ANNALS OF FACULTY ENGINEERING HUNEDOARA
– INTERNATIONAL JOURNAL OF ENGINEERING
Tome X (Year 2012) – FASCICULE 1 (ISSN 1584 – 2665)

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REDUCING ENERGY CONSUMPTION TO THE TEST OF DAMPERS BY USING A COMPACT PLATFORM FOR TESTINGS (CPTD)

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ABSTRACT: *In this article is presented a comparative study on energy consumption between two installations (stands) for shock absorbers testings. Tests to be carried on a shock absorber are likely statics and dynamics. Dynamic testing of damping systems specific in construction of technical equipment within INMA Bucharest are conducted to date on the installation HIDROPULS. Due to very high energy consumption (as observed from the values presented in the article) was imposed to achieve of a new test bench named Compact Platform for Testing of Dampers CPTD.*
KEYWORDS: *hidropuls, dampers, energy consumption*

INTRODUCTION

In accordance with the new EU Energy Policy developed in 2007, energy is an essential element of development of the Union. But equally it is a challenge to the EU countries regarding the impact of energy sector on climate change, of growth of dependency on the energy resource import as well energy price increases. In the case of not taking of drastic measures at EU level, at the current rate and at the existing technologies, the emissions of greenhouse gases will increase from year to year by about 5% at EU level and at global level by about 55% until 2030.

The European Commission has proposed in the set of documents that represents the new EU Energy Policy the following goals:

- *reducing greenhouse gas emissions by 30% until 2020 compared to 1990;*
- *Energy Strategy 2007-2020 / DRAFT;*
- *increasing the share of renewable energy from less than 7% in 2006 to 20% of its total energy sources until 2020;*
- *increasing the share of biofuels to at least 10% of all fuels used in 2020;*
- *reducing its global primary energy consumption by 20% until 2020.*

One of the priority elements energy of the energetic strategy is to improve energy efficiency. Increasing energy efficiency has a major contribution to achieving security of supply, sustainability and competitiveness. Reduction of energy demand through increasing energy efficiency is a winning policy, that besides the saving of primary energy resources leads and to the reduction of greenhouse gases. The representative synthetic indicator of the efficiency of energy use at national level is the energy intensity, respectively energy consumption to produce one unit of Gross Domestic Product.

In 2003 was elaborated the National Strategy for Energy Efficiency which highlighted, among other things, the economic potential of energy efficiency in various sectors. Following this strategy, was established as a strategic objective the improvement of energy efficiency in Romania on the entire chain of natural resources, manufacturing, transport, distribution and final use, by the optimal use of specific mechanisms of market economy, estimating a 3% per year reduction in energy intensity over the whole national economy until 2020 compared to 2001.

Reducing of negative effects of energy production process on the climate requires concrete and sustained actions. In this context, Romania must act sustained and consistently to align with European actions that promote the Lisbon objectives. In order to limit the increase of predicted global temperature, respectively of emissions of greenhouse gases, Romania must act promptly, particularly in the field of energy efficiency and renewable energy sources. The actions aiming at promoting of energy efficiency and renewable energy sources will contribute both to the reduction of negative environmental impact and to increase the supply security, reducing the level of dependency on energy imports of Romania [4].

The Directive no. 2006/32/EC on energy efficiency at end users which is compulsory for Romania since 2008, provides that EU Member States undertakes to realise the reduction of final energy consumption by at least 9% in a period of nine years (2008-2016) compared to the average consumption in five years for which there are available data (2001-2005). In this sense, will adopt the following measures on energy efficiency field:

a) *use of financial instruments for energy savings, including energy performance contracts which provide the supply of predetermined and measurable energy savings;*
b) *acquisition of equipment and vehicles based on lists of energy efficiency specifications of different categories of equipment and vehicles, minimum cost analysis, lifecycle or comparable methods to ensure profitability;*
c) *use energy audits and implementation of recommendations resulted regarding profitability [3].*

MATERIALS AND METHOD – THE HIDROPULS INSTALLATION

The installation was mounted inside the specially arranged area from INMA in 1989. Initially the unit was equipped with a computer type ROBOTRON, Generation 2, computer programs being recorded on cassettes. During the use of the installation was found the insufficiency of capacity to control of this type of computer and also the impossibility to adapt of a data acquisition system, enabling the automatic tracking and modification of the installation parameters according to the evolution of the tested structure, which led to the adaptation in 1995 of an IBM PC AT computer fitted with data acquisition system and specific application programs.

The installation is endowed with the latest generation command and control equipment, of some brand manufacturers in the field, (Hottinger Baldwin Messtechnik, Microstar Laboratories, National Instruments) by means of which the research activity acquires the high quality function due to the accuracy, reliability and its ergonomy. Hidropuls is a complex installation of equipment, devices, subsystems for electrical and hydraulic drive, installations and auxiliary buildings, designed to ensure the technical conditions for static testings (static strength, deformations) and dynamic (alternative or pulsed loadings for endurance tests, vibrations).

Fig. 1 - Pumping aggregates with specific monitoring system

Hidropuls installation has the following composition:

1) *four pumping units (fig.1), providing the oil flow rate and pressure from hydraulic power supply installation of cylinders carrying out the loadings of the tested structures;*

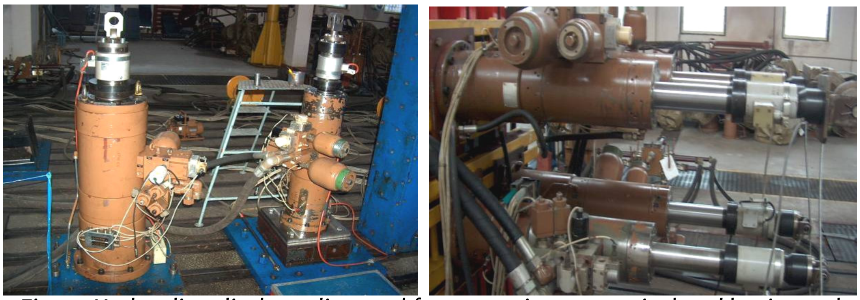

Fig. 2 - Hydraulic cylinders, disposed for operating on vertical and horizontal

2) *twelve hydraulic cylinders, shown in Figure 2, are the execution elements for applying the mechanical loadings; the cylinders used in the INMA have capacities for applying of forces of 10, 25, 100 and 250 KN, the movement (stroke) performed being of maximum 200 mm (or ± 100 mm compared to mechanical zero position) for all cylinders.*

Fig. 3 - Command cabinets - rear and frontal view

3) *twelve command cabinets, each providing control functions for operating of an each one hydraulic cylinder; each command cabinet contains:*

- *Electronic control system for automatically adjusting in the two operating modes concerning the application of strain:*
- *actuating with force control, the displacement resulting from plastic or elastic deformations of the strained structure;*
- *actuating with the control of displacement, the force resulting from the reaction of the tested structure at an imposed deformation;*
- *electronic devices for measuring the functional parameters: force, displacement, oil pressure;*
- *the electrical and electronic installation that drives the hydraulic cylinders. [3]*

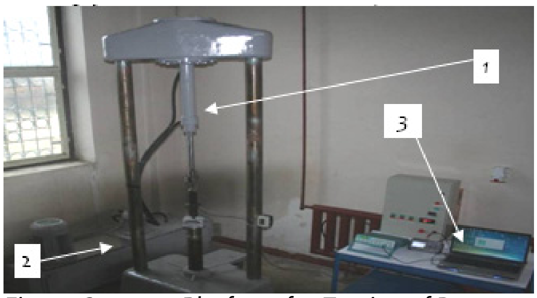

Fig. 4 - Compact Platform for Testing of Dampers (stand). 1 –mechanical system; 2 – hidraulic system; 3 – command and control system

CONSTRUCTIVE DESCRIPTION OF THE EXPERIMENTAL MODEL

The Compact Platform for Testing of Dampers (stand), CPTD consists of the following systems:

1. *mechanical system (fig. 5)*
2. *hydraulic system (fig. 6)*
3. *command and control system (fig. 7, 8)*

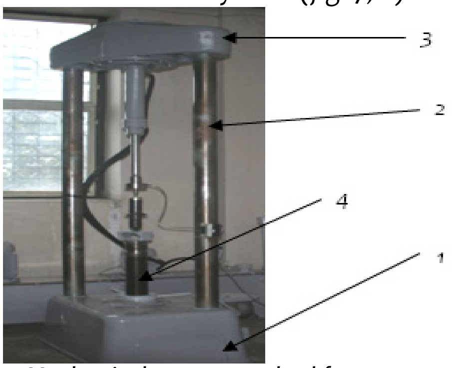

Fig. 5 - Mechanical system. 1 – bed frame; 2 – column guidance; 3 – higher pillar; 4 – driver screw

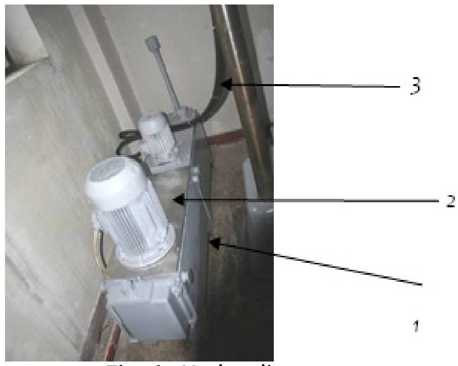

Fig. 6 - Hydraulic system 1 – oil tank; 2 – pump engine; 3 – hydraulic hose

Fig. 7 - Command and control system. 1 – control panel; 2 – data acquisition system with oscilloscope; 3 – signal generator; 4 – laptop data processing

Fig. 8 - Control panel. 1 – on / off buttons; 2 – failure button; 3 – indicator lamps; 4 – oil temperature regulator; 5 – digital display strain gauge signal

FUNCTIONAL DESCRIPTION

The Compact Platform for Testing of Dampers CPTD has the role to realize the running-in and to determine the elastic characteristics of all types of dampers, by follow the next stages:

1. *Through command and control system of hydraulic group and damper positioning system is performed the following operations:*
   - *the hydraulic group is act to obtain the necessary pressure to the hydraulic cylinder;*
   - *it is act the damper positioning system to adapt the working distance to its dimensions.*
2. *Through the mechanical system the damper assembly is done on stand.*
3. *Through the control and measurement system of parameters of the damper submitted for testing the following operations can be performed:*
   - *is established the frequency of testing and damper stroke by ordering the signal generator;*
   - *real time viewing of elastic characteristic on the oscilloscope display and check framing of it within the limits required by the manufacturer.*
   - *data acquisition is performed (force, displacement) necessary to achieve of elastic characteristic of the of damper. [2]*

RESULTS

The test of dampers on The Compact Platform for Testing of Dampers - CPTD and on the HIDROPULS installation was done for three different types of commercial dampers, used to equip a diverse range of cars and trucks:

- *bi-tubular dampers for road vehicles - type 1, presented in this article;*
- *bi-tubular dampers designed to road vehicles - type 2;*
- *dampers designed to trucks with masses larger than 5 tons - type 3;*

For these dampers have risen the control characteristics 3 (F-s) and were performed the tensile tests. It also has determined the energy consumption and for simultaneous testing of multiple dampers of the types listed above.

Specific electricity consumption for each type of damper on the two installations for testing dampers was done with three-phase power analyzer type C.A. 8332 and C.A. 8334 (fig.9). These measurement instruments not only allow obtaining of some current images on the main characteristics of a network as well as to the monitoring of variations in a certain period. The multi-task measurement system simultaneously handles all the measurement functions for different amplitudes, detection, continuous recording and displaying them without any constraint.

Measurements that can be performed are as follows:

- *the measurement of effective value of AC voltage up to 480 V (between phase and neutral) or up to 830 V (between phases) for 2 wire, 3 wire or 4 wire;*
- *of alternating current effective value up to 3000 A rms;*
- *the measurement of frequency at 50 Hz networks, 60 Hz (from 10 Hz to 70 Hz);*
- *calculation of amplitude coefficients for currents and voltages;*
- *calculation of short-term voltage fluctuations;*
- *calculation of disbalance between phases for voltage and current;*
- *measurement of angles and harmonic rates (relating to fundamental value or relating to the actual value) for voltage, current or power, up to order 50;*
- *measurement of active, reactive and apparent power for each phase separately and their sum. Calculation of power factor, deviation factor and tangent factor. The amount of electric power from a time individually chosen by the user;*
- *monitoring of the average value of any parameter, calculated for a period from one second to two hours;*
- *registration, labeling and characterization of disturbances in time: thresholds, power lines arrows and interruptions, exceeding of thresholds of power and harmonics;*

Fig. 9 - Three phase energy analyzer

Detection of transitory processes and recording of the associated waveforms. [2, 3]

Calculation of electrical power required for each test on the two types of installations was carried out in sinusoidal regime. Thus, given that we are dealing with a three-phase balanced voltage and current, the consumed active power or real is calculated by the formula:

$$P = \sqrt{3\,x\,U_l\,x\,I\,x\,cos\varphi}$$

where: φ – phase angle between phase voltage phase current; I – current intensity; U_l – voltage line or between phases.

Fig. 10 - Bitubular damper testing for road vehicles - type 1 on Compact Platform for Testing of Dampers - CPTD (left) and on HIDROPULS installation (right)

BITUBULARE DAMPER TESTING FOR ROAD VEHICLES - type 1

In Figure 10 is shown the clamping respectively the testing of a damper for road vehicles maximum weight of 2 t, both on Compact Platform for Testing of Dampers CPTD, and on HIDROPULS installation. The testing comprises two phases:

- *Phase A – testing the damper operation in order to prepare it for actual testing and preliminary verification of the functionality;*

□ *Phase B – actual testing, respectively raising of the elastic characteristic F-s of the damper.*

The catching of the damper on the test bench was made with a specific clamping device simulating the mounting conditions on the vehicle.

□ *Place of the test: Testing Department – INMA Bucharest*

□ *Measuring instruments used:*

- *dynamometer traction - compression as part of force measurement chain of the CPTD, serial 923 794;*
- *plane parallel gauge toolkit, serial 652802, measurement uncertainty, $U=0,5\mu m+5\times10^{-6}L$;*
- *data acquisition card DAP 3200 e / 214 – S.U.A.;*
- *Digital thermometer with surface sensor, tip 871 A, serial T-50362, measurement uncertainty 1,5 °C;*
- *calliper 0÷1000 mm serial 013-02-87, measurement uncertainty 0,2 mm;*

Testing parameters:

A. Testing the maximum stroke and operation of damper

Maximum stroke: 250 mm

Testing on operation of damper was made according to STAS 9381-88 and consisted of :

- *number of courses of running-in: 8 to 10 complete cycles;*
- *damper rod stroke: 200 mm*
- *speed of the rod: 0,1 m/s*
- *electrical control signal of movement (provided by the functions generator of the platform) - with amplitude of ± 10 V, triangular;*

B. Testing the maximum stroke and operation of damper

Maximum stroke: 250 mm

Testing on operation of damper was made according to STAS 9381-88 and consisted of :

- *number of courses of running-in: 8 to 10 complete cycles;*
- *damper rod stroke: 200 mm*
- *speed of the rod: 0,1 m/s*
- *electrical control signal of movement (provided by the functions generator of the platform) - with amplitude of ± 10 V, triangular;*

C. Raising of the elastic characteristic F-s

Raising of the elastic characteristic F-s of the damper was done, the following results being obtained as a result of comparative testings on the two testing installations:

C1) HIDROPULS installation

Reference signal	The testing force	Frequency testing 0.3 Hz	Frequency testing 0.4 Hz	Frequency testing 0.5 Hz	Frequency testing 1 Hz	Frequency testing 1.5 Hz
Sinusoidal	F_{maxD} (daN)	57.02	70.03	72.03	92.06	82.02
	F_{maxC} (daN)	116.02	131.04	150.07	160.06	150.02
Triunghiular	F_{maxD} (daN)	28.08	56.04	57.07	57.07	53.05
	F_{maxC} (daN)	72.07	77.03	93.05	130.07	126.05

C2) Compact Platform for Testing of Dampers - CPTD

Reference signal	The testing force	Frequency testing 0.3 Hz	Frequency testing 0.4 Hz	Frequency testing 0.5 Hz	Frequency testing 1 Hz	Frequency testing 1.5 Hz
Sinusoidal	F_{maxD} (daN)	57	70	72	92	82
	F_{maxC} (daN)	116	131	150	160	150
Triunghiular	F_{maxD} (daN)	28	56	57	57	53
	F_{maxC} (daN)	72	77	93	130	126

Determination of specific electricity consumption (fig. 11) for bitubular damper for road vehicles - type 1 was performed with three-phase energy analyzer for installation HIDROPULS, and for CPTD the energy was determined directly from the frequency converter display with which the control panel is fitted. The energy consumption values recorded for the two types of installations are presented in Table 1.

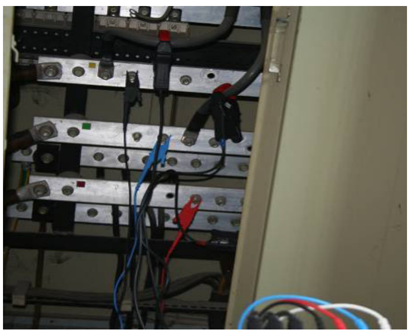

Fig.11. Determination of specific energy consumption

Table 1

Bitubular damper	Energy consumption HIDROPULS installation [kWh]	Energy consumption CPTD [kWh]
Frequency testing 0.3 Hz	50.45	9.30
Frequency testing 0.4 Hz	50.75	9.45
Frequency testing 0.5 Hz	52.50	9.65
Frequency testing 1 Hz	53.80	10.05
Frequency testing 1.5 Hz	54.65	10.35

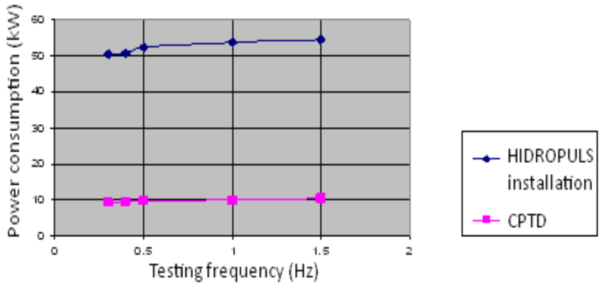

Fig. 12. Comparative consumption for bitubular damper

Using the data from Table 1 was performed the compared energy consumption chart between the two types of installations: Compact Platform for Testing of Dampers CPTD - experimental stand and respectively the HIDROPULS installation, for a type of bitubular damper purchased from trade for road vehicles. [3]

CONCLUSIONS

Following the tests carried out it was found that the CPTD platform can reproduce various reference signals to drive the dampers in different forms, with different frequencies and amplitudes, being able thus simulate the full range of vibration and tasks l that dampers are subjected by their daily use, but also the mechanical stresses to which must be subjected for testing, stipulated in standards and other regulations. Also, on the Compact Platform for Testing of Dampers - CPTD can be performed s simultaneously testing at endurance of several dampers, depending on their type and size.

In terms of determining the energy consumption of electricity necessary for putting into service of hydraulic systems specific to each installation, this was determined by means of three-phase energy analyzer. Following the measurements was found a significant decrease in electric energy consumption necessary for any type of damper testing using the Compact Platform for Testing of Dampers - CPTD.

From graphics obtained by testing of each type of damper can be seen that by using the Compact Platform for Testing of Dampers - CPTD results a decrease of about 5 times of the consumption of electricity used, as follows:

- *for testing of a type of road bitubular damper - type 1, the average consumption of electricity was 9.76 kWh;*
- *for testing bitubular dampers designed for the road vehicles - type 2, the average consumption of electricity was 9.75 kWh;*
- *for testing of dampers for trucks with masses larger than 5 tons - type 3, the average consumption of electricity was 9.97 kWh.*

By comparison, HIDROPULS installation is more energy-intensive, due to higher capacity of the hydraulic group and of specific motor for drive, requiring for the same type of dampers an average of 52.43 kWh of electrical energy bitubular dampers designed for the road vehicles - type 1, 52.29 kWh for bitubular dampers designed for the road vehicles - type 2 and 52.41 kWh for dampers for trucks with masses larger than 5 tons - type 3.

The tests performed aimed to checking the capacity of the Compact Platform for Testing of Dampers - CPTD, to carry out tests in accordance with the standards in force, achieving a significant reduction in electric energy consumption per test damper (of approximately 5 times). The results were recorded and confirmed the ability of CPTD for testing under simulated and accelerated regime of any type of damper. [1,2,3]

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