# MULTIFUNCTION VEHICLES ON THE COMBINED RAIL-WHEEL MOTION

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**Abstract:** The modern multifunction vehicles on rail-pneumowheel motion and their possible trends have been considered. The structures of combined motion mechanisms and chassis characteristics for their unitization have been analysed. There has been shown the possibility of creation of the mobile combined motion vehicles on MAZ-6303 and MKZh-416 (Sh-406 "Belarus") chassis powerful enough to be used for carrying the equipment for rail and motor roads maintenance and reparation or as locomobiles for shunting and train work.

## Introduction

In the real sector of economy of the Republic of Belarus and countries of the CIS more than 75 % of enterprises in various branches of industry and agriculture have got the flow of traffic limited to 25-30 waggons per day. Under these circumstances the traditional transport technologies using TGK, TGM, TEM, ChME, etc. diesel-locomotive shunters with horsepower of 1500 and adhesion weight of 130 tons result in rather high costs where there is the prevalence (up to 70%) of energy supply costs. The main reason for such situation is the inefficient power (up to 20…25%) and time (up to 20%) use of diesel locomotives.

Meanwhile the track length of approach rail lines in Belarus is 1121, 4 km. The maintenance and repairing of these lines with the use of heavy-duty track machines are often difficult because of minor curve radii and small scope of work.

The reduction of costs in this situation is possible by introduction of multifunction vehicles on combined rail-pneumowheel motion. The cooperation of leading national wheeled machinery manufacturers, Transport Logistics Department of the Ministry of Defence of the Republic of Belarus and the Belarusian State University of Transport in this area has enabled to develop a number of experimental models of such vehicles on the national pneumowheeled chassis basis.

## Engineering level of multifunction vehicles on the combined rail-wheel motion

Modern requirements for mobility, multifunctionality and efficiency of military, railway and road-building machinery set the task of making the multipurpose vehicle meant for using it both as a mobile power-hungry carrier of the equipment for rail and motor roads maintenance and reparation for transport military troops and organizations with approach rail lines at their disposal and as a locomobile for shunting and train work.

The solution of this problem is possible by equipping pneumowheeled vehicles with attached implements of combined rail-wheel motion which provide movement and performance of work operations both on motor roads and railways. Besides the installation of changeable implements will allow to use pneumowheeled vehicles for the year-round maintenance of motor roads, load-unload operations, land improvement, maintenance of bridges and tunnels on motor and rail roads as well as for elimination of various emergency situation effects.

Attached implements of combined rail-wheel motion can be installed on production vehicles, tractors and special chassis for their movement on railroads with 1520 mm and 1435 mm gauge without taking pneumowheels off. The structure of attached implements allows their field assembling, placing the vehicle on rail track (at rail (level) crossings and zero levels) and also moving it from one rail gauge into another. The installation of attached implements does not reduce the speed of motor cars on roads

but their capabilities on roadless sections are slightly decreased because of the geometrical terrain deterioration.

In railway military troops of the USSR the combined rail-wheel motion was in different motor cars and vehicles [1]: GAZ-69 was used as a staff rail inspection car, UAZ-450 and UAZ-452A were used as passenger and freight rail inspection cars and also as ambulance vehicles, railmotor cars GAZ-63, GAZ-66, ZIL-130, KrAZ-257 and KrAZ-219 were for shunting work and transportation of goods, passengers and for discharging of link packages under track-laying machines.

The present multipurpose UPM-1 track machine adopted by railway military troops is also based on pneumowheeled T-158 tractor chassis (manufactured by Kharkov Tractor Plant) and on combined rail-wheel motion with hydraulic drive for setting it into on-position [2]. The UPM-1 complex includes component blocks for the execution of preparatory, main and finishing road-metalling on small distributed railway objects work.

In the Armed Forces, Services for the Elimination of Emergency Situations and Railway Enterprises of the European countries the most widely-spread vehicle for mechanization of track, road-building and recovery work is Unimog by Mercedes-Benz. This chassis is an aggregate unit for various equipment manufactured by Gleisbaumechanik and Zweihoff (Germany), Geismar and Socofer (France), Case (UK), etc.

The analysis of the present machinery stock on combined rail-wheel motion in the Republic of Belarus shows that the manufacturing capability is low and there is a considerable physical depreciation of the machinery while foreign machinery is characterized by high purchase and operation costs and requires adaptation to the existed operating conditions (1520 mm gauge, low temperatures in winter, problems with unitization with national attached implements).

## Analysis of structures of the combined rail motion mechanisms

Vehicles on combined rail-wheel motion make their tractive and braking forces because of adhesion of drive pneumatic wheels with rails. Tractive force depends on coupling gravity force, i.e. drive wheel gravity force and also on rail conditions (moisture, pollution) and pneumowheel protectors [3, 4]. The influence of rail conditions and pneumowheel protectors is defined by the adhesion coefficient which is higher for “pneumowheel - rail” pair than for “metalwheel - rail” pair and is 0,68 – 0,85 for dry and 0,35 – 0,45 for wet rails against 0,22 – 0,24 and 0,15 – 0,20 respectively [5–7]. The exeption is ice-covered rails where the adhesion of pneumowheels with the rail coefficient is falling down to 0,15.

In the majority of constructions the mechanical drive of mechanisms of changing the machinery on combined rail-wheel motion from run-in position into on-position for placing vehicles on rails is used. For example, for lifting and dropping of UAZ-450, KrAZ-257motor car wheel pairs the worm reduction gearboxes have been applied, and for GAZ-63, GAZ-66, ZIL-130 – motor winches. At the same time the mechanical drive does not provide high efforts the development of which may be necessary during the installation of crush loading vehicles on a rail track. Besides, the changing of machinery on combined rail-wheel motion from run-in into on-position with the help of the mechanical drive takes a considerable amount of time (about 10 minutes). So as an alternative to mechanical drive it is reasonable to use hydraulic drive. But to improve the survivability of the entire machinery, which is especially important for railway military service, the combination of drives, e.g. electro- or hydro-mechanical, is more preferable (figure 1).

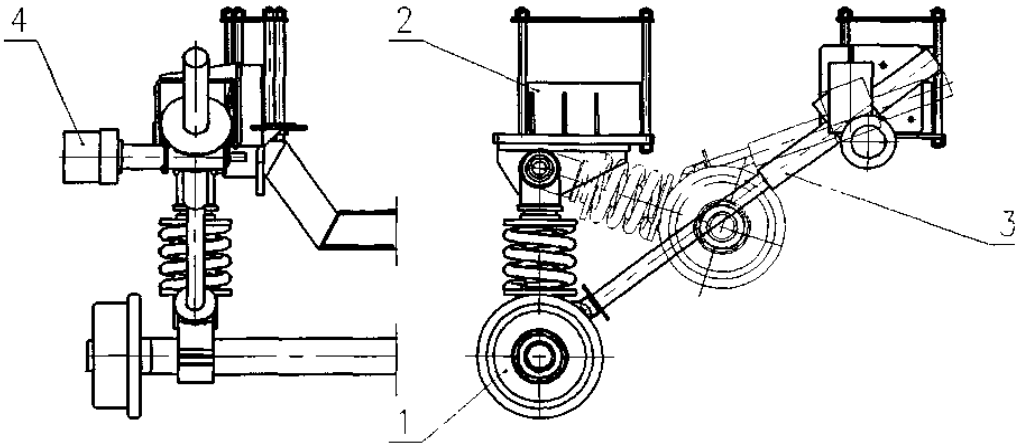


**Figure 1: Lift-drop mechanism of the combined motion wheel pair:**
**1** – wheel pair; **2** – bracket; **3** – reduction gear;
**4** – drive (hydraulic or electric motor)

**Choice of chassis for multifunction rail-pneumowheeled vehicles**

The operation of multifunction vehicles on railroads and motor roads (paved, unpaved, roadless sections) as well as the necessity to bring different kinds of equipment make high demands of basic chassis. It means the assurance of high power density and tractive force developed by pneumowheeled mover in different traffic conditions. In addition to that the chassis must provide the possibility of the auxiliary power take-off for the drive of the attached processing equipment both when it is parked and in motion. The analyses of power-hungry machinery produced by native enterprises shows that for the assembling of the equipment for permanent way maintenance and repairing MKZh-416 (Sh-406 "Belarus") chassis by Minsk Tractor Plant is the most efficient, and for using it as locomobiles or light rail inspection cars – MAZ-6303 chassis by Minsk Automobile Plant [8, 9]. But these chassis require frame improvement for the increasing strength characteristics, transmission improvement for maximal tractive force provision (for Sh-406 the reduction of the front driving axle track is required, and for MAZ-6303 – the reduction gear installation with 7,79 transmission ratio) as well as the installation of the additional pneumo- and hydro-systems. Basic chassis technical characteristics for these vehicles are given in Table 1.

**Table 1: Chassis technical specifications for multifunction vehicle making**

| Characteristics | MAZ-630308 | Sh-406 "Belarus" |
|---|---|---|
| Total weight, kg | 24500 | 10100 |
| Wheel arrangement | 6 x 4 | 4 x 4 |
| Total weight distribution, kg<br>on front axle<br>on rear axle (rear bogie) | <br>6500<br>18000 | <br>5555<br>4545 |
| Carrying capacity, kg | 14800 | 3500 |
| Engine capacity, kW | 294 | 88 |
| Speed, km/h | Up to 100 | 3,5 – 50 |

Apart from that MAZ-6303 chassis may provide the additional power take-off up to 100 % when it is parked and up to 50 % when in motion and Sh-406 "Belarus" hydro-system has got a hydro-output for operating fluid feed of various hydraulic equipment.

The requirements for the improvement of the chosen chassis as well as the orientation of some of their components, aggregates and devices for operating mainly on motor roads (e.g. tyres, gearboxes, clutch gears) indicate the necessity to continue the search and the of the purpose-designed chassis which ensures the effective operation of various equipment on motor and rail roads.

**Creation of national multifunction vehicles on combined rail-wheel motion**

Keeping in mind the above accepted engineering solutions during the mechanisms of combined rail-wheel motion design the unitization of the latter with MAZ-6303 chassis has been done (Pic. 2). The combined rail-wheel motion of the created vehicle has got complementary rail wheels on spring suspension for remaining on rails and taking part of mass load upon them. Tractive and braking forces are realized due to the adhesion of driving pneumatic wheels with rails. Front steerable wheels at this time are 70…100 mm above the rails, and steering control is blocked. When moving on roads the mechanisms of the combined rail-wheel motion take the run-in position by means of hydro-mechanical drive [10].

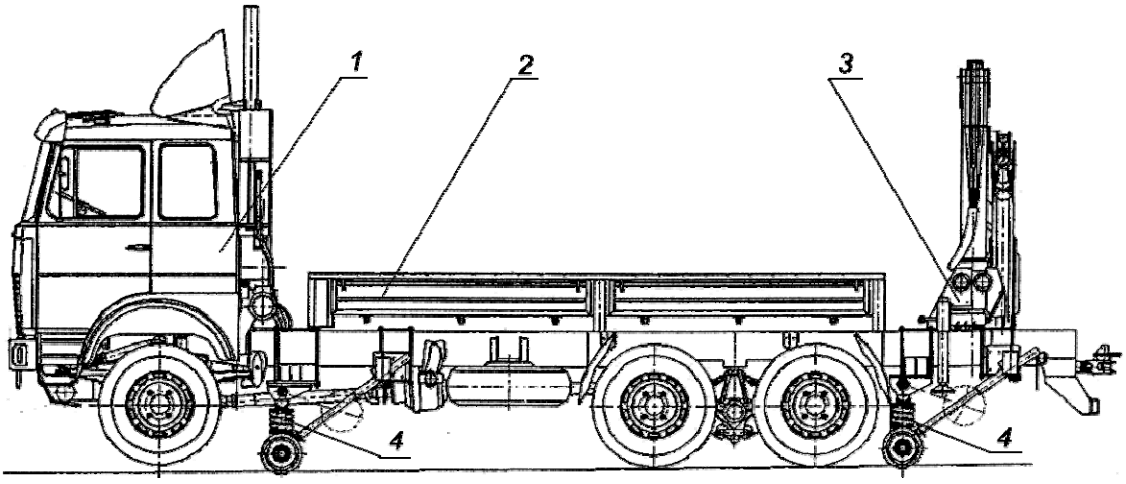


**Figure 2: Locomobile on MAZ-6303 chassis:**
**1** – MAZ-6303 chassis; **2** – cargo bed; **3** – hydraulic manipulator; **4** – combined rail-wheel motion

The installation of automatic coupling, additional compressed air feed pneumatic system for rolling stock brakes, complex locomotive safety controls (CLUB-UP) and point-to-train radio enables the locomotive to carry out all kinds of shunting work in accordance with the requirements of Operational Regulations of Belarusian Railways.

The tests have shown that locomobiles on MAZ-6303 chassis can work with maximal mass of train under 1000 tons (number of waggons – up to 12). The nominal number of waggons at the speed of 40km/h is 4-5. The fuel consumption is 20 l/mach.-h against 180 l for TEM locomotive, and the price is USD 150 000 against BR 1,5 mln.

The installation of optional equipment (hydraulic manipulator with a grab bucket, part-gripper for sleepers renewal and brush, snowplough, box body, etc.) ensures the year-round road maintenance, load-unload operations, land improvement, maintenance of bridges and tunnels on motor and rail roads as well as the elimination of various emergency situation effects [10].

To increase the approach rail lines maintenance and repairing efficiency is possible with the help of the multipurpose light-duty track machine on the combined rail-wheel motion the construction of which is similar to the above mentioned machine based on combined railway MKZh-416 (Sh-406 “Belarus”) machine chassis.
This machinery may be used in building, restoration and maintenance of rail track with 1520 mm gauge laid on wooden and ferroconcrete sleepers with R43, R50 and R65 rails and any kind of ballast as well as a locomobile for shunting and train work, the year-round cleaning and maintenance of motor roads, territories and structures.

The vehicle is equipped with block for sleeper-mark installation and gap clearance spacing (Pic. 3). The installation of automatic coupling, additional compressed air feed pneumatic system for rolling stock brakes, safety controls and point-to-train radio also allows to perform all kinds of shunting work in accordance with the requirements of Operational Regulations of Belarusian Railways [10].

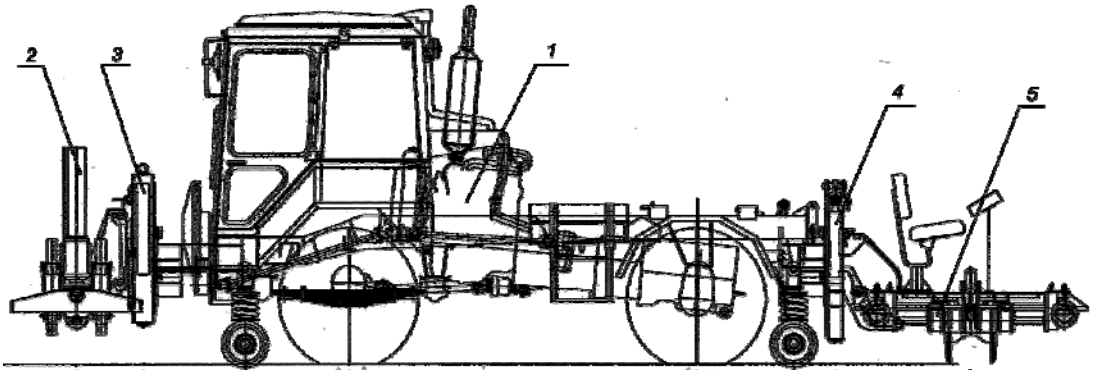


**Figure 3: Light-duty track machines on Sh-406 "Belarus" chassis:**
**1** – Sh-406 "Belarus" chassis on combined motion; **2** – lift - track lining unit;
**3** – front hinge; **4** – rear hinge; **5** – block for sleeper-mark installation and gap clearance spacing

The tests have shown that this vehicle can do shunting work with 2-3 units of rolling stock or cycled track maintenance and repairing operations. The comparison of the vehicle with the most widely-spread VPR-1200 (VPR-02) machine for track raising and lining shows that when the productivity is 5,2 times smaller (125 m/h against 650 m/h) the multipurpose track machine fuel consumption is 4 smaller (10,5 l/mach.-h against 40) and its price is about USD 100 000 against BR 1,0 mln. The analogue – Unimog (Mercedes-Benz) has got the price € 500 000.

## Conclusion

To develop this research is suggested in different aspects. Firstly, there is the possibility of organization of multifunction vehicles on the combined rail-wheel motion on customer's chassis manufacturing. Secondly, the development of a multilink train on the combined rail-wheel motion for the intercontinental transportation. Thirdly, the creation of a rail bus for passenger transportation on lines with small passenger turnover and areas passing through the national reserves and parks. The sum of investments may be defined on the basis of concrete conditions of cooperation.

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