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Analysing the possibility of using a hydraulic transmission with motor wheels for the nomad at off-roader

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Annotation. Problem. *The creation of transport vehicles for operation in difficult road conditions requires solving a complex of problems related to the fulfilment of the necessary requirements for speed and traction characteristics, in particular, shifting modes, overcoming climbs, manoeuvrability and increased speed with its stepless change, anti-skid properties. Such requirements are achieved thanks to constructive solutions in transmissions of various types.* ***Goal.*** *The aim is an attempt to create a full-flow continuously variable transmission with hydrostatic transmission and motor-wheels instead of a step-mechanical one to improve the technical characteristics of the all-terrain vehicle and the technological possibilities of manufacturing the transmission by the block method when using standard components.* ***Methodology.*** *Based on the analysis of the technical characteristics of the analogue all-terrain vehicle with a mechanical multi-gear transmission and a review of achievements in modern hydrostatic transmission with hydraulic motor-wheels, static calculations were carried out to assess the possibility of creating a stepless full-flow hydro volume transmission and building its hydraulic schematic diagram. Calculations are based on mathematical models created on the basis of the laws of mechanics and hydraulics.* ***The results.*** *According to the results of the calculations, it has been shown that it is fundamentally possible to create a stepless hydrostatic transmission for an all-terrain vehicle with the specified traction and speed characteristics. Further research is proposed on the analysis of the dynamics of the hydrostatic transmission of the all-terrain vehicle and the creation of a corresponding experimental model of the vehicle.* ***Originality.*** *For the analogue all-terrain vehicle, the hydraulic motor-wheels required for the working volume were selected, which provide the parameters of traction and speed characteristics and allow creating an original transmission without the use of reducers and gearboxes.* ***Practical meaning.*** *The obtained results are planned to be considered as recommended for carrying out a functional and cost analysis in the design and determination of technological possibilities in the manufacture of a hydrostatic transmission of an all-terrain vehicle. It is also proposed to consider the method of calculating the hydrostatic transmission of an all-terrain vehicle in the educational process for master's students of industrial mechanical engineering when studying the disciplines related to the design of hydraulic drives and their tests.*

Key words: *all-terrain vehicle, transmissions of off-road vehicles, hydrostatic motor-wheels and pumps, traction-speed characteristics, transmission calculation.*

Introduction

In modern conditions of special civil and military operations, there is a great need for vehicles to overcome difficult road conditions. Therefore, great attention is paid to the creation of off-road mobile machines. Basically, this class of machines has a kinematic scheme with all leading wheel hubs, and maneuvering is carried out according to the so-called on-board scheme. The need to supply mechanical on-board separate power to the driving wheels, as well as the requirements for anti-skid properties of the machine, require the creation of original designs of transmissions and means of their control. Of course, when designing a transmission, the designer must perform a technical task with a large number of parameters. First, these are the requirements of the traction-speed characteristics, according to which it is necessary to ensure the maximum torque on the driving wheels when shifting and moving uphill, the ability to tow other vehicles, and at the same time be able to drive at high speed in good road conditions, for example, on the highway. Secondly, it is necessary to fulfill the requirements for the maneuvering of the machine with the help of lateral turning systems, as well as to ensure anti-skid properties.

At the same time, the creation of such transmissions on the example of trucks is accompanied by requirements for the automation of gear shifting or provision of stepless systems without power interruption with maximum comfort for the driver. Therefore, the article is devoted to the analysis of transmissions of off-road vehicles, in particular, the mechanical transmission of a domestic off-road vehicle, an assessment of the technical level of modern hydrostatic transmission and hydraulic motor-wheels, comparative calculations regarding the fulfillment of the requirements of traction and speed characteristics of an all-terrain vehicle. Based on the results of the calculations, an attempt is made to select the hydraulic motor-wheels and pumps required by the parameters for the implementation of the analogue transmission. As the base machine for the analysis, a domestically developed highway was chosen.

Analysis of publications

The object of research is the transmission of an all-terrain vehicle as a vehicle with a high degree of passability in adverse road conditions [1]. Transport is classified according to the type of movement (tracks, wheels, air cushion, auger mechanism), engine type (gasoline or diesel), application (transportation of passengers, cargo, tractors). All-terrain vehicles are amphibians that can overcome water obstacles, are used in off-road conditions and to overcome possible obstacles.

The companies «MAD NOMAD», «Kvadro International» and «Zavod all-terrain vehicles Tornado» [2-4] are engaged in the production of all-terrain vehicles in Ukraine. At the «Arms and Security 2021» exhibition, a new all-terrain vehicle manufactured by the Ukrainian company MAD NOMAD called NOMAD ATV was demonstrated to the general public [2]. Thus, the ATV (all-terrain vehicle) segment has expanded with another novelty. The Sherp and Atlas ATVs are joined by a new representative of the NOMAD ATV model. The machine is designed for off-road movement, has ultra-low-pressure tires that allow it to drive on various surfaces, from swamp to sand (Fig. 1) [2]. The mechanical transmission of this machine is selected for analysis in order to assess the possibility of its modernization to hydraulic volume stepless.

Fig. 1. All-terrain vehicle NOMAD ATV from the Ukrainian company MAD NOMAD

The main indicators of vehicle transmissions are their traction-speed characteristics and the means of providing them with transmissions of mechanical, hydrodynamic (with complex torque transformers), hydrostatic transmission based on full-flow layout solutions, as well as two-flow with volumetric hydraulic drive and a mechanical branch of power transmission. An overview of transmissions of the above types for tractors, construction and road vehicles, and locomotives for railway transport is given in works [5-7].

The analysis of structural solutions of hydraulic full-flow transmissions regarding the fulfillment of the requirements of the traction and speed characteristics of agricultural machines, in particular grain and fodder harvesters, is considered in the works of domestic specialists [8, 9].

Studies on all-terrain vehicle transmissions, in particular braking modes, the use of anti-skid devices, and the calculation of dynamic characteristics are considered in [10-13].

The domestic experience of using on-board hydraulic motor-wheel drives refers to the TS-10 industrial crawler tractor-bulldozer manufactured by KhTZ [14]. This is a transmission with axial-piston adjustable hydraulic motors in combination with planetary gearboxes and a system of electronic control of speed and lateral rotation with the help of feedback based on the speed of the leading sprockets of the tracks. The dynamic characteristics of such a hydraulic transmission are considered when using the VisSim application program package, taking into account the change in the hydromechanical efficiency of hydraulic motors when reducing their working volume to increase the speed of the tractor in conditions of limited power of the drive internal combustion engine of the rotation of axial piston pumps [15, 16].

Purpose and Tasks

The purpose of the study is to evaluate the possibility of creating a full-flow stepless transmission with a volume hydraulic drive and motor-wheels instead of a step mechanical one to improve the technical characteristics of the all-terrain vehicle and the technological possibilities of manufacturing the transmission by the block method when using standard components. The statement of the problem envisages carrying out verification calculations of the mechanical transmission based on the parameters of the traction-speed characteristics of the NOMAD ATV off-road vehicle in relation to the determination of rotation frequencies and torque on the driving hubs.

The second stage of the work is an analytical review of modern achievements in the field of volumetric hydraulic drives, in particular, the development of high-torque gearless hydraulic motor-wheels based on a radial piston multicycle scheme. To determine the parameters of the hydraulic transmission regarding the pressures and flow rates of the working fluid when using hydraulic power, the necessary calculations were made based on the laws of mechanics and hydraulics. The final stage of the work is the development of the hydraulic schematic diagram of the on-board transmission and the analysis of the technical operational properties of the proposed radial-piston hydraulic motor-wheels.

Main part

A special feature of the NOMAD all-terrain vehicle is the body made of polyester-based composite material. A patented transmission with central and wheel gearboxes is also installed. In Nomad, air circulates between all wheels, that is, when one wheel hits an obstacle, the air from it is redistributed to the other. Thanks to the compressors, the driver can independently change the pressure while driving with one press of a key and select the mode depending on the conditions. The all-terrain vehicle has a reinforced safety frame that has already been tested, and the machine itself has received safety certificates.

Technical characteristics of the NOMAD ATV all-terrain vehicle: Equipped and full weight – 2200/3000 kg, respectively; The maximum speed on land – is up to 50 km/h; The maximum speed on water – is up to 7 km/h; Diesel engine – Cummins 2.8 ISF; Engine power – 129 hp (95 kW); The maximum engine torque is – 310 N.m; Length / width / height: 3600 mm / 2530 mm / 2570 mm; Ground clearance – 580 mm; Ultra-low pressure tubeless tires – 1640x640-24"; The volume of the fuel tank is – 90 l; The average fuel consumption is – 4 liters per hour.

The mechanical transmission of the all-terrain vehicle has a 6-speed gearbox, from which torques up to 10 kNm are transmitted to the hubs of the wheels with the help of central and wheel gearboxes. Such indicators allow NOMAD ATV not only to overcome off-road terrain, but also to tow equipment that exceeds its own weight by several times.

Let's consider the initial characteristics of the transmission of the all-terrain vehicle from the point of view of the possibility of using instead of mechanical gearboxes hydraulic drive with high-torque radial-piston hydraulic motor-wheels that directly rotate the hubs.

For an all-terrain vehicle, the maximum rotation frequency of the hydraulic motor-wheel (hub) is equal to:

$$n_{hmw.max} = 60\frac{v_{atv.max}}{\pi \cdot d_w} = 5{,}3\frac{v_{atv.max}}{d_w} = 5{,}3\frac{50}{1{,}64} = 161{,}59\,\text{rpm}, \tag{1}$$

where $v_{atv.max}$ = 50 km/h – is the maximum speed of the car; d_w = 1.64 m – the outer diameter of the tire.

The maximum traction force of the machine is equal to:

$$F_{atv.max} = 10^{-3}\frac{M_{hmw.max}\,2 \cdot z}{d_w} = 10^{-3}\frac{10000 \cdot 2 \cdot 4}{1{,}64} = 48{,}78\ \text{kN}, \tag{2}$$

where $M_{hmw.max}$ = 10000 Nm – torque of one hydraulic motor-wheel according to the technical characteristics of the all-terrain vehicle, Nm; z – is the number of hydraulic motor-wheels.

We determine the working volume of the hydraulic motor:

$$V_{hmw} = \frac{M_{hmw.max}}{0{,}159 \cdot \Delta p_{hmw} \cdot \eta_{hm.ef}} = \frac{10000}{0{,}159 \cdot 32 \cdot 0{,}9} = 2183{,}8\ \text{cm}^3, \tag{3}$$

where Δp_{hmw} = 32 MPa – pressure drop on the hydraulic motor and $\eta_{hm.ef}$ = 0,9 – hydromechanical efficiency of the hydraulic motor, which are previously set.

After choosing from the catalog the working volume of the hydraulic motor $V_{hmw.cat}$ = 2029 cm^3 from the MHP20-Poclain series [17], we determine the actual pressure drop in the hydraulic drive of the transmission in the mode of maximum traction force (we will mark this mode as «1»):

$$\Delta p_{hmw.work1} = \frac{M_{hmw.max}}{0{,}159 \cdot V_{hmw.cat} \cdot \eta_{hm.ef.cat}} = \frac{10000}{0{,}159 \cdot 2029 \cdot 0{,}9} = 34{,}4 \text{ MPa}, \quad (4)$$

Such a hydraulic motor has a maximum rotation frequency of 317 rev/min with a working volume reduced by 4 times according to the technical characteristics, which fully meets the requirements for the maximum speed of the all-terrain vehicle.

Let's find the speed of the car v_{atv1} at maximum traction based on the power of the drive internal combustion engine and with preliminary consideration of the efficiency of the transmission:

$$v_{atv1} = \frac{3{,}6 P_{engine} \cdot \eta_{tr.ef}}{F_{atv.max}} = \frac{3{,}6 \cdot 95 \cdot 0{,}8}{48{,}78} = 5{,}6 \text{ km/h}, \quad (5)$$

where P_{engine} = 95 kW – power of internal combustion engine; $\eta_{tr.ef}$ = 0,8 – transmission efficiency (set in advance).

At this speed of the machine, the rotation frequency of the hub is equal to:

$$n_{hmw1} = 5{,}3 \frac{v_{atv1}}{d_w} = 5{,}3 \frac{5{,}6}{1{,}64} = 18{,}1 \text{ rev/m}. \quad (6)$$

These values of the speed of the machine and the frequency of rotation of the hydraulic motor-wheel (hub) are the maximum, but radial piston hydraulic motors also work at lower rotation frequencies, stably up to almost 1.0 rev/min, which makes it possible to move the machine at almost any «creeping» speed.

The torque of the hydraulic motor at the maximum speed of the all-terrain vehicle, or the maximum frequency of rotation of the driving wheels, can also be found taking into account the power of the drive internal combustion engine and the efficiency of the transmission:

$$M_{hmw.min} = \frac{P_{engine} \cdot \eta_{tr.ef} \cdot 9550}{4 \cdot n_{hmw.max}} = \frac{95 \cdot 0{,}8 \cdot 9550}{4 \cdot 161{,}59} = 1122{,}9 \text{ Nm}, \quad (7)$$

Then the sufficient working volume of the hydraulic motor takes the following values:

$$V_{hmw.min} = \frac{M_{hmw.min}}{0{,}159 \cdot \Delta p_{hmw} \cdot \eta_{hm.ef.cat}} = \frac{1122{,}9}{0{,}159 \cdot 32 \cdot 0{,}9} = 245{,}2 \text{ cm}^3, \quad (8)$$

Since the minimum working volume of the MHP20-Poclain hydraulic motor according to the technical characteristics has a value of $V_{hmw.min.cat}$ = 507 cm^3, we will find the actual pressure drop (we will mark this mode as «2»):

$$\Delta p_{hmw.work2} = \frac{M_{hmw.min}}{0{,}159 \cdot V_{hmw.min.cat} \cdot \eta_{hm.ef.cat}} = \frac{1122{,}9}{0{,}159 \cdot 507 \cdot 0{,}9} = 15{,}48 \text{ MPa}, \quad (9)$$

Thus, reaching the maximum speed of the all-terrain vehicle is possible when using radial-piston hydraulic motors and with a significant margin of pressure.

Let's find the value of the traction force at the maximum speed of the all-terrain vehicle:

$$F_{atv.min} = 10^{-3} \frac{M_{hmw.min} \cdot 2 \cdot z}{d_w} = 10^{-3} \frac{1122{,}9 \cdot 2 \cdot 4}{1{,}64} = 5{,}48 \text{ kN}, \quad (10)$$

It should be noted that the positive result obtained regarding the possibility of using radial-piston hydraulic motors of multi-cycle action in the transmission of all-terrain vehicles is due to the creation by the company «Poclain Hydraulics» of hydraulic motors of the MHP series with increased technical characteristics. Thus, in hydraulic motors of the previous MS18 and MS25 series with close working volumes relative to the modern MHP20-2029 model, the maximum rotation frequency did not exceed 100 rev/min and 145 rev/min [18], that is, significantly less and would not allow the all-terrain vehicle to have the maximum speed in 50 km/h.

The theoretical consumption of the pump Q_{p1} and Q_{p2} (or pumps in the case of an on-board rotation scheme of the machine) to ensure the functioning of the hydraulic transmission is found according to the formulas:

$$Q_{p1} = 10^{-3} \cdot n_{hmw1} \cdot V_{hmw.cat} \cdot z = = 10^{-3} \cdot 18{,}1 \cdot 2029 \cdot 4 = 146{,}9 \text{ l/ min}, \quad (11)$$

$$Q_{p2} = 10^{-3} \cdot n_{hmw.max} \cdot V_{hmw.min.cat} \cdot z = = 10^{-3} \cdot 161{,}59 \cdot 507 \cdot 4 = 327{,}7 \text{ l/ min}, \quad (12)$$

The obtained results make it possible to draw a conclusion about the use of serial axial-piston pumps produced by foreign manufacturers or the domestic enterprise «Hydrosila».

In Fig. 2 shows a cross-section of a multi-cycle radial-piston hydraulic motor of the MHP model of the «Poclain Hydraulics» company, the principle of operation of which and its components are shown in a specialized video (Moteur a pistons radiaux – In Situ Experts Hydrauliciens.mp4-VLC, MHP Motor Range-Poclain Hydraulics).

The main parts of the hydraulic motor are the profile cam-copier 1, the cylinder block 2, in the radial borings of which pistons 3 with rollers 4 are located. At the maximum working volume of the hydraulic motor (Fig. 2, a), the zones $p1...p8$ and both ring collectors $A1$ and $A2$ the end distributor are under pressure are under injection pressure. When the working volume of the hydraulic motor is reduced by half (Fig. 2, b), only 4 zones are under pressure: $p1, p3, p5, p8$, and only the annular collector $A1$.

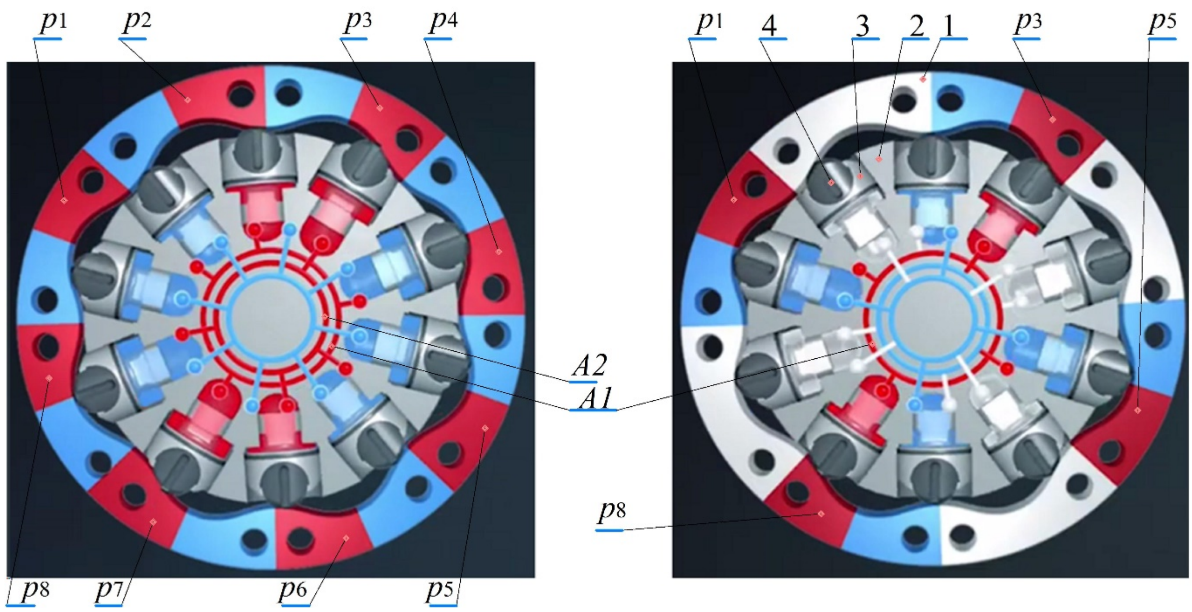

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Fig. 2. Multi-cycle radial piston hydraulic motor of the MHP-Poclain model on operating modes with maximum (a) and reduced (b) working volumes

Dependencies of the efficiency on the pressure and the relative frequency of rotation of the MHP hydraulic motors are shown in Fig. 3. In hydraulic motors of the MHP20 series, the zone of the highest efficiency of 93% is limited to a pressure of 24 MPa and a rotation frequency of 55% of the maximum value, in hydraulic motors of the MHP27 series, this zone is extended to 30 MPa and 60% of the rotation frequency. These indicators are given as averages at the maximum value of the working volume and after 100 hours of operation of the hydraulic motor on the working fluid of the HV46 class at 50°C. That is, it is assumed that the friction pairs of the hydraulic motor will be adjusted to achieve the efficiency values according to the graphical dependence.

The starting (displacement) torque is taken as approximately 85% of the pressure value when the hydraulic motor rotates

The «Poclain Hydraulics» company provides diagrams of the external radial force on the hydraulic motor-wheel hub for the durability of the radial thrust bearings of the hydraulic motor shaft in million revolutions B10 at an average pressure of 15 MPa and at a kinematic viscosity of the working fluid of 25 cSt (Fig. 4).

To achieve such durability, no axial force on the bearings is assumed.

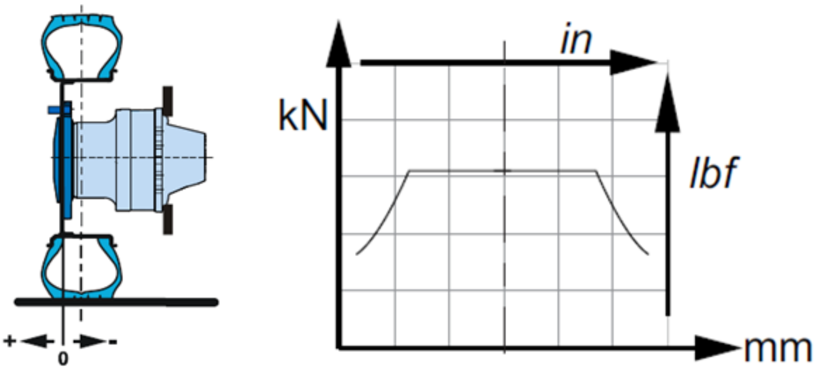

Fig. 4. Permissible load on the hydraulic motor-wheel of the MHP-Poclain series from the location of the load on the hub

According to Fig. 5, the hub 2 of the driving wheel of the machine and a set of brake discs 3, which is used for parking and working braking, are mounted on the shaft 1 of the hydraulic motor. The parking brake of the normally closed type has a piston 4, which is constantly pressed against the discs 3 by a spring 5. To release the brake, it is necessary to supply the working fluid under pressure through the hole X, which leads to the movement of the piston 4 to the right until the compression of the spring 5 and thus disconnects the compression of the discs 3 among themselves. For the operation of the service brake, it is necessary to supply the working fluid under pressure to the hole XD, which leads to the compression of the discs 3 and the braking of the shaft 1 with the hub 2. The hydraulic schematic diagram shows the main openings of the hydraulic motor A and R for communication with the hydraulic drive pump, as well as openings 1 and 3 inlet and outlet of the working fluid for cooling the discs of the brake system (flow direction is shown by arrows).

The parking brake system creates a braking torque of 18 kN.m and up to 24 kN.m in an emergency situation when used when the car is moving. Release pressure in the range from 10 MPa to 13.5 MPa. During working (dynamic) braking, the braking torque can reach 32 kN.m with pressure on the brake piston up to 7 MPa. Braking torque increases linearly as a function of control pressure.

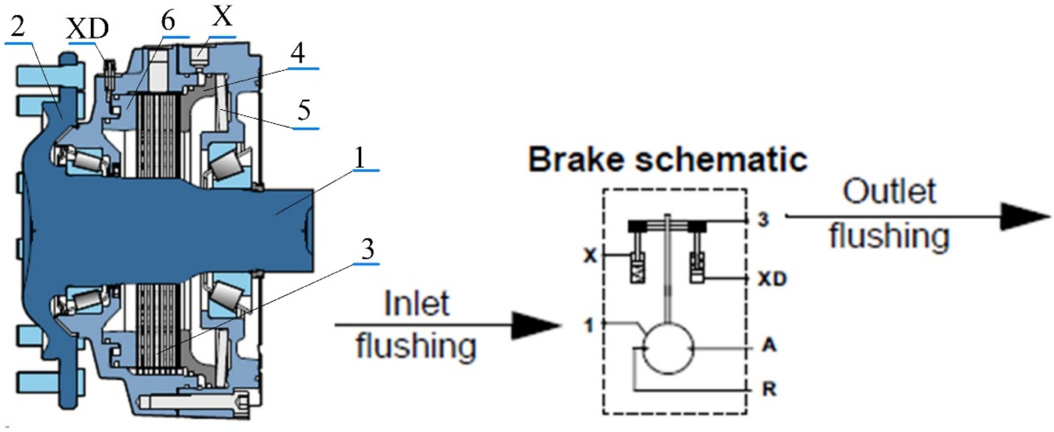

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Fig. 5. Hub block with a combined brake (a) and its hydraulic schematic diagram (b) of the MHP-Poclain hydraulic motor

In MHP-Poclain hydraulic motors, the Boosted brake™ function of braking with the help of a volumetric hydraulic drive is provided, which reduces the use of friction brake discs and exceeding the engine speed [19, 20]. At the same time, the maximum working volume of the hydraulic motor is set and the process of converting the kinetic energy of the vehicle into heat in the working fluid of the hydraulic drive, which is then cooled, is underway. The Boosted brake™ braking system is recommended for use on vehicles that need to slow down frequently, and diesel engines have low braking power.

To cool the braking system, it is necessary to supply through hole 1 working fluid with a flow rate of 2.5 l/min at frequent rotation of the hydraulic motor up to 150 rpm and 4 l/min at increased rotation frequency up to 200 rpm (Fig. 6). In Fig. 7 shows the structural diagram of the proposed hydrovolume transmission of the all-terrain vehicle with hydraulic motor-wheels of the right Mr1 and Mr2 and left Ml1 and Ml2 sides.

This scheme is built on the analogy of the on-board hydraulic drive developed by the Bosch Rexroth Group company for the TS-10 crawler tractor-bulldozer [14, 15].

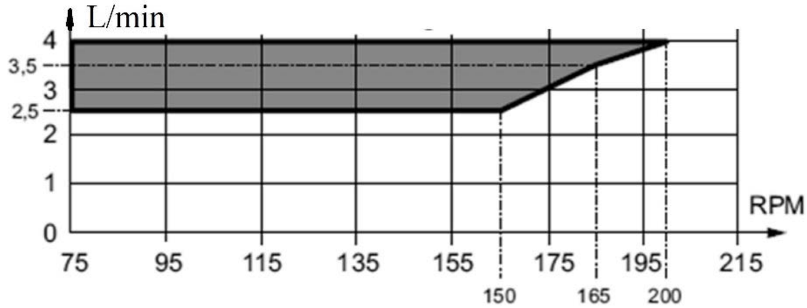

Fig. 6. Dependence of the consumption of the working fluid for cooling the brake discs on the frequency rotation of the MHP-Poclain hydraulic motor

Hydromotors rotate the hubs HBr1 and HBl1of the all-terrain vehicle. The tandem pumps Pr and Pl are driven through from the Engine and supplies hydraulic energy to the hydraulic motors of the respective sides. Communication between pumps and hydraulic motors is carried out with the help of high-pressure hoses of HPH, which simplifies the layout of the transmission. All hydraulic machines have an adjustable working volume - axial piston pumps with stepless adjustment, hydraulic motors with step adjustment. Electrohydraulic systems with proportional electromagnets Y1...Y6 are used to control the working volume.

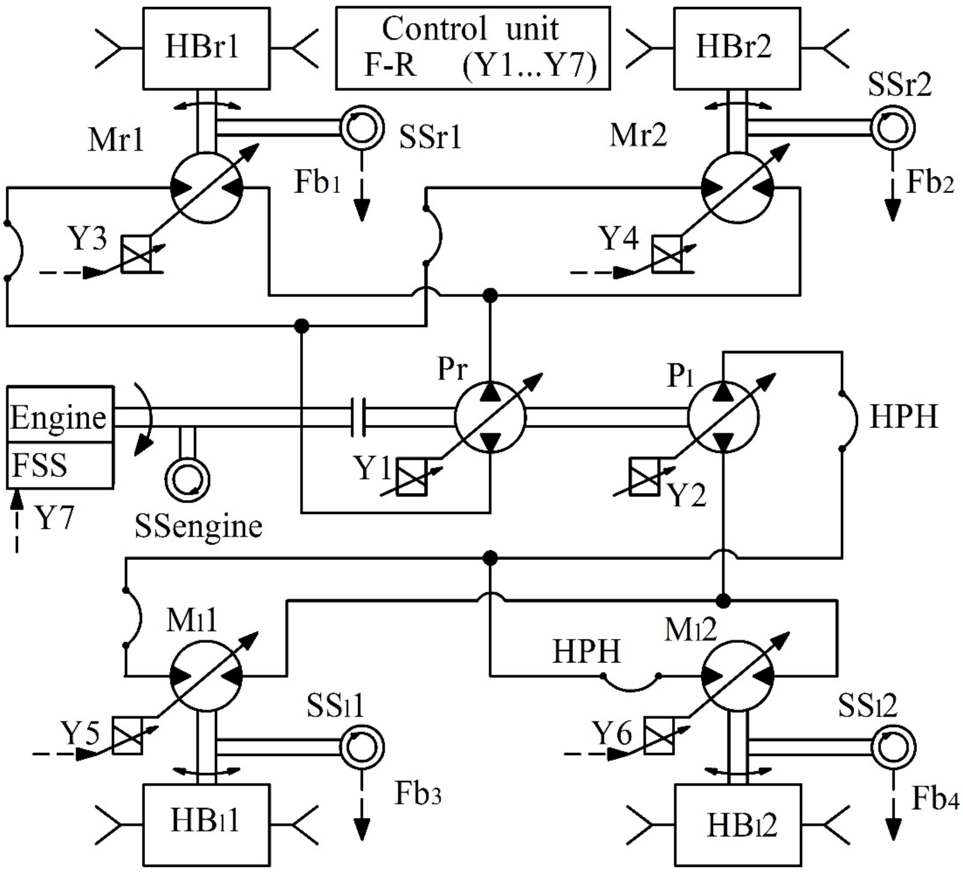

Fig. 7. Structural diagram of the hydrovolume transmission of an all-terrain vehicle with hydromotor-wheels

Conclusion

Based on the results of static calculations of the mechanical transmission of the road vehicle, an analysis of the possibility of replacing this transmission with hydrostatic transmission with hydromotor-wheels of the radial-piston multi-cycle type was carried out. The basis for carrying out such a replacement was the appearance of hydraulic motor-wheels of a higher technical level in terms of the maximum rotation frequency. In addition, such hydraulic motor-wheels are equipped with brakes of parking and dynamic types.

Thus, the appearance of radial-piston hydraulic motor-wheels with increased technical characteristics and the availability of the necessary range of axial-piston pumps, including those of domestic production, make it possible to create a hydrostatic transmission practically without the manufacture of separate special units and units, that is, it does not require an enterprise that is engaged in the creation of off-road vehicles, the creation of technological links with precision machine tools, including finishing equipment.

Further stages of research involve the calculation of the dynamics of the hydrostatic transmission taking into account the specific modes of its operation with variable parameters of the hydraulic motor-wheel with an adjustable working volume in relation to fluid leaks from piston pairs and distribution nodes, the module of compressibility of the fluid, the speed of operation of the modes of external load and pump supply changes over time. Particular attention should be paid to the modes of gradual change in the working volume of hydraulic motors from the point of view of their compensation with the help of a stepless change in the supply of pumps using an electronic control unit with feedback of the modes of operation of the transmission in the full traction-speed range.

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Аналіз можливості застосування гідравлічної трансмісії з мотор-колесами для всюдихода NOMAD ATV

Анотація. Проблема. *Створення транспортних машин для роботи в тяжких дорожніх умовах вимагає рішення комплексу задач, пов'язаних з виконанням потрібних вимог до швидкісно-тягових характеристик, зокрема режимів зрушування, подолання підйомів, маневреності та підвищеної швидкості з безступеневою її зміною, антибуксувальних властивостей. Такі вимоги досягаються завдяки конструктивним рішенням в трансмісіях різних типів.* ***Мета.*** *Спроба створення повнопотокової безступеневої трансмісії з об'ємним гідроприводом і мотор-колесами замість ступеневої механічної для підвищення технічних характеристик машини-всюдихода і технологічних можливостей щодо виготовлення трансмісії блоковим методом при застосуванні стандартних комплектуючих вузлів.* ***Методологія.*** *На основі аналізу технічної характеристики всюдихода-аналога з механічною багаторедукторною трансмісією і огляду досягнень в сучасних гідравлічних трансмісіях з гідромотор-колесами проведені статичні розрахунки для оцінки можливості створення безступеневої повнопотокової гідрооб'ємної трансмісії і побудови її гідравлічної принципової схеми. В основі проведення розрахунків лежать математичні моделі, створені на основі законів механіки і гідравліки.* ***Результати.*** *За результатами розрахунків показано, що принципово можливо створити безступеневу гідрооб'ємну трансмісію для всюдихода с заданими тягово-швидкісними характеристиками.*

Запропоновані подальші дослідження щодо аналізу динаміки гідрооб'ємної трансмісії всюдихода і створення відповідного експериментального зразка машини. ***Оригінальність.*** *Для всюдихода-аналога виконаний вибір необхідних за робочим об'ємом гідромотор-колес, які забезпечують параметри тягово-швидкісної характеристики і дозволяють створити оригінальну трансмісію без застосування редукторів і коробок передач.* ***Практичне значення.*** *Отримані результати заплановані для розглядання як рекомендовані для проведення функціонально-кошторисного аналізу при проектуванні та визначенні технологічних можливостей при виготовленні гідрооб'ємної трансмісії всюдихода. Запропонований також розгляд методики розрахунку гідрооб'ємної трансмісії всюдихода в учбовому процесі для студентів-магістрів галузевого машинобудування при вивчені дисциплін, пов'язаних з проектуванням гідроприводів та їх випробуваннями.*

Ключові слова: *всюдихід, трансмісії позашляхових машин, об'ємні гідромотор-колеса та насоси, тягово-швидкісна характеристика, розрахунок трансмісії.*

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