Science Research
2016; 4(6): 153-156
http://www.sciencepublishinggroup.com/j/sr
doi: 10.11648/j.sr.20160406.12
ISSN: 2329-0935 (Print); ISSN: 2329-0927 (Online)

Report

Pseudo-Driverless Driving and Automatic Recovery of Braking Energy as a Compromise Between Environmental and Automotive Approaches

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To cite this article:
Marat Salakhov, Artem Bulah. Pseudo-Driverless Driving and Automatic Recovery of Braking Energy as a Compromise Between Environmental and Automotive Approaches. *Science Research.* Vol. 4, No. 6, 2016, pp. 153-156. doi: 10.11648/j.sr.20160406.12

Received: October 31, 2016; **Accepted**: January 17, 2017; **Published**: February 7, 2017

Abstract: Our innovation synthesis lab is taking on sophisticated robotic, pneumatic and hydraulic components of modern cars, questioning the practical value of their use as they are now. Potential energy can be accumulated by a mechanical braking power, instead of accumulating it on the galvanic plates. Well-proven eccentric cams, planetary gears and ratchets will continue their service in future. And ratchets are priceless when equipped with innovative floating quarter-turn teeth combined with designer roller rail system. As for driverless freight vehicles, talks about full automation are not only premature, they are going nowhere: apart from expenses on route security, creating otherwise inefficient infrastructure compatible with such vehicles will pose enormous costs.

Keywords: Pseudo-Driverless Driving, Braking Energy, Eccentric Cams, Planetary Gears, Ratchets

1. Introduction

Russian innovations are traditionally known for being straightforward. Far-fetched descriptions of chemical properties were silenced by Mendeleev's blunt periodic table, labyrinths of telephone wiring challenged by Popov's radio waves. NASA space shuttles have never made it to the operating phase, and we're still flying on Sergei Korolev's "arrows".

And even though the car industry is not exactly our thing, we do have some masterpieces of our own: the legendary Niva, the one-of-a-kind UAZ-452, not to mention the king of tanks, the T-34.

With its unique noxological model, our innovation synthesis lab is taking on sophisticated robotic, pneumatic and hydraulic components of modern cars, questioning the practical value of their use as they are now. We think that ignoring prospects of fuller use of potential energy that can be accumulated using braking power instead of accumulating it on galvanic plates is absolutely unjustified [1]. Well-proven eccentric cams, planetary gears and ratchets will continue their service in future. And ratchets are priceless when equipped with innovative floating quarter-turn teeth combined with designer roller rail system.

As for driverless freight vehicles, talks about full automation are not only premature, they are going nowhere: apart from expenses on route security, creating otherwise inefficient infrastructure compatible with such vehicles will pose enormous costs. And then there are the interests of professional truckers who are extremely socially active and will do anything to sabotage the proposed fully-autonomous solutions by causing accidents and (or) simply stealing.

We would also like to share our outlook on evolution of electric cars. Their weak point is short driving range. We suggest using 1.5-meter shell batteries with diameter similar to that of the common gas tank. These shell batteries can be taken out of the vehicle where they are positioned like the magazine in the Makarov handgun, and placed at the charging station for quick recharge. At the first stage, while the charging station network is not mature yet, you can simply leave some of your batteries to be recharged as you go and

collect them on your way back. And thanks to lessening the weight of your vehicle, the rest of the ride will be faster and more economical. It is reasonable to place such charging stations within traffic circles. At the second stage you will be able SWAP your standard batteries with already charged ones, spending half the time needed to fill a "normal" car with gas. If we introduce robotics to the battery swapping process, this project becomes even more competitive [2].

2. Pseudo-Driverless Operation Method

The risk to be late to the point of destination, the need of going through routine operations (taking off and braking) again and again, the impossibility to do anything useful while waiting inside the car and inadequate maneuvers of fellow drivers are the most essential among the factors getting on the nerves of those stuck in traffic jams. All of them can be leveled by rigidly hitching several following cars, provided you have their drivers' consent. However, this comes hand in hand with inconvenience and extra concerns. At the same time, a lot of effort is put into researching driverless trucks as well as additional safety for premium cars [3].

Warning systems for early detection of humans or other obstacles on the road that initiate deceleration are well known. Furthermore, there is a variety of collision avoidance systems. The emergency braking system, the system alarming the driver by sending vibrations to the steering wheel if it detects drowsiness, the system providing automatic partial wheel braking on the opposite side in case of accidental crossing of solid road marking, and finally the system informing the driver about the presence of a car in the so called dead zone have also proven themselves to be quite effective.

The objective of the declared useful model is not only making a car jammed in traffic automatically stop thanks to distance sensors monitoring the safe interval to the car in front, but also enabling taking off and following the chosen object, basically simulating a rigid hitch that does not require a driver behind the wheel of the towed vehicle. In other words, we get something between a driverless car and a car equipped with active safety systems. And an automatic gearbox to provide driverless control is not needed at all. Connecting one of the non-driving wheels to a low-powered electric motor shall solve the problem of taking off in difficult road conditions as well as slowing down, no matter the type of transmission.

The declared method of pseudo-driverless control relates to the means of increasing driving comfort, road safety and maybe even optimizing freight traffic.

Devices helping the driver park and descent, improving driving safety and efficiency, reducing stress and shortening maneuvering time are known in the prior art.

The system for preventing the vehicle from collisions and the method of its operation (Rospatent registration number 2014 124 969 (US)) as well as a similar method 2012122076/11 (DE) are also known.

These are aimed at monitoring the driver's actions and providing assistance in long trips. The objective of the declared useful model is increasing the driver's comfort when moving along busy urban streets. It is achieved by using modern devices controlling distance, automatic take-off, course change and stop in the author's interpretation. These devices act as a rigid hitch of sorts, but with the opportunity of short-term arrangement between the leading and driven vehicles of other traffic participants.

Speaking about this useful model's option for cargo transport making long-distance and international trips, it should be noted that the current requirements for drivers' labor conditions and rest either do not to fully exploit the vehicles' potential or take a crew of two drivers. Version 2 of the declared model makes it possible to add the option of conditionally driverless mode for the period of crew rest on the road sections without intensive traffic or complex route for one or several vehicles moving in column with the leading vehicle controlled by an on-duty operator that can track the state of the driven vehicles via wireless connection and video on the screen of a special device installed in the leading vehicle [4].

3. Braking Energy Recovery Method

We know that the greatest harm to environment is caused by vehicles with high engine revolutions at low speeds. This operation mode is typical for taking off (starting) and acceleration. Taking into account the large number of stops when moving around the city, we can say that this idea is relevant not only in the environmental context, but also from the resource economy standpoint. The idea is to use braking energy to generate additional momentum when taking off. The proposed recuperator accumulates not electrical, but mechanical energy. Schematically, energy accumulation can be represented in two stages (braking and acceleration) as a sequence of units [5, 6].

At the first stage, the speed drops to 6 km/h, the pulley electromagnetic clutch locks automatically turn on and engage the wheel disk on the inner side – the pulley thus begins to rotate and decompresses the 10-kN spring attached to the vehicle frame through the shaft transmission. When the speed drops to 0 km/h, the solenoid retainer fixes the 10-kN spring and clutch locks turn off. After that, the pulley returns to the initial position under the action of the 0.5-kN spring. At the second stage, when the first gear is enabled, the clutch locks turn on again, then the retainer of the spring turns off; the spring transfers force to the wheel in the direction of motion while waiting for the start. 1 to 1.5 m into the motion, the shaft reaches the neutral position, the clutch locks turn off, and the energy accumulation system goes into standby mode.

When implemented on the stand, this concept has undergone minor changes. In particular, it is better to use a spring suspension instead of a separately-mounted 10-kN spring, and a pendulum reducer and a ring gear fastened to the inner side of the rim instead of a pulley; the reducer rotates against the direction of wheel rotation due to the satellite. Thanks to blocking the planetary gear, it also provides for impulse transmission at the beginning of motion.

The prospects are obvious: in addition to the already

mentioned environmental and resource-saving aspects, budget cars acquire properties typical of more expensive models: adjustable clearance and the effect of an all-wheel drive. For the electric and hybrid cars, this unit will also contribute to improvement of operating characteristics.

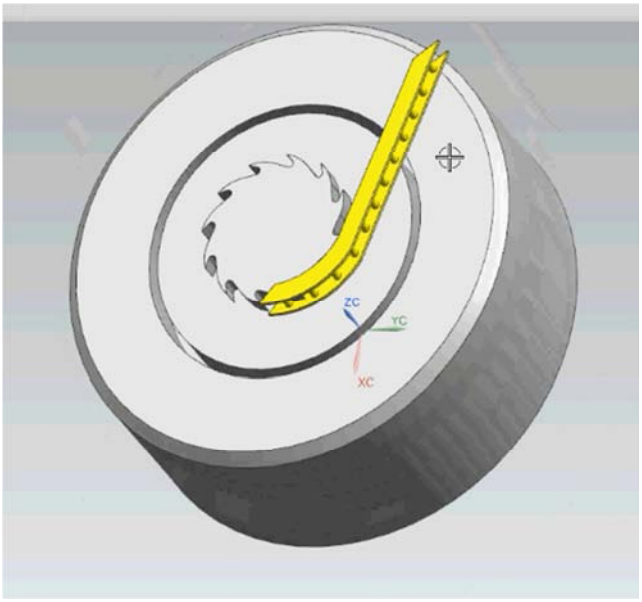

Figure 1. *Original rack mechanism.*

When conducting experiments on MAN TGS 28-360 trucks and road trains, several changes were introduced to the recuperator project, all aimed at reducing take-off inertia, especially with the truck loaded and operating in the urban mode, which is characteristic for the delivery vehicles used by Magnit and other large company networks. For example, the pneumatic system, which makes it possible to change the height of cargo platform, simplifies energy recovery, and the original rack mechanism (figure 1) lessens the load on the truck's transmission and power unit. When used on the tractor's non-leading wheels or on a trailer, the recuperator enables increasing the vehicle's traction, which is especially urgent in winter, when snowfalls make passage of road sections in adjacent territories difficult. Similar arguments can be used to substantiate application of the declared method on urban buses [7, 8].

The declared method of braking energy recovery is one of the means of improving vehicle design.

The methods of energy recovery due to energy transfer through the electric generator to the storage battery are known from the prior art. There are solutions based on the accumulation of energy in the pneumatic systems receivers. These devices work efficiently on high revolutions, but electrical and pneumatic methods prove to be inappropriate if short-term potential accumulation when driving at the speed of pedestrian is required.

The objective of the declared useful model is short-term recovery of braking energy through the use of a spring mechanism and the potential energy of the vehicle's weight gained when lifting the vehicle on built-in jacks with subsequent take-off relief.

It can be achieved by the turning the lifting unit on when braking, fixing the vehicle body position and then turning on the wheel cranking unit to the angle of 30–170 degrees at the beginning of motion, which makes it possible to transfer the momentum facilitating the start. This is especially important considering that it takes the lion's share of energy to overcome inertia in starting positions, particularly in the urban operation mode.

The following devices were invented and patented (applications to the Rospatent have been sent) during the research:

A) The inter-axle external locking differential for front-wheel-drive vehicles (can be mounted either at the factory or when tuning, without dismantling the gearbox).

B) Lever self-extractor. Its operating principle is based on using the shell circuit of the original decorative threshold (front or rear crossbar) with a T-shaped lever temporarily installed into it, the lower end of the lever resting on the ground and the upper one in contact with one of the vent rims of the drive wheel by means of the tighten belt. If a triangle support is welded to the lever's lower end, it can be used as a jack for lifting wheels.

But remember: the idea is to use braking energy to generate additional momentum when taking off.

Considering certain drawbacks of the traditional gears, we have simplified the design in the course of further experiments.

We use a brake drum (disk) with a half-turn stroke (better with dual clutch) and a return spring to store energy, which allows not to resort to using a ring gear on the wheel rim. A roller rail (stiff chain) is used to transmit energy to the wheel [9].

Further on, there is a ratchet gear: a disk with quarter-turn revolver rods evenly distributed around the circumference which lay flat on the side of roller rail at rest, providing for projection of the tooth beyond the disk. This allows to move the disk down with the rake, giving extra momentum to the vehicle. During movement under the action of centrifugal forces, the connecting rods take the position in which they lie completely within the circumference of the disk and do not touch the roller rail. You can rigidly connect the eccentric with a roller bearing with the drum to adjust clearance. A more gradual increase of the eccentricity is better for lifting the vehicle body by 3 to 4 cm, and a steep descent for lowering it with release of energy used to facilitate the start (in this case the rail with the ratchet may not be necessary).

The prospects of the study are obvious: in addition to environmental and resource-saving aspects (reduced fuel consumption, increased life of clutch plates and brake pads), budget cars acquire properties typical of more expensive models: adjustable clearance and the effect of an all-wheel drive. It is good for freight transportation, especially road trains and urban buses, and very useful for electrical and hybrid vehicles.

4. Conclusion

Summarizing the innovations described above, we can state that as opposed to the known engineering solutions [10] we do not claim to offer a completely driverless driving system. It is expensive and, considering the events in Berlin and Nice, fraught with a risk of terrorist attacks. We seek to make driving in congested traffic easier. The solution can be limited to a couple of forward-looking sensors. We also suggest equipping vehicles with low-power electric motors on non-driving wheels, which will eliminate difficulties in adaptation of a manual gearbox to start and stop modes of slow vehicle motion.

As far as braking energy recovery is concerned [11], it has already been mentioned that the innovation is primarily focused on urban traffic for which frequent stop and start is typical. We believe short-time recuperation can be achieved with a low-cost system for mechanical transfer of surplus energy. An eccentric cam helps lift the vehicle body a couple of centimeters. This capability will also be useful when moving in deep ruts or a snow-covered area. The original rack mechanism with floating gear imparts additional momentum in the direction of movement.

Forthcoming is research in improvement of driver visibility using one camera (rather than tens of them) attached to a telescoping mobile tripod, a solar cell on pull-out parking panels, a bicycle frame with an external luggage box, inter-wheel differential lock external unit for a front-wheel drive vehicle, etc.

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