ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XVII, NR. 2, 2010, ISSN 1453 - 7397

Ioan Ruja, Florin Breaban, Constantin Marta, Marius Tufoi, Viorel Bizau

Laboratory Facilities for Testing Thermal Engines

This work presents an electromechanical plant through with which is realised couples different resistant, MR (0 ÷ M_{RN}), on the gearbox shaft of internal combustion engine. The purpose is to study the plant in phase and stationary behaviour of the main technical parameters that define the engine operation such as: torque, speed, temperature, pressure, vibration, burnt gas, noise, forces. You can take measurements to determine engine performance testing and research on improving engine thermal efficiency. With the proposed plant is built by measuring the characteristic internal combustion engines (tuning characteristic and functional characteristic) and determine the technical performance of interest, optimal.

Keywords: *engine, testing, diagram acquisition, modeling.*

1. Introduction

Heat engines are systems that convert heat of a fuel into mechanical work through a working fluid. In the tests being put on the engine heat on the stand, present interest the construction by measurements of the following curves:

1.1 Features adjustable

1.1.1 Fuel consumption characteristics

This means the variations: effective power (P_E), specific fuel consumption (C_C) and coefficient of excess air (λ) depending on fuel consumption (C_O), to speed construction [1]. For construction of these curves, the achievement of n = ct is obtained by modification of MR at each change of fuel flow (Q_C).

Load factor is:

$$K = \frac{P_e}{P_{ec}} \quad (1)$$

where:
P_e is the effective power of the engine;
P_{ec}– is the effective power continues.
Excess air coefficient

$$\lambda = \frac{L}{L_{\min}} \tag{2}$$

where:
L is quantity of air available;
L_{min}- minimum quantity of air for theoretical combustion of 1 kg fuel.

Load engine corresponding to effective power Pe delivered to a specific engine speed. The engine load is adjusted by changing the position of throttle valves or injection pump rack. Is determined the optimal pole (C_{emin}) and maximum power (P_{emax}) and corresponding consumption of these points are defined for each engine tested.

1.1.2 Advanced features

This means the variations: effective power (P_e), specific fuel consumption (Ce) according to the advance (β) at constant load and constant speed. To build that characteristic, M_R is changed with the advance in order to maintain n=ct. Is determined the optimal advanced graphics (β_{optim}) for C_{emin} and P_{emax} obtained simultaneously.

1.2 Functional characteristics

1.2.1 Characteristic of load

This means the variations: hourly fuel consumption (C_O), effective specific fuel consumption (E_C), function load (P) at constant speed. The variation of load (P) is obtained from the shutter or rack in the injection pump and the speed remains constant changing M_R. This type of characteristic allows the determination on the test stand, the engine performance at n =ct and limiting the power (P) of its various considerations (compounds emission pollutants, mechanical stress). Characteristic of load, allows determination of stationary operation points in adjustment phase of the engine.

1.2.2 Characteristic of speed

This means the variations: effective power (Pe), torque (M), fuel consumption zone (C_O), actual fuel consumption (E_C) according to the speed (n) in different tasks (P) constructed. Load (P) is determined from the shutter or the injection pump rack, and the speed is modified by changing M_R. We can study the influence of various external factors (weather conditions, nonlinear friction) on the shape characteristics.

1.2.3 Regulatory feature

This means the dependence: Pe = f(n). The thermal ignition engines are required to limit the maximum speed (nmax) idling and under load.

1.2.4 Feature loss

This is the change of power loss (Pm) according to the speed (n). Is obtained by training the heat engine (powered off) by the DC motor (MCC) at different speeds and measuring the resisting torque of the gearbox shaft.

1.3 Indicial responses

The value of load step i(t) = P is chosen by the experimenter. In figure 1 is present the possible indicial response for Twingo engine in speed and in figure 2 is present the possible indicial response for Twingo engine in temperature. The experimental obtained results will be compared with theoretical results.

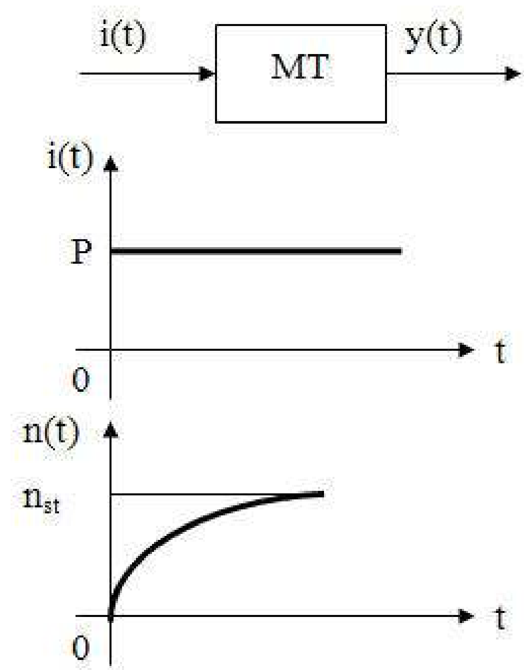

Figure 1. Indicial response in speed

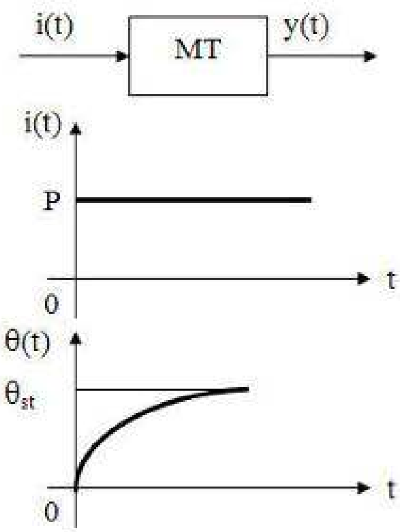

Figure 2. Indicial response in temperature

2. Theoretical considerations

2.1. Modelling production equipment of resistant torque M_R.

To load the output shaft of the gearbox of the engine with a torque resistant, is required an equipment to generate a torque M_R, changed slightly. To this purpose it proposes a plant with block diagram shown in figure 3. Resistant torque is produced by two electric machines, mechanically coupled, or made with the same shaft, under a DC generator and the other under field excited asynchronous generator capacitor. Total resistant torque shaft of the gearbox, MR has the expression:

$$M_R = M_{R0} + M_{GCC} + M_{GAS} \tag{3}$$

The resistant torque M_R is produced by a module composed of a DC generator with separate excitation (GCC) and a squirrel-cage asynchronous generator (Gas) mechanically coupled. By modification the resistance Rx and capacity Cx is obtaining a variable resistant torque on shaft mode, MR $(0 \div M_{RN})$ where: M_{R0} is the initial friction torque [2], [3], [4].

$$M_{RGcc}=k_{gcc}\cdot \Phi_{ex}\cdot I_A \tag{4}$$

M_{RGcc} is the torque produced by DC generator with separate excitation.

$$I_A = \frac{E-U}{R_A + R_X} \tag{5}$$

$$M_{RGas} = \frac{3\cdot R_2 \cdot U_1^2}{s\cdot \Omega_0 \cdot \left[\left(R_1 + \frac{R_2^{'}}{s}\right) + \left(X_1 + X_2\right)^2\right]} \tag{6}$$

M_{RGas} is is the torque produced by asynchronous generator.

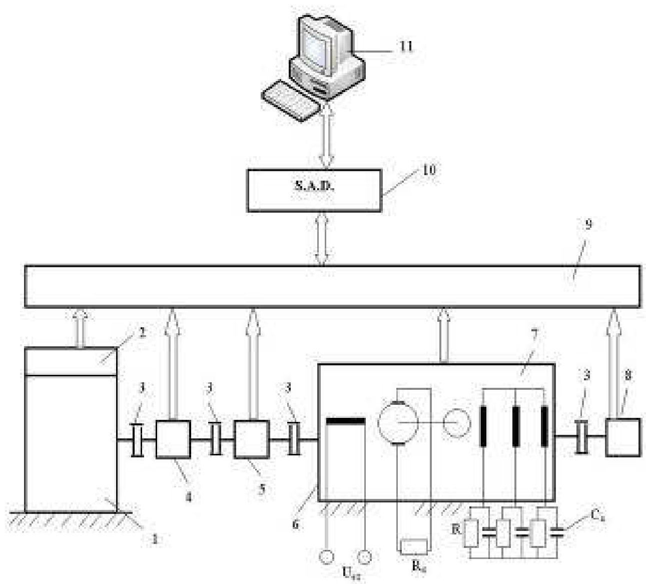

Figure 3. Block diagram of experimental plant

1.Internal combustion engine; 2.- sensors; 3.- coupling mechanical; 4 .- gearbox; 5.- torque transducers, 6.- DC machine; 7.- asynchronous machine; 8.- speed transducers; 9.- module interfaces; 10 .- Data acquisition system (SAD) 11 .- PC, RX - variable load resistance R. - fixed load resistance, CX-capacity variable.

$$U_1 = X_C \cdot I_C \tag{7}$$

$$X_C = \frac{1}{2 \cdot \pi \cdot f_X \cdot C_X} \quad (8)$$

By changing its RX and CX is set the desired torque MR. With sensors of: torque, speed, pressure, acceleration, noise, carbon monoxide, temperature and data acquisition system (SAD) it shall record the necessary construction and measurement of physical quantities desired curves and presented in Chapter 1. Resistant power produced is:

$$P = \Omega \cdot M_R \quad (9)$$

2.2. Identification of internal combustion engine

From the answer clues of n = f (t) and θ = f (t) is calculated: the constant time delay T1 transfer coefficients K_{Mi} times out Tμ1 and transfer function of internal combustion engine, $H_{MAI}(s)$.

3. Experimental results

So far, they obtained the following partial results:

3.1. The construction of a part of the proposed plant

Construction of a part of the proposed experimental plant and measurement system for testing thermal engines is shown in Figure 4.a and 4.b.

Figure 4.a View of experimental plant

Figure 4.b View of measurement system

Engine under test is type Renault Twingo, 1200 cm3, with gasoline injection.

3.2. Construction of virtual instrument

Virtual instrument for recording parameters is achieved with graphic language LabVIEW, National Instruments product, version 8.5, Figure 5.a. and 5.b [5]. Figures 6, 7 and 8 presents physical stand vibration, transducers and acquisition system of data

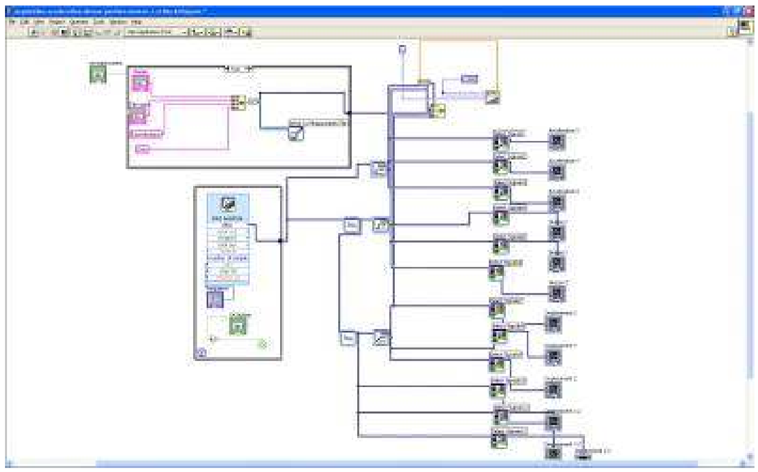

Figure 5.a. Block diagram of virtual instrument created with LabView 8.5

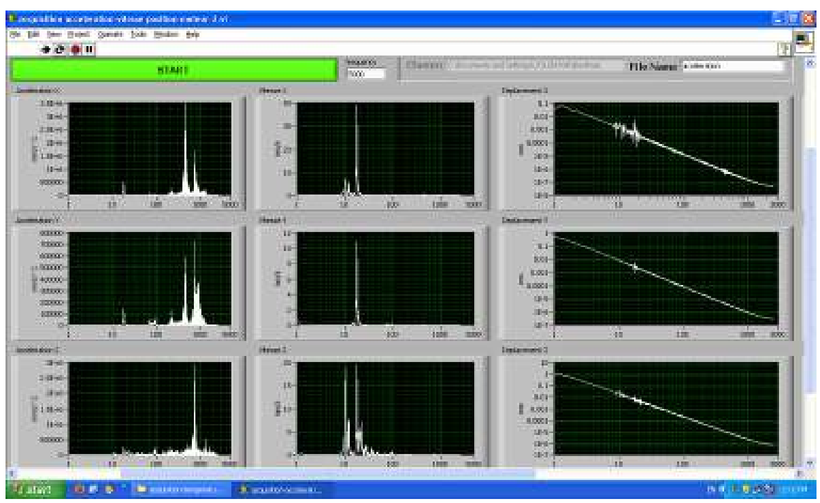

Figure 5.b. Diagrams of speed characteristics

Figure 6. Measurment of temperature with temperature sensor

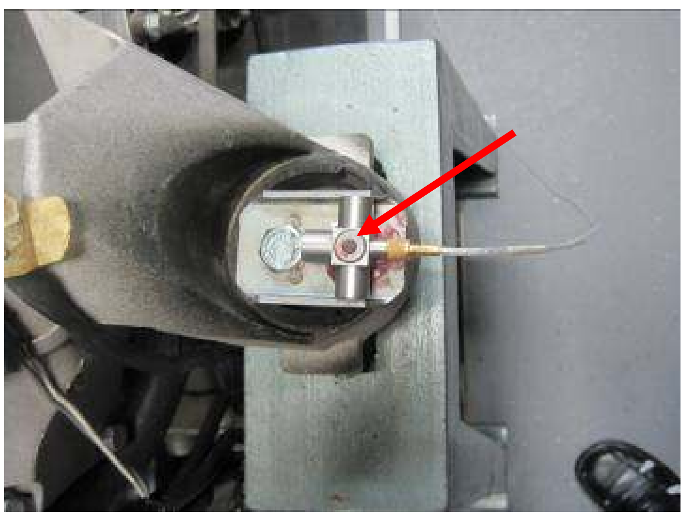

Figure 7. Three axis accelerometer 10G

Figure 8. NI eDAQ-9172 data acquisition system

3.3. Registration of data

Registration of temperature of engine is shown in Figure 9.

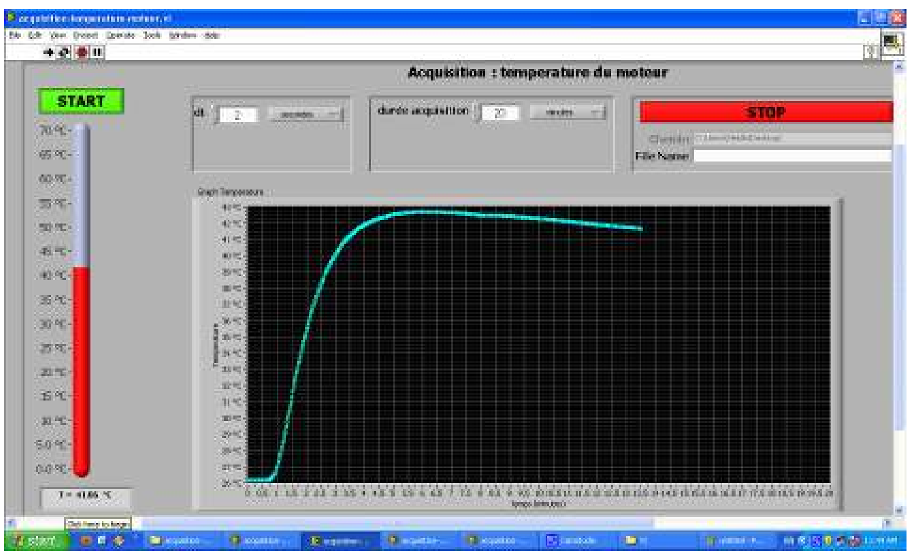

Figure 9. Experimental resluts of temperature

4. Conclusion

As a result of the activities made till present, we have the following conclusions:

-The possibility of internal combustion engine test at rated load over nominal by appropriate choice of the two electric motors; - Realization of dynamic and static testing schemes without the need for mechanical brakes, which require large volumes and introducing non-linear sizes; -The possibility of involvement of small internal combustion engine, electric cars by passing under the engine, with the advantage of a flexible laboratory facility; -The possibility of change in real times the physical quantities and their processing through the system of data acquisition;

- Is possible to continue studies and investigations on the basis of the Twingo engine test stand built.

References

[1] Mocuta, G.E., Dan, I. D. and Rosca C.A., *Technique for Determination of Fuel Consumption in Diesel Locomotives,* Scientific Bulletin of the "Politehnica" University of Timisoara, Transaction of Mechanics, 2009, 54 (68) , 31-42.

[2] Poddar, G., Joseph A. and Unnikrishnan A.K., *Sensorless Variable-Speed Controller for Existing Fixed-Speed Wind Power Generator With Unity-Power-Factor Operation,* IEEE Transaction on Industrial Electronics Society, 2003, 50, 1007-1015.

[3] Loparo, K.A., Adams, M.L., Wei Lin, Abdel, M.F. and Afshari N., *Fault Detection and Diagnosis of Rotating Machinery,* IEEE Transaction on Industrial Electronics Society, 2000, 47, 1005-1012.

[4] Yen, G.G. and Kuo-Chung Lin, *Wavelet Packet Feature Extraction for Vibration Monitoring,* IEEE Transaction on Industrial Electronics Society, 2000, 47, 650-658.

[5] Ruja, I., Szabo, S. and Liuba, G., *Applications of Measuring and Recording Technical Size with Virtual Instruments,* Journal of Virtual Instrumentation, 1998, 1, 85-92.

Addresses:

- Prof.Dr. Eng. Ioan Ruja, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, i.ruja@uem.ro
- Prof.Dr. Eng. Florin Breaban, Université d'Artois, Bethune, France, florin.breaban@univ-artois.fr
- Conf. Dr. Eng. Constantin Marta, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, c.marta@uem.ro
- PhD Stud. Eng. Marius Tufoi, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, m.tufoi@uem.ro
- PhD Stud. Eng. Viorel Bizau, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, v.bizau@uem.ro