THE INCREASING OF ENERGY EFFICIENCY OF THE ROAD MOTOR VEHICLES THROUGH THE IMPLEMENTATION OF THE KINETIC ENERGY RECOVERY HYDRAULIC SYSTEMS

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The paper presents a hydraulic system used to recovering of the kinetic energys of the motor vehicle, in the braking phase. This saved energy is used in the acceleration phases, in order to increasing energy efficiency of the motor vehicles propulsion systems. All the system is conceived like a mechatronics system, for the medium and heavy motor vehicles and contains a hydro-mechanic subsystem, an electronics subsystem and an informatics subsystem. The implementation of the recovering system on one motor vehicle transforms it in a hybrid vehicle and leads to decreasing of the fuel consumption and to reduce the gas emissions.

Keywords: hydraulic system, *hybrid systems, energy recovering, road vehicles.*

1. Introduction

The development of road transport has a strong impact on the environment, global warming of the planet and the resources of fossil fuels.

In order to reduce these effects, manufacturers of motor vehicles considers that a radical solution to improve the situation is changing the propulsion of vehicles by promoting hybrid propulsion systems, considered as a future solution for a substantial reduction in fuel consumption and pollutant.

Typical, the kinetic energy of the motor vehicle, accumulated in the accelerating phase, in the braking phase is converted in the thermal energy which is, normally and irremediable, wasted in atmosphere [1]. To reduce the fuel consumption and to limit the emission of motor vehicle, the manufacturers have developed less polluting vehicles and reduced fuel consumption. In this category, are, also, vehicles with hybrid propulsion systems The propulsion systems which have in addition to a conventional internal combustion engine, at least one capable of providing torque to the wheels car and recover some of the kinetic energy, are known as *hybrid Regenerative Systems*. The main objectives of the *hybrid systems* are the *recovering kinetic energy* of the road motor vehicles and reducing the *fuel consumption* and, also, the *reducing of the environment pollution.*

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In this respect, the Hydraulics and pneumatics Research Institute-INOE 2000-IHP, together with its partners: the *Politechnica* University from Bucharest, INCDMF, INMA and ROMFLUID, were involved in the development of a research project, which aims to recover kinetic energy, during braking road vehicles, by developing a hybrid thermal-hydraulic system, and use it in the starting phases of motor vehicles. The project was conducted under the *Excellence Research Program* and funded by *National Authority for Scientific Research*..

Based one a vast documentation on the INTERNET, regarding the technical realization in the recovering energy field, where studied a lot of technical solutions which allow the designing, manufacturing and testing one functional model and where made the necessary measuring in order to demonstrate the functionality, efficacy and efficiency of the functional model .

2. The presentation of the hydraulic system for energy recovering

The hydraulic system for energy recovering represents the main physical product, resulting from the finalization of the maintained research project. The aim of the hydraulic system is the recovering the kinetic energy, in the braking phase of the medium and heavy motor vehicle. The technical problem, which is solved by the hydraulic recovery system, is the capturing and storing of the lost energy in the braking phases at the medium and heavy motor vehicles.

The method consists in using one mechanic and hydraulic module, which is able to capture and to convert the kinetic energy into the hydrostatic energy and, also, storage and reuse it for acceleration and starting of the vehicles, figure1.

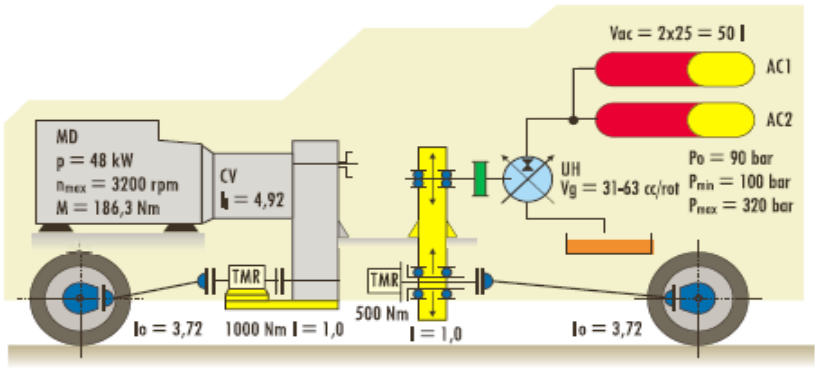

Fig. 1 The conceptual model of the kinetic energy recovery system

In the following, is presented a Romanian technical solution for an energy recovery system, which is based on a hybrid system compound by a mechano-hydraulic module and, also, an existing system with thermo-engine and mechanical transmission, all conceived as a mechatronics system..

2.1 The conceptual model of the energy recovery system

The hydraulic recovering system of the kinetic energy was designed to be implemented on one Romanian automotive, well-known as ARO 243 type, which has a 4x4 driving system. In the conceptual model of the kinetic energy recovering system, figure 1, it distinguishes the Diesel engine MD, the gearbox CV and the gear transmission to the front wheels, through one torque transducer (TMR) and one Cardan axle. It can see the mechanical transmission to the hydraulic machine/unity UH, the tank for low pressure LT and the storing system for height pressure, which is compound of the two hydraulic and pneumatic accumulators AC1 and AC2. The hydraulic power is transmitted, to the breech wheels, through the one torque and rotation transducer (TMR) and one Cardan axle. The hydraulic machine can be connected, in parallel, anywhere in the driveline, but, generally, is mounted between gearbox and differential mechanism.

The main part of the recovery system is the hydraulic machine with variable geometrical volume [2], [3], that can work both as a pump, in the braking process, and, also, as a hydraulic motor, in the starting process of the motor vehicle. The hydraulic machine is acted through one gear box transmition, being assisted by an electro-hydraulic system, which is interfaced with the subsystems for braking and acceleration of the vehicle, all controlled by a processor.

The operation of the recovery system has needed a lot of sensors and transducers, for monitoring and controlling the evolution of parameters [4].

2.2 The block diagram of the mechatronic recovery system

The kinetic energy recovering system was developed in a mechatronics conception, which is considerate as being the unique capable technology to manage, in very short time, the transient working regimes, in the braking and accelerating phases, in order to integrate the interaction of the some hydro-pneumatic components,into the mechatronic ensembles, figure 2.

The energy recovery system, figure 2, through the three basic mechatronic subsystems, assure the control and monitoring for mechanic and hydraulic parameters, allows data acquisition from the transducers for moment/couple, temperature, flow and pressure. Data from the transducers are transmitted within the serial communication line [4]. The electronic module is equipped with a console which allows visualization and modification of the functional parameters.

The mechatronic system contains: *mechanical and hydraulic* subsystem, *electronic subsystem* for command and control and, also, the *informatic subsystem* for data management, which allows the measurement and control for all system parameters. The interface between the first two subsystems is the subsystem of sensors and transducers, which provide information on the evolution of the main parameters of the system.

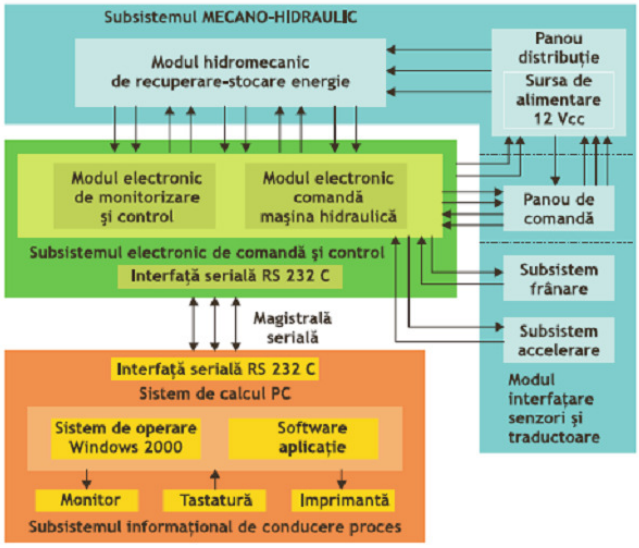

Fig. 2 The block diagram of the mechatronic system for recovering kinetic energy

This component defines the mechatronics basis for the system design and development. The mechatronic system is working on the basis of dedicated software, which allows monitoring and recording of the evolution of output sizes and the control parameters of the system. The electronic module calculates the hydraulic power at the hydraulic machine, as a product between pressure and flow, and transfers it through a serial communication line to the system. The system is equipped with a Lap Top or PC computer, control the input functional parameters, and the visualization of the measured output parameters.

The main command output size is swivel angle of the block of pistons of the hydraulic machine, which determines the variation of the flow and, on the other hand, the running regime like pump or motor, in function of the braking or accelerating regime.

2.3 Some theoretical results obtained by modeling and simulation

In order to optimise the main constructive and functional features, the main components of the system were selected from the theoretical results obtained from the mathematical modelling and the computer simulation work, [5]. It was necessary to know the dynamic behaviour of the experimental hybrid motor vehicle, in braking phase and where elaborated a mathematical modelling and a simulation program [6]. After the simulation, where obtained a lot of variation diagrams for the interesting parameters, presented in the next figures.

For example, in the figure 3 is presented the kinetic energy variation during the braking process and in the figure 4 the vehicle braking velocity variation.

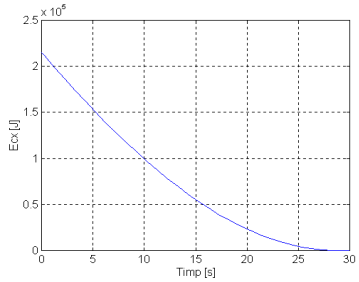

Fig. 3 The kinetic energy variation

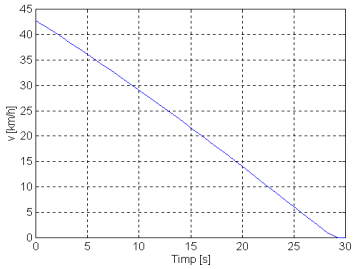

Fig. 4. The braking velocity variation

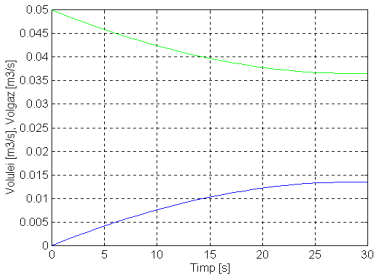

Fig. 5 The fluids variation in accumulators

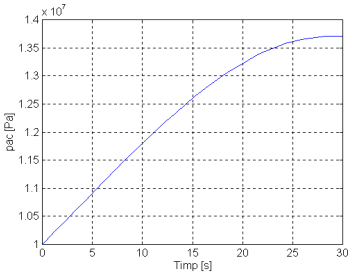

Fig. 6 The braking pressure variation

In the figure 5, are presented the gas volume variation, which is in continuous decreasing process and the oil volume variation, which is in increasing process. In the figure 6, is presented the pressure variation in the storage accumulators battery.

The diagrams from figure 5 illustrate the accumulating hydrostatic energy, which create the condition to use this energy in acceleration phases. The variation of others parameters were obtained, also, by mathematical modelling and computer simulation.

2.4 The main physical modules of the energy recovering system

The main physical modules, which compound the energy recovery system, are presented in the next figures: the hydro-mechanic module in the figure 7, the hydraulic central in figure 8; the battery of accumulators in the figure 9; the electronic and informatics systems are presented in figure 10.

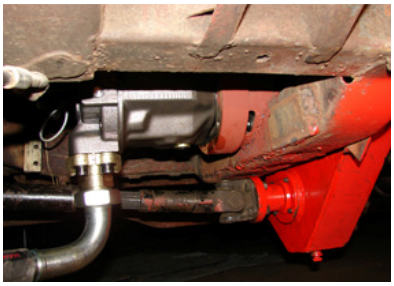

Fig. 7 The hydro-mechanic module

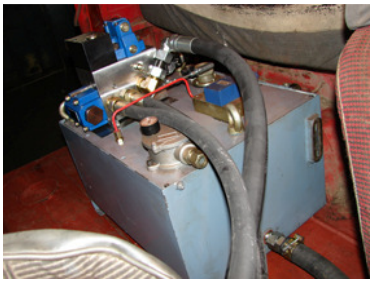

Fig. 8 The hydraulic central

Fig. 9 The accumulators battery

Fig. 10 Electronic and informatics systems

The implementation of the recovering system on one motor vehicle transforms it in a hybrid vehicle and leads to decreasing of the fuel consumption and to reduce the gas emissions. Before the implementation on the motor vehicle, in order to develop the experimental research, the main modules of the mechatronic system, for the recovering braking energy, where subjected on the laboratory testing, in order to verify the main functional parameters.

3. Conclusions

The paper presents the possibility to design, manufacturing and implementing the energy recovery systems on motor vehicles.

From the above, can say that the hydraulic systems for energy recovering are good solutions in order to increasing of energy efficiency of the road vehicles.

The adopted technical solution allows extrapolation to different sizes of vehicles, for medium and heavy vehicles, and can be mounted on vehicles both new and old motor vehicles, in an action for the rehabilitation or upgrading them.

Hydraulic and electrical components, are available on the market and allow realization, in good conditions, of the kinetic energy recovery systems.

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