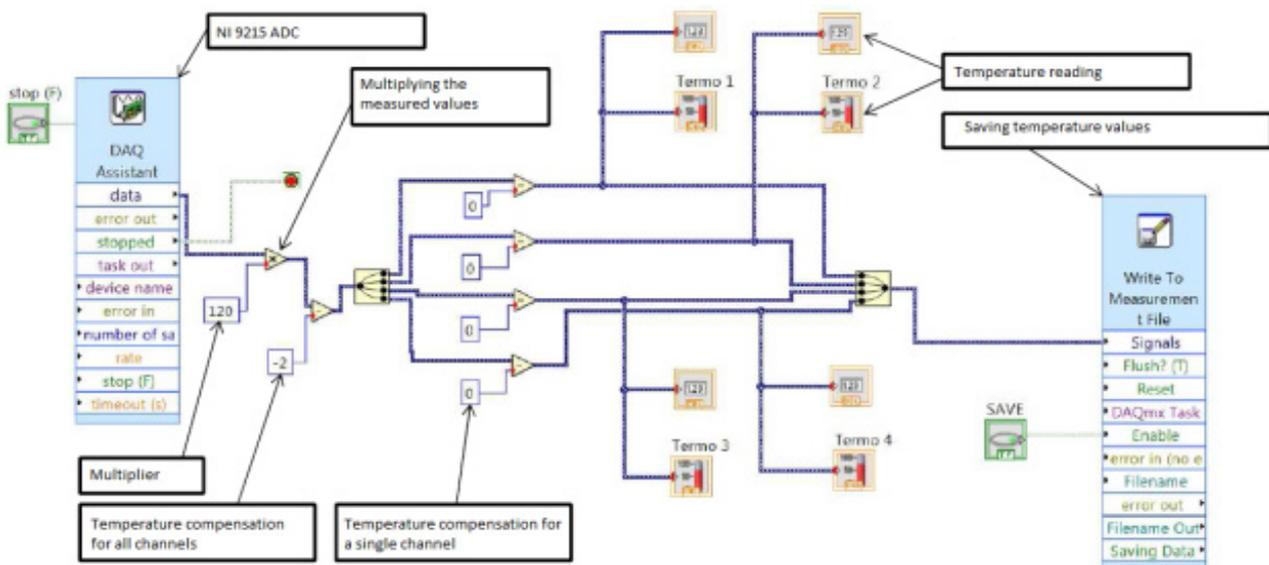


Fig. 7. Connection diagram temperature measurement system

GUI version of the program is shown in Fig. 8. On the panel marked with the number 1 are visualizations of temperature, derived from individual thermocouples. The panel labelled 2 are numerical values represented by the data from panel 1 (accuracy 0.01 deg. In the range of 0-10, 0.1 in the range of 10-100 and 10 deg. In the range of 100-700). After pressing the button “Stop” (3) is stopped the loop program. In any case, it is possible to write data to a file, use the “save” (4).

### 3. Experiment’s overview

#### 3.1. Substance A

The first substance was pellet (Fig. 3), and its parameters are located in Tab. 1 [6].

1.5 kg of substance A was placed in reactor chamber. Gasification process was started. Process of temperature increase is showed in Fig. 9.

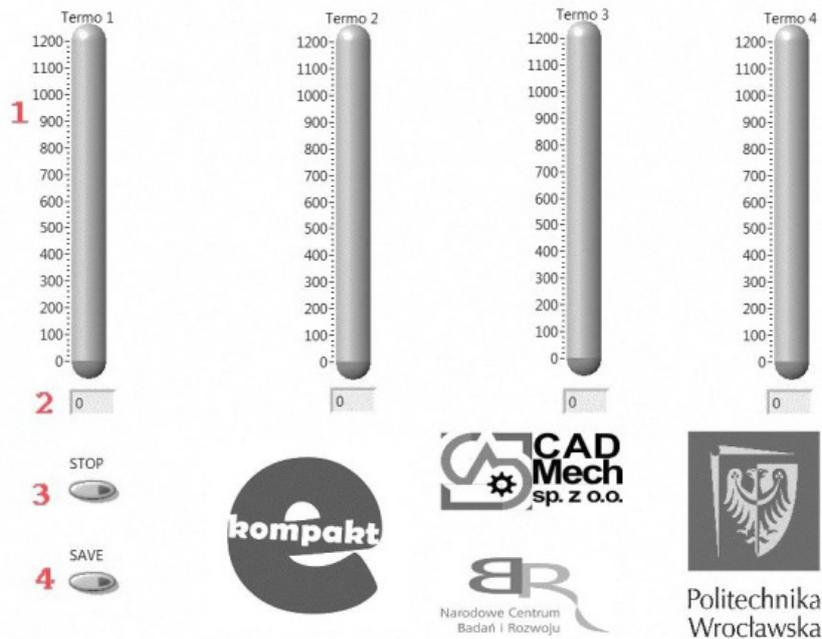


Fig. 8. GUI “thermo”

Tab. 1. Parameters of the A substance [6]

No.	var.	[%]
1.	humidity	8-14
2.	ash	1.5-6.5
3.	caloric value [GJ/mg]	13.5- 18.0
4.	carbon	45.0- 51.4
5.	hydrogen	5.09- 6.67
6.	brimstone	0.1- 0.4
7.	nitrogen	0.6-2.5

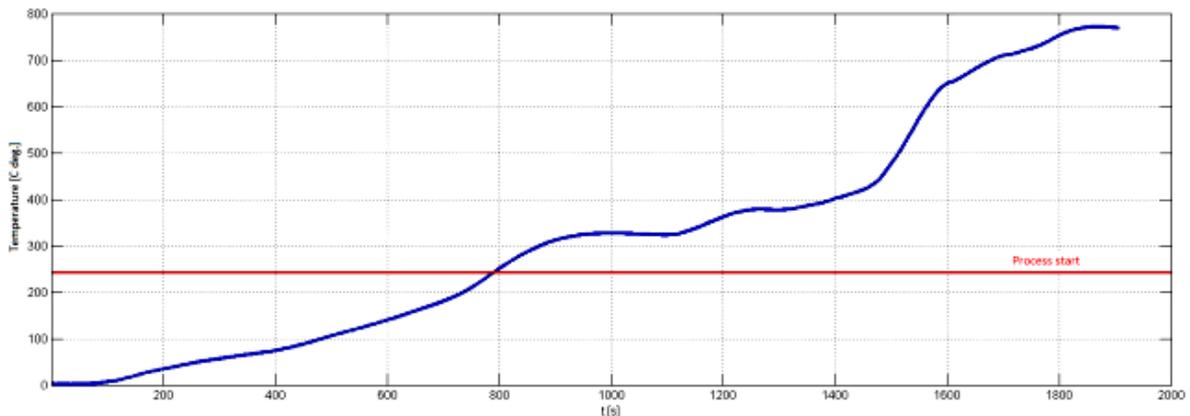


Fig. 9. Gasification process in chamber (substance A, 1.5 kg load, max. temp. 774°C)

In Fig. 9, the borderline (horizontal) is showed – it represented a start of process (temperature 240°C, under it process had active character, i.e. not produced gas suitable for combustion process). Samples of temperatures in passive process are over borderline. These samples were a base for effectivity defines. All samples, over borderline were grouped into 10 groups indicated on temperature range (for each sample). Values over 240°C are passive and increase effectivity. Histogram of these groups is in Fig. 10.

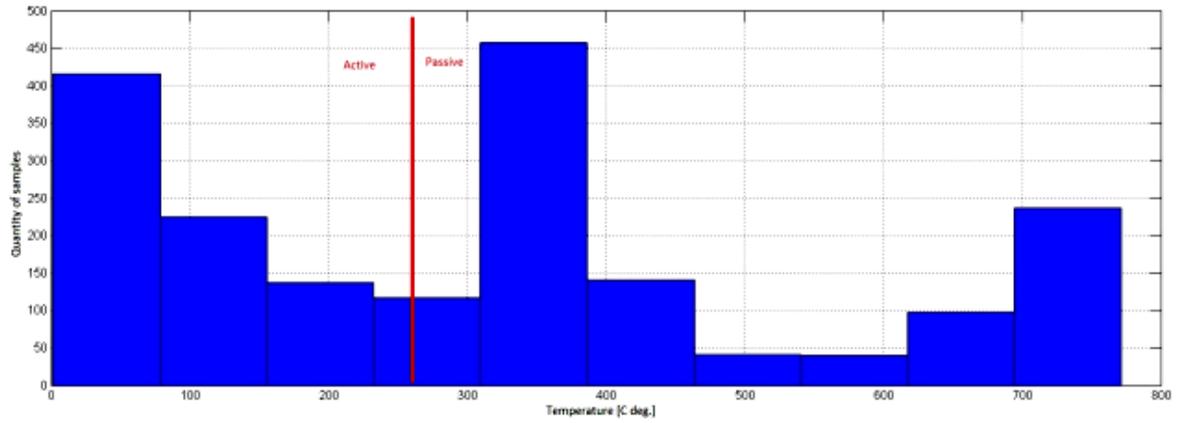


Fig. 10. Histogram of reactor effectivity for substance A

In passive process 1128 samples was measured, which means that 59.2% of all samples had passive character. Fig. 11 shows changes of temperatures in outlet (Fig. 1: TII and TIII).

Figure 12 showed temperatures changes, measured by TIV (Fig. 1). It was placed in output, thus showed factor of burning process (and represented temperatures of gas burn).

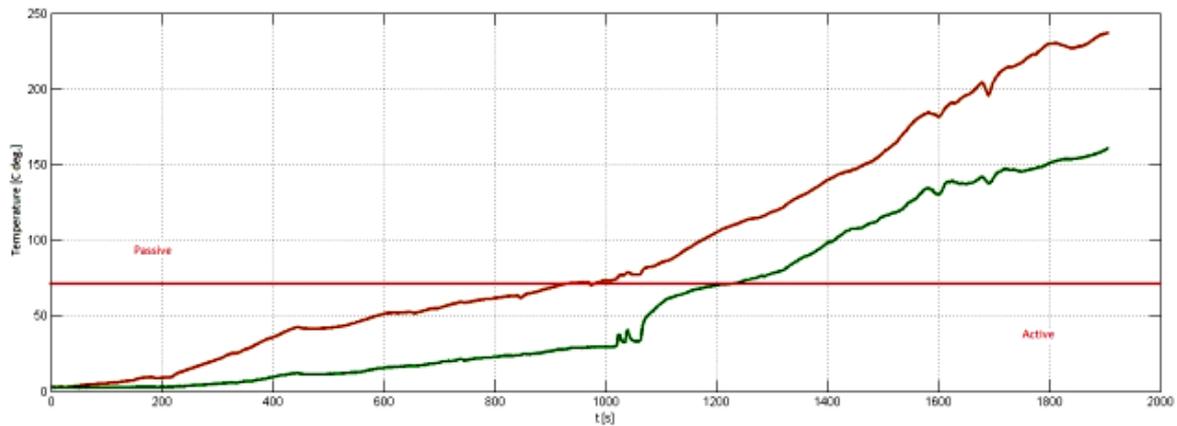


Fig. 11. Burning process of substance A: TII and TIII (green)

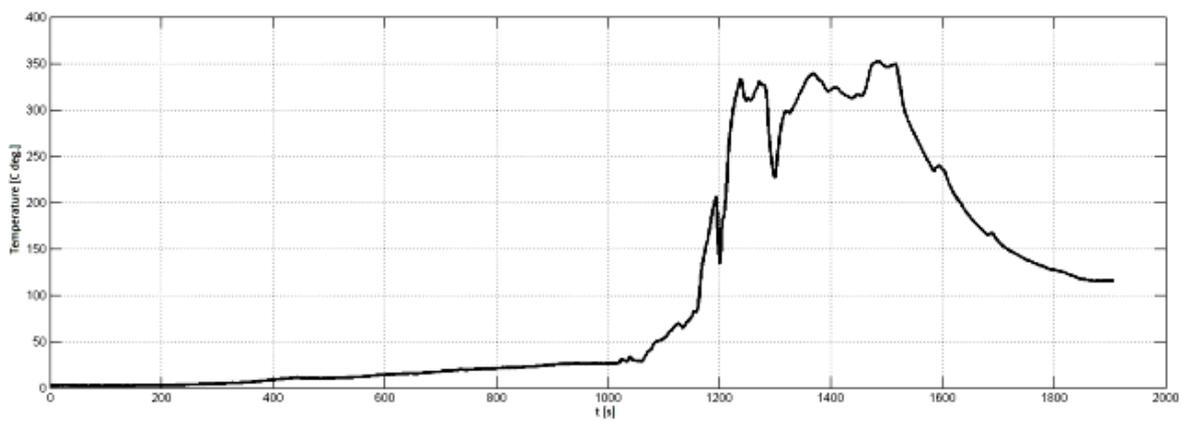


Fig. 12. Gas burning process for substance A: TIV

### 3.2. Substance B

Substance B was a sawdust and its parameters is located in Tab. 2 [6].

0.75 kg of substance B was placed in reactor chamber. Gasification process was started. Process of temperature increase is showed in Fig. 13.

Tab. 2. Parameters of the B substance [6]

No.	humidity [%]	ash [%]
1.	6-10	< 0.5

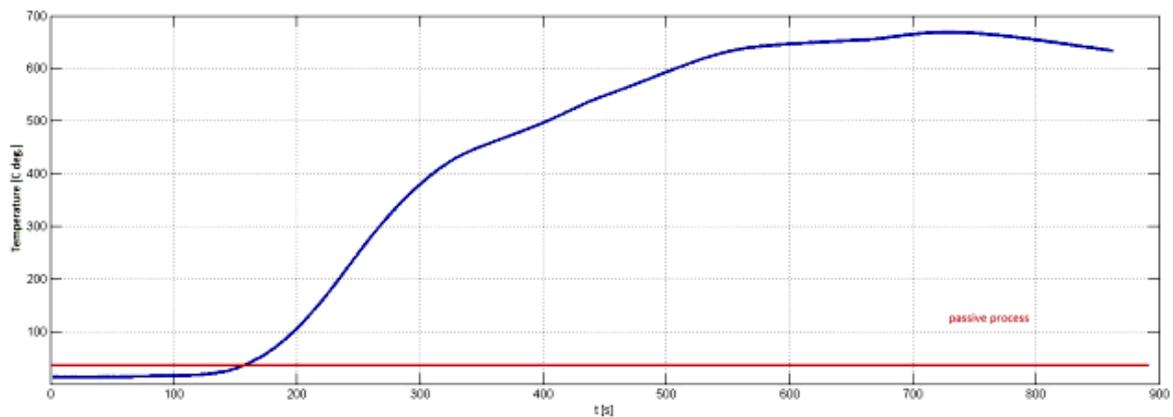


Fig. 13. Gasification process in chamber (substance B, 0.75 kg load, max. temp. 668°C)

Gasification process of substance B was more rough character (in time duration sense) and its energetic efficiency was too small to start combustion (thus gas burning on output). Passive process in this case, is a process, which not needed an extra (outside) energy. The quantity of respective sample is showed in Fig. 14.

The quantity of passive samples was 712, which indicate on 86% of all samples. Fig. 15 shows changes of temperatures in outlet (Fig. 1: TII and TIII).

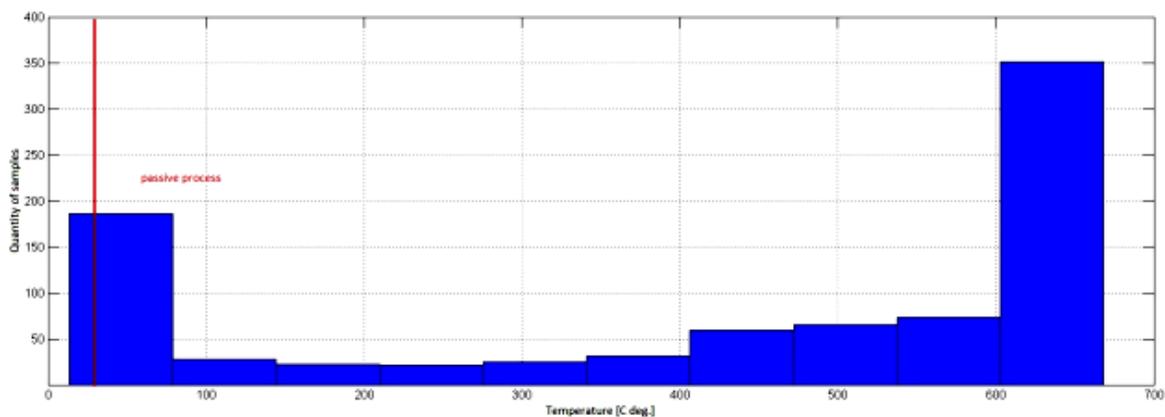


Fig. 14. Histogram of reactor effectivity for substance B

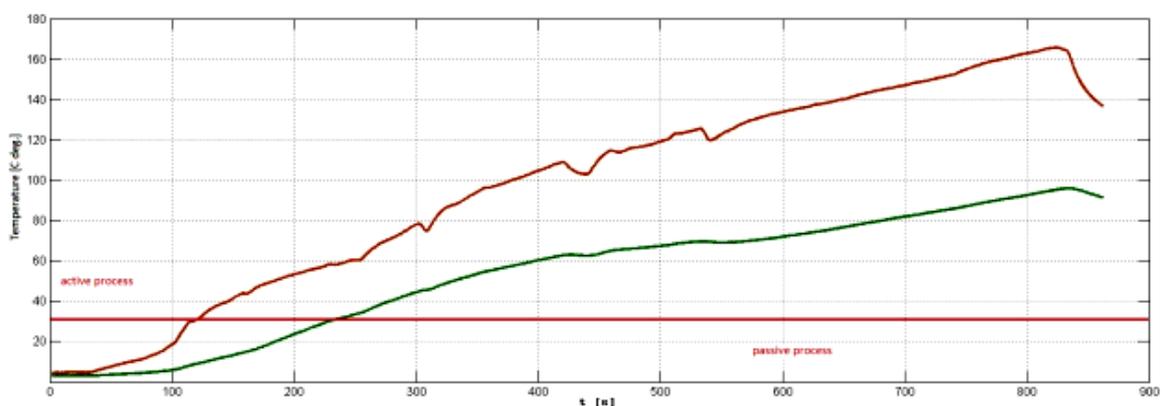


Fig. 15. Burning process of substance B: TII and TIII (green)

Figure 16 showed temperatures changes, measured by TIV (Fig. 1). It was placed in output, thus showed factor of burning process. In case of substance B output gas burning was not started.

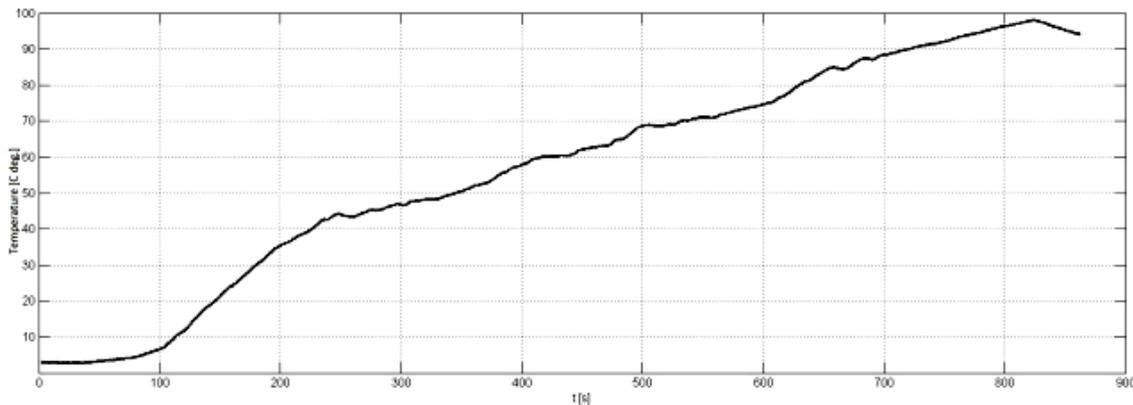


Fig. 16. Gas burning process for substance B: TIV

#### 4. Conclusions

Thermocouples K type was a proper (from sensitivity, resolution and answer time point of view) kind of sensors for examination of the gasification process.

Small value of sampling frequency (in this case 1 Hz) is enough to obtain measurement information. For this value, multiplexed ADC cards are enough.

There exist of methodology for grade efficiency of gasification process, but if process has passive character.

Gasification processes, directed to supply of combustion process must have enough density of gas for burn. In this case, pellet is good and sawdust is poor base for process.

Maximum value of temperature, which was achieved, was 774°C for substance A, and 668°C for substance B. Definitely it is factor of substances' densities and amount of substance in this same capacity (1.5 kg for substance A and 0.75 kg for substance B).

Programming languages, like MATLAB and LabVIEW completely covered project software needs.

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