MOTORBIKE ACCELERATION IMPROVING USING HYBRID ENGINE

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***Abstract* – The paper presents the possibility of acceleration of two-stroke combustion engine used in motorcycle. This paper deals with the method of charging and discharging electric energy main sources, mechanical to electrical energy conversion and vice versa. Basic conception comes out of combustion engine and microprocessor controlled electromotor cooperation. The braking energy charges supercapacitors, and is used when acceleration is needed.**

Abbreviations: hybrid propulsion system, CAN bus, combustion engine, electromotor.

Acronyms:

ERM	Electric Rotary Machine
ECU	Electronic Control Unit
PWM	Pulse Width Modulation
RPM	Revolutions Per Second
DYNO	Dynamometric Stand

I. INTRODUCTION

Lower exhalation, lower consumption, lower weight and smaller dimension are required from today's combustion engines. At the same time more power and reliability are required, too. If we want to connect these contradictory requirements, we need to find other methods of combustion motor construction, and new propulsion unit conception.

The construction of two-stroke motors is elaborated very well nowadays. If no new "revolutionary" modification will come, it is possible to say that today's development stage is final. Maximum improvement of individual parameters will be several percent.

This paper discusses one of possible ways of increasing power and decreasing exhalations of two-stroke motors with the help of ERM, generator, and other electronic components forming together a hybrid system.

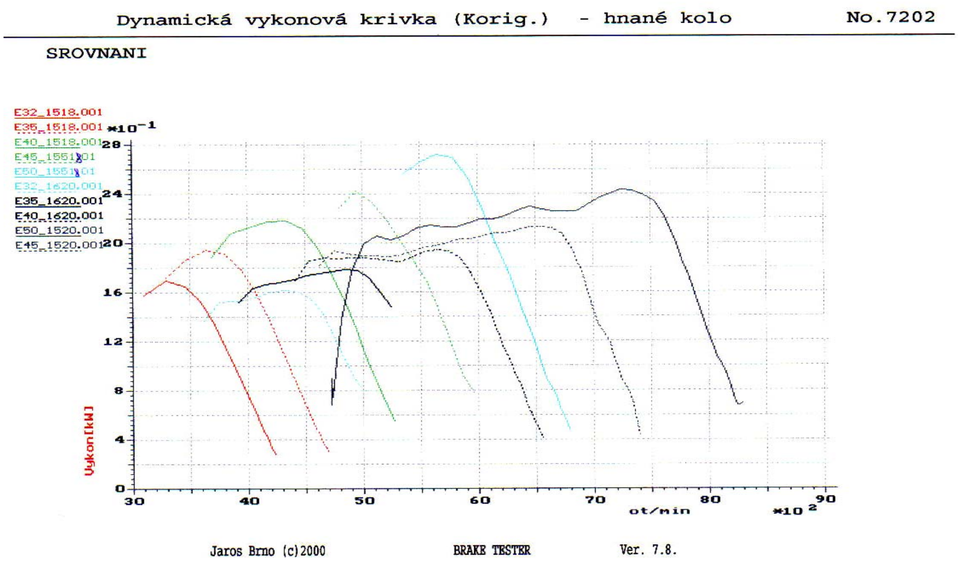

figure 1: particular characteristics of the ERM

II. DEVELOPMENT

Electric system unit

Concept of the system is designed for motorbike use. We can easy calculate from motorbike data records, total acceleration time is 2-3 times longer than deceleration time. Specific ways of the combustion engine loading should be minimized when the motorbike is in deceleration mode. In this case the breaking mode is the main source of easy recuperative energy. Concept of the system has been chosen after first tests on dynamometric stand (item DYNO).

Components tests and measurements for the choice of power train regulation characteristics

Parametric tests of ERM. Having tested more ERM types we decided to use synchronic ERM with electronic commutation. Usable power of the chosen ERM is depending on running potential, running status of the control unit, and maximal current load. Results of measurements are shown in figure 1.
ERM vendor permits short time overload for 80A with charge potential up to 40V. Our measurements confirmed that the ERM can be overloaded more provided enough cooling is granted.

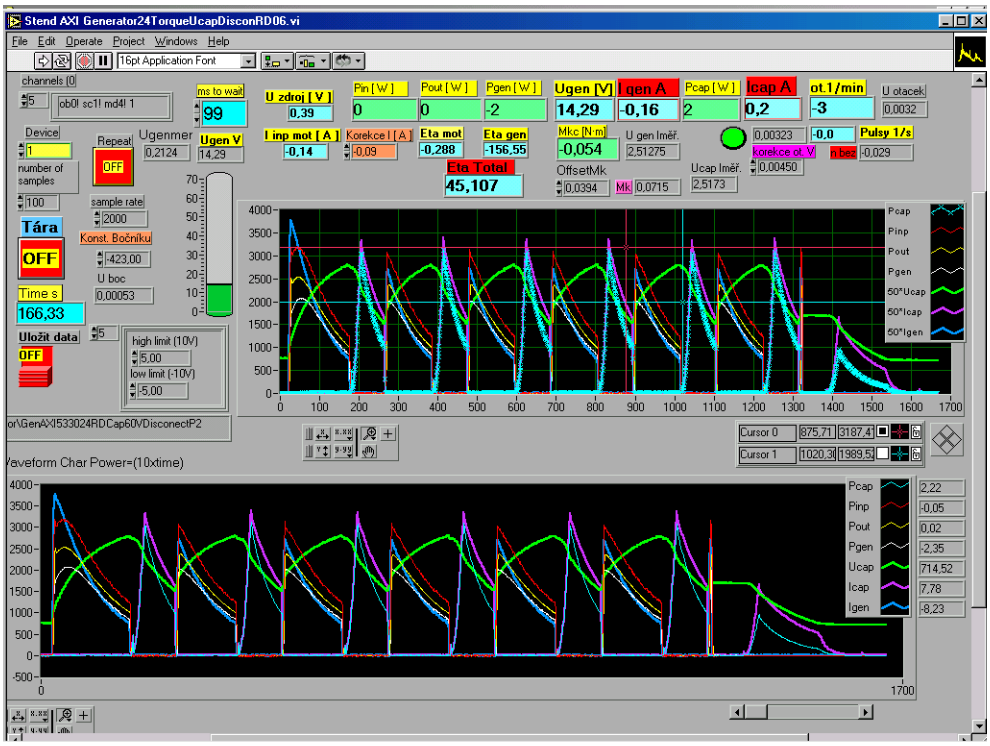

figure 2: stand for measurement of basic generator characteristics

Efficiency of the system ERM – regulator (converter) is on the edge 84% with required output power 2000W on the output shaft and with the charge voltage 40V. But the heat loss is 400W in this mode disregarding mechanical losses caused by the belt drive.

Parametric tests of generator. Generator tests give us results necessary for decision which of 6 different generators prototypes will be the best for our purpose. Generator tests were realized in two steps:
Step 1: The generator is powered by ERM. Basic tests were done by following laboratory model: Generator and ERM are connected to shaft clutch. *Output power is defeated at resistor in heat.*
Step 2: The generator is driven by combustion engine, and the capacitor charging is tested. Results of measurements on DYNO gave us interesting values of parameters for six different generator prototypes (see: figure 3). It is very helpful for decision which generator is optimal for given combustion engine.

Electronic control unit (ECU)

Measured input signals:
- RPM engine – rpm of combustion engine,
- RPM ERM – rpm of three-phase ERM,
- Ucap – supercapacitor voltage,
- Igen – generator current,
- Imot – three-phase ERM current (current is measured in regulator branch),
- Throttle – position of throttle control,
- Brake – position of brake control,

Generated output signals:
- CNTRL motor – control signal for three-phase ERM regulator,
- CNTRL disc – control signal for disconnecter,
- POWER regul – power on switch for three-phase ERM regulator,

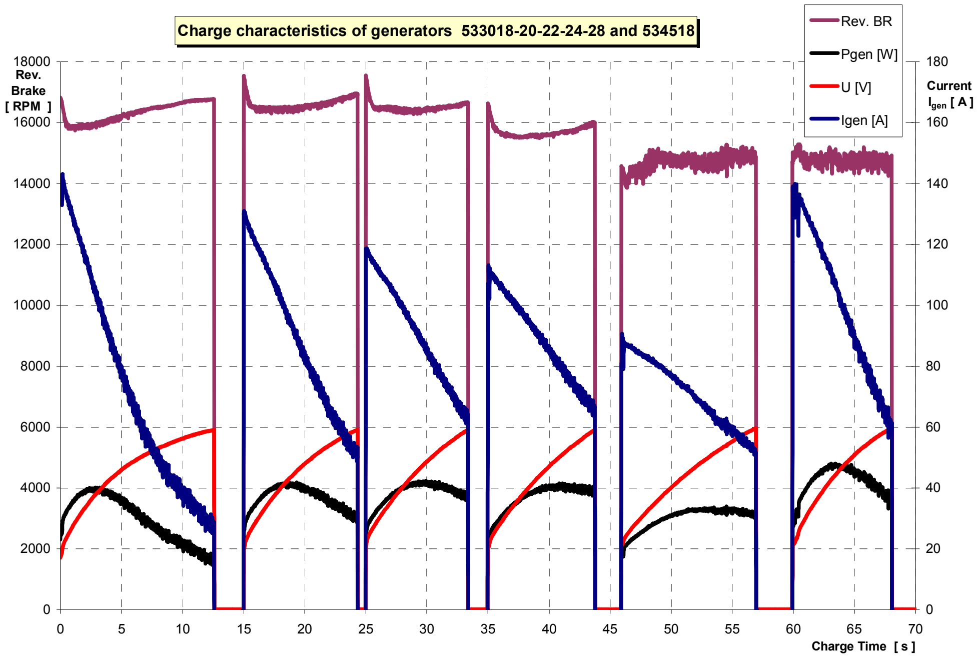

figure 3: Power characteristics of tested generators.

Basic description of ECU. All components are placed at two sided printed circuit board (PCB). Main processor is the Texas Instrument MSP430F149. Rpm signals are optically separated by optocouplers. Voltage of supercapacitor is measured directly together with charge current from disconnecter and discharge current to ERM. We have used hall sensors based on current sensor Allegro ACS754. ERM regulator is controlled by signal from microprocessor. This signal depends on the super-capacitor voltage, on actual rpm, and on required function. Disconnecter is controlled by PWM signal. This solution was used as it protects generator and super-capacitors against current overloading. The charging current is controlled by a ramp function, which can be set by PC connected through serial port or CAN bus.

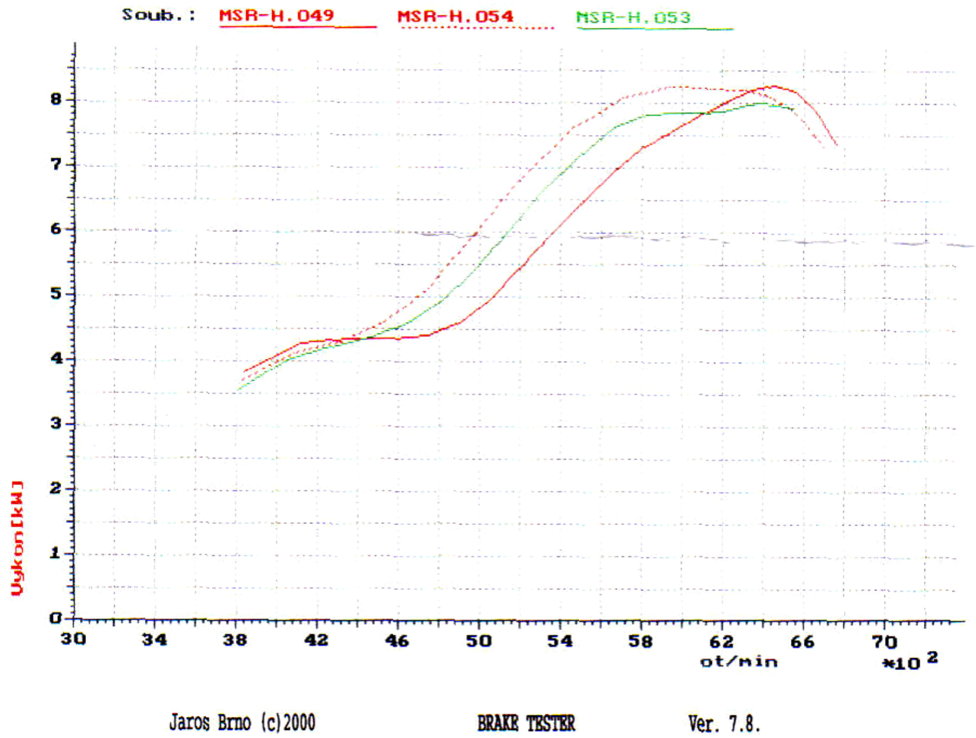

figure4: power characteristics of tested small two-stroke engine with ERM

Modes of hybrid activation system

In the case that we activate vehicle hybrid system, it is the best to use for electric energy generating and storing vehicle deceleration mode. In standard case vehicle deceleration means irreversible kinetic energy wasting, the energy is dissipated mostly in the vehicle brake system. In view of kinetic energy transformation to electric energy the shift down mode of the motorbike is very interesting. Activating generator in this mode can store electric energy into superkapacitor with maximum efficiency. This offers the possibility to extend the ERM runnig time. It means increased support from ERM (both number and intensity) in accelerating the combustion engine.

We gain a few moments with very high revolution engine. Hybrid system could also generate two positive secondary effects.

First, the combustion engine is decelerated by generator, so the chance to over-rev and damage combustion engine is limited.

Second positive effect is much higher internal dynamics; this is important mainly at two-stroke engine. It means that when accelerating on DYNO we can measure in full load mode in combustion engine and ERM aggregate higher power than in the same mode if combustion engine and ERM were measured separately, and powers were summarized.

Generator, ERM and combustion engine is working in one power train (complete hybrid system on the DYNO)

These tests were realized with complete power train momentum with generator (on DYNO model). We measured different generators and belt train ratios. All the necessary data were recorded in real time and immediately evaluated. This helped us to optimize generator charging intensity and generator charging speed.

According to tests we ran we identified basic regulation loops and programmed into ECU. We assembled power train unit without generator application tests after separated generator tests and ERM tests as we described it here in previous part. Many tests followed after basic ECU programming and first mechanical tests. It was necessary for real conditions mapping, and to optimize the ERM and combustion engine collaboration. ECU is programmed to use one of variant engine power characteristics (see: figure 4). Red solid curve is without booster, red dashed curve is with booster 1 kW.

We tested automatic recharging after ERM stop (see figure 5). This type of experiment showed us that it is possible to charge supercapacitor when booster is off and combustion engine still increasing rpm. We have identified basic regulation loops which were programmed into ECU. Charging and discharging rate was not limited (within applicable range).

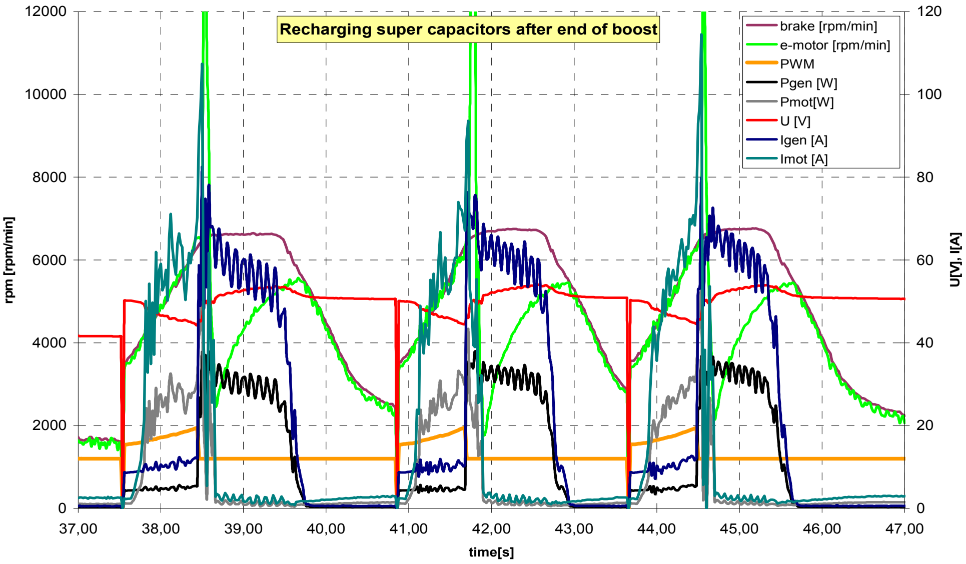

figure 5: Complete measurement data record of charging after boost.

III. CONCLUSION

This method of acceleration improves combustion engine transient characteristic expressly, and it increases power of combustion engine, too. At this time, the system is tested. We evaluate recorded data. Next step is creating algorithm optimizing the control of using the supercapacitor energy. Algorithm of efficient transfer will control charging and discharging supercapacitor, and it will improve time for motorbike acceleration.

We need to perform basic software simulation using real characteristics of all blocks involved in hybrid system.

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