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STRUKTURA SYSTEMU POMIAROWEGO NIEKONWENCJONALEGO OBWODU ENERGETYCZNEGO

A STRUCTURE OF THE MEASUREMENT SYSTEM FOR A NON-CONVENTIONAL ENERGETIC CIRCUIT

W artykule omówiono automatyczny systemu pomiarowy, który zastosowano w niekonwencjonalnym obwodzie energetycznym. Podstawą niekonwencjonalnego obwodu energetycznego jest układ trójzmienny, w którym silnik spalinowy o zapłonie samoczynnym jest podstawowym źródłem energii. System ten produkuje energię elektryczną i energie ciepłą na trzech poziomych termicznych. Opisany system jest niekonwencjonalny ponieważ zastosowano niekonwencjonalny obwód chłodzenia silnika spalinowego, który zaprojektowano jako termokompresor dla absorpcji ciepła z tego obwodu.

Słowa kluczowe: *niekonwencjonalny system energetyczny, system pomiarowy, niekonwencjonalny silnik spalinowy.*

The paper deals with an automated measuring system implemented in a non-conventional energetic circuit. The basis of a non-conventional energetic circuit is a trivalent system in which the ignition combustion engine is the source of primary energy. The system produces electric and thermal energy at three thermal levels. The system is referred to as non-conventional because of the non-conventional cooling circuit of the combustion engine which has been designed as a thermo compressor for absorptive cooling circulation.

Keywords: *non-conventional energetic system, measurement system, non-conventional combustion engine.*

1. Introduction

The aim of using energy contained in fuel in a more effective way together with the aim of reducing negative impact of “waste heat” produced by a combustion engine on the environment have led to the use of cogeneration and three-generation equipment.

Within the framework of the basic research task funded by the Agency for Support of Research and Development of Slovakia we have been solving the problem of a more efficient non-conventional usage of the part of energy taken away by the combustion engine cooling system for the production of cold. This type of combustion engine is simply referred to as the cooling engine. The preliminary scheme of the solved adsorption refrigerant system is illustrated in Fig. 1 and a view of an actual functional laboratory sample can be seen in Fig. 2.

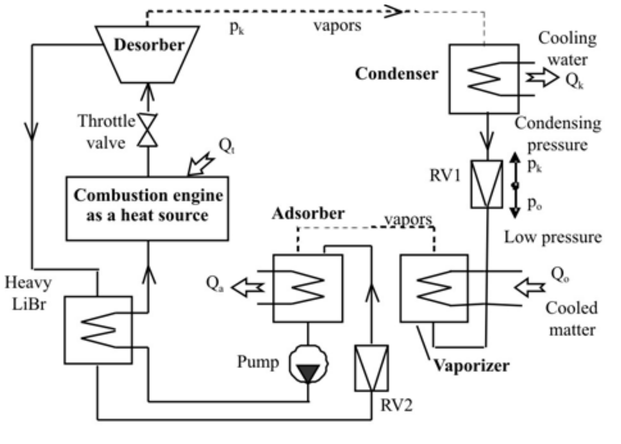


Fig. 1. Preliminary scheme of the solved adsorption refrigerant system

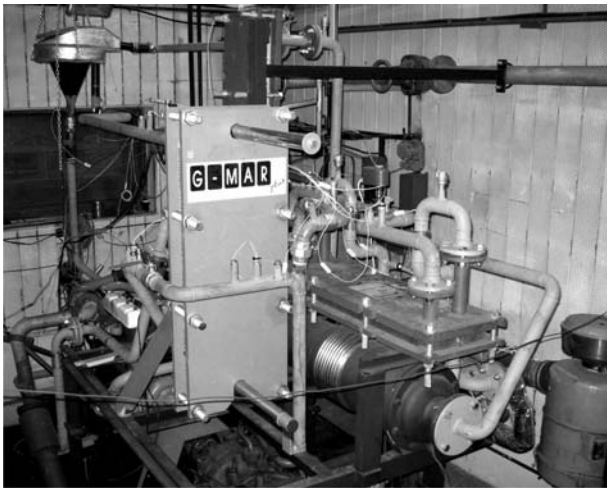


Fig. 2. A view of an actual functional laboratory sample

2. Measurement system

Construction work of the energetic plant with a non-conventional combustion engine has already started. The measurement system of the equipment is to be assembled soon. All important quantities on parts of the energetic system will be measured in order to evaluate the engine working state, temperature distribution, pressure distribution and thermal balance of the system [5]. The quantities measured on the combustion engine are as follows:

- torque by a strain-gauge sensor of the force,
- rotational speed of the combustion engine crankshaft by the incremental sensor position (which has 3600 impulses per revolution),
- temperatures measured by thermocouples of K and J types: temperature of intake air, temperature of oil, tempe-

rature of cooling liquid in the inlet and outlet, temperature of compressed air behind the blower, temperature of exhaust gasses in front of and behind the turbine,
- pressures: atmospheric pressure, air pressure behind the blower, pressure differences on the flow meter diaphragm in the inlet piping, pressure in the lubricating system,
- the fuel pump control rod position,
- fuel consumption measured by the mass method (measurement of consumption time).

The quantities measured on the refrigerant circuit are following [3]:
- flow of the LiBr cooling liquid,
- temperatures in all important places for evaluation of the thermal balance using thermocouples of K type,
- under-pressure in the desorber that functions of a vaporizer,
- pressure of cooling liquid in the engine in a place behind the electric pump.

A scheme of the measurement system of the non conventional energetic unit is illustrated in Fig. 3. The basic scheme of the non-conventional energetic unit with a cooling combustion engine is illustrated in Fig. 4.

The special software for computer measurements and control of the test bench was developed. The work was divided into two stages [5]:

1st stage (debugging of the problems regarding data acquisition). To begin with it was necessary for the measurement software to be able to record at least the following data:
- analog inputs on measurement cards (engine torque, temperatures, pressures, voltage),
- digital input from the incremental sensor of rotation.

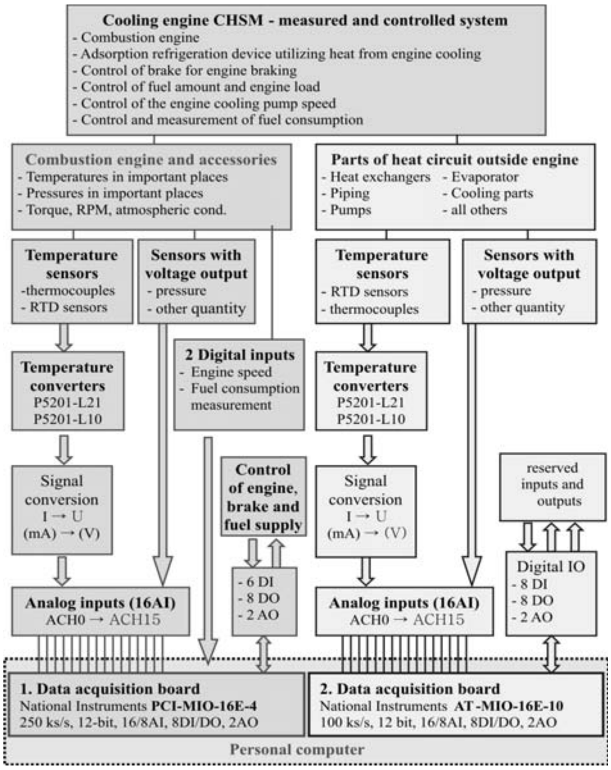


Fig. 3. Scheme of the measurement system of a non conventional energetic unit [5]

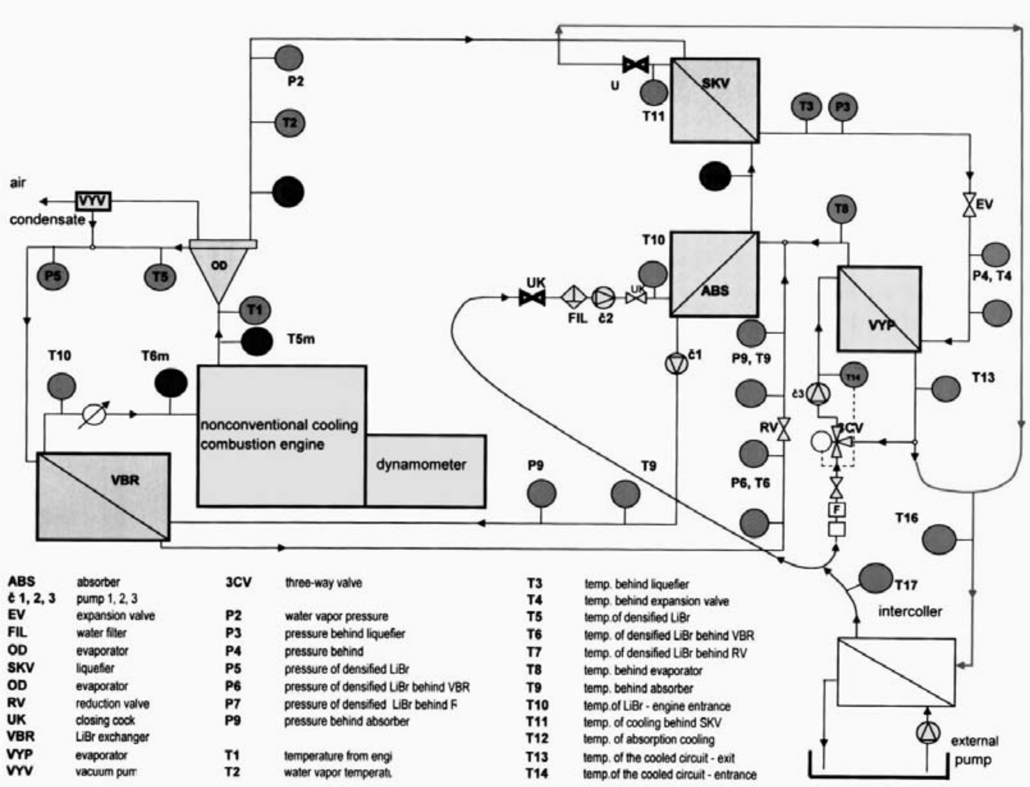


Fig. 4. Basic scheme of excellent laboratory unique sample of the non-conventional energetic unit with marked locations of sensors [5]

In the first stage the software has to meet the following more detailed specifications:

1.1. The software must allow for choice of a suitable sampling rate in order to enable the following:
   - measurement of steady modes of the engine where a low sampling rate is sufficient,
   - measurement of very fast dynamic modes, such as an engine run down, engine run up where a high sampling rate is necessary.

The sampling rate would be optional for instances in an interval from 0.2 Hz to 20 kHz.

1.2. There must be a choice of the impulse number for evaluation of the crankshaft running speed. The used sensor has 3600 impulses per one revolution. This demand is similar to the one mentioned above.
   - When unevenness of the crankshaft running will be measured, the running speed must be evaluated very fast.
   - For measurement of the steady state a higher impulse number would be sufficient for the engine speed evaluation.

1.3. The software must allow for defining ranges of measured temperatures, pressures and so on.

1.4. The software must allow for saving measured data on the disk in a suitable format, for instance “xls” or “csv”, to enable additional manipulation with data.

1.5. The software would enable to determine appropriate quantities from the measured data.

For instance, the engine power from the torque and rotational speed, air flow from the measured pressure difference on diaphragm, reduction of the measured parameters onto normal conditions, etc.

2^nd^ stage (debugging of the problems regarding control). After the first stage has been successfully completed the issue of control is to be dealt with:

2.1. Evaluation and control of fuel consumption measurement (measurement of the consumption time on the base of impulses from weight, fuel valve control, change of the fuel mass for measurement). On the base of the fuel heat value the software will directly calculate a specific fuel consumption and overall efficiency of the engine.
   - maintain the constant engine speed (on the base of the real measured value),
   - maintain the constant engine torque.

2.3. The software should be able to control and measure the pump fuel rod.

2.4. The software should be able to statistically process the quantities.

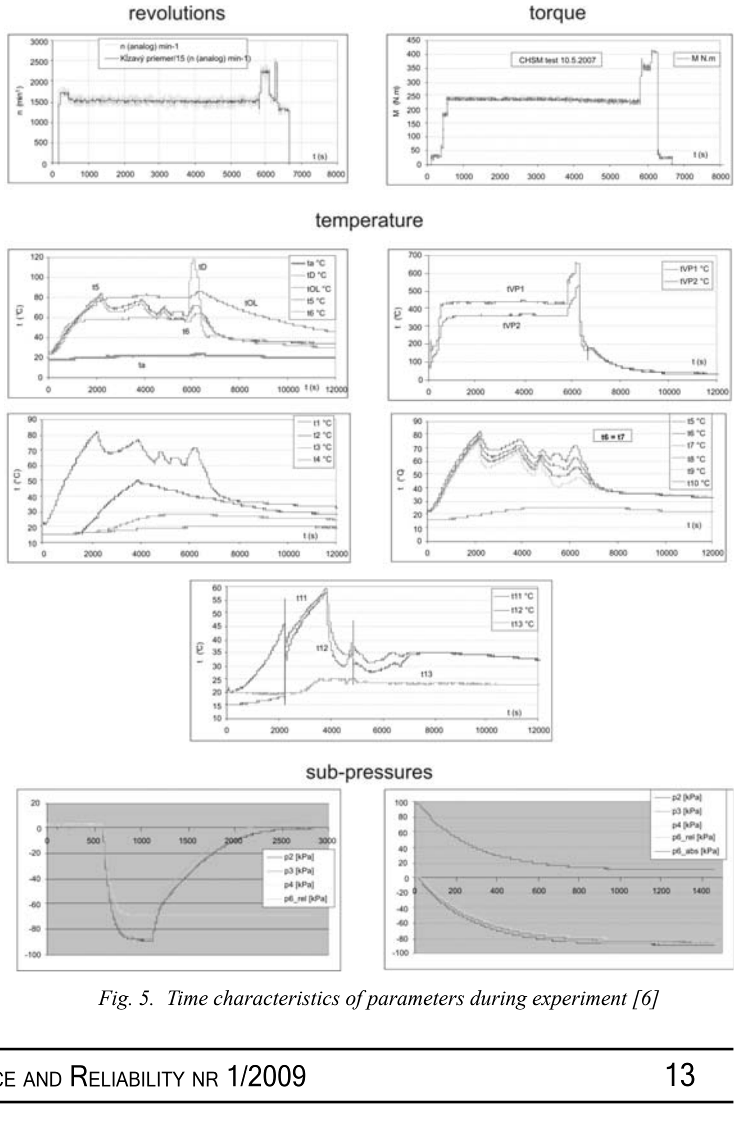
2.5. The software should be able to control the whole test by the given procedure. The modes and their duration will be defined before the measurement.

3. Experiment

For the purpose of further analysis and verification of spreading and distribution of temperatures not only in parts of the cooling engine but also in the all non-conventional energetic system some comparative measurements on the laboratory sample were carried out under the following conditions:

- the whole system was filled with the original cooling liquid,
- the sampling frequency was 2 Hz,
- the fixed testing regime of the engine in the interval of 650 – 5 800 s,
- the specific engine output in the interval of 5 900 – 6 100 s,
- the maximum engine torque in the interval of 6 180 – 6 270 s,
- the engine idle run in the interval of 6 300 – 6 630 s,
- the stopping of engine in 6 650 s,
- the system inertia observed in the interval of 6 650 – 12 000 s.

The basic time characteristics of revolutions and torque as well as of some temperatures and sub- pressures taken in the marked locations according to Fig. 4 are shown in Fig. 5. For the purpose of identification of temperatures in different locations of the system some shots made by a thermo camera were recorded during the experiment, see an example illustrated in Fig. 6.


revolutions

torque

temperature

sub-pressures

Fig. 5. Time characteristics of parameters during experiment [6]

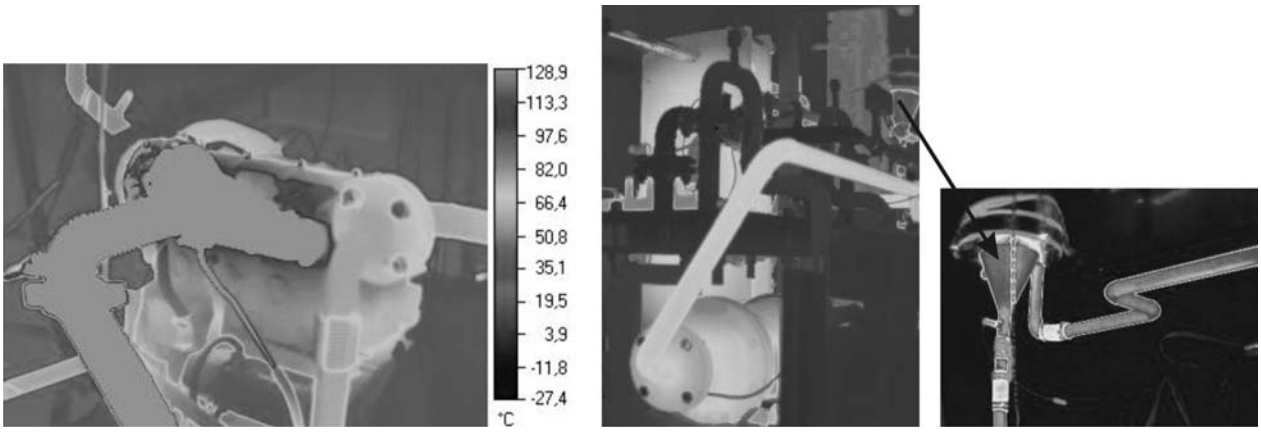


Fig. 6. A thermo camera shot of the cooling engine and part of energetic circuit and of evaporator [6]

4.Conclusion

The experiment has shown that the designed and constructed diagnostic system is reliable. The fact that the system is open allows for its extension or reduction in compliance with requirements and tests. The system can be used not only for verification of the non conventional energetic system parameters but, due to its adaptability, also for diagnostics of other energetic machinery and equipment.

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