DEVELOPMENT OF MODEL OF WORK BY MODULAR WHEELS FOR SELF-PROPELLED MACHINES

Bekenov T.N., doctor of technical sciences (L.N.Gumilyov Eurasian National University, *Astana*);
Nussupbek Z.T., candidate of technical sciences (*Saken Seifullin Kazakh Agrotechnical University, Astana*);
Tassybekov Z.T., candidate of technical sciences (Nazarbayev University, *Astana*)

From the literary sources known the equation of the traction balance of vehicles, including cars, which is derived from the condition of the interaction of the entire machine with the road (base). The inertia force entering the traction balance equation is calculated through the coefficient of accounting for the rotating masses of the entire machine. In addition, in the literature describes the calculation of the interaction of single wheels by the road, depending on the nature and direction of the forces and moments acting on these wheels, that is, different modes of power loading of the wheels. At the same time, the connections of the front and rear wheels in the general regime of their force loading are not given and are not considered, respectively, the equations of the power balance of the wheels separately in cases of their uneven motion are absent. Therefore, the consideration of the individual processes of interaction of modular wheels with the road is necessary to establish the relationships between them, as well as with the machine as a whole. In particular, this concerns the redistribution of tractive forces on the wheels of machines in assessing their patency and efficiency.

To assess the traction and coupling properties of self-propelled wheeled all-wheel drive vehicles and justify the reasons for the redistribution of tractive forces on their wheels, it is necessary to choose the simplest design scheme, that is, their four wheel variant. In this case, the parameters of the wheels of machines, depending on the properties of the wheels themselves and the type of power transmission, will be considered, assuming that the support is solid. At the same time, the effect of transient processes is excluded from the analysis, since we will only consider the initial steps in the formation of parameters in conditions of acceleration of machines.

With the motion of full-drive vehicles with a blocked transmission even in a linear trajectory, at low speed there is a circulation of power in the transmissions due to the re-distribution of traction forces on the wheels. The reason for such phenomena is applied to cars with a wheel formula 4x4 is that their front wheels are relative to the rear lagging (with the equality of weight conditions of bridges and air pressures in tires) when starting during acceleration /1, 2/. The torques on the wheels of the machine in the process of its starting (at constant air pressures in the tires of all wheels) will obey the condition:

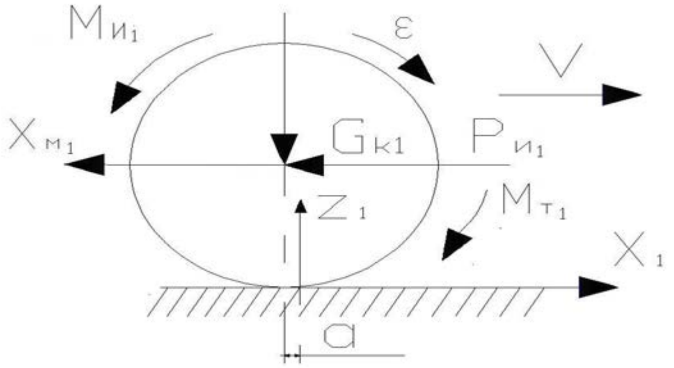
$M_{к2} > M_{к1}$,

$M_{к1}$, $M_{к2}$ – Torque respectively on the front and rear wheels, which is confirmed by experiments performed on the machine 4BC-10 /3/. At the same time, the pressure in the tires of the front wheels above the air pressure in the tires of the rear wheels ensures an increase in the rolling radius of the front wheels over the radius of the rear wheels /1, 2/, and the condition is fulfilled accordingly $M_{к1} > M_{к2}$, which is also confirmed in the work /3/.

The cars Ural 377 (6x4) and Ural 375 (6x6) also have the following reasons for the re-distribution of traction forces regularities in the differences in the radius of movement of the wheels of various drive train /1, 2/. All of this also agrees with the experiments /4/.

Proceeding from the analysis it can be seen that in order to more fully determine the reasons for the redistribution of tractive forces between the wheels, it is necessary to choose the design scheme of a vehicle consisting of 4 driving wheels as the simplest in this respect and for this calculation scheme to develop a model of redistribution of traction forces on modular wheels Its various axes.

Consider the interaction of the front drive wheel of the machine with the road (picture 1).



Picture 1 – Interaction of the front drive wheel with the road

According to the calculation scheme, we obtain equations /5, 6/:

$$X_1 = X_{м1} + P_{и1} = X_{м1} + jm_1, \quad (1)$$

$$z_1 a + X_1 r + M_{и1} = M_{T1}, \quad (2)$$

$$X_1 = P_{T2} - P_{f1} - \frac{j}{r^2}(J_Я i_{TP}^2 \eta_{TP} + 2J_1), \quad (3)$$

$$P_{и1} = jm_1, \quad \varepsilon = \frac{j}{r}, \quad M_{и1} = J_1 \varepsilon,$$

X_1 – the tangential reaction of the road to the front wheels, H; $X_{м1}$ – reaction of the rear of the car to the front wheels, H; z_1 – reaction of the road to the front wheels, H; $M_{и1}$ – moment of inertia of the wheel, Hм; M_{T1} – traction moment of the front wheel, Hм; $P_{и1}$ – inertial force of the forward moving wheel, H; $J_{Я}$ – moment of inertia of the motor rotor, *kgм²*; J_1 – moment of inertia of the front wheel, *kgм²*; P_{T1} – tractive power of the front wheel, H; m_1 – weight to front wheels, *kg*; j – acceleration, *м/s²*; f – rolling resistance coefficient; ε – angular acceleration; r – wheel radius, *м*.

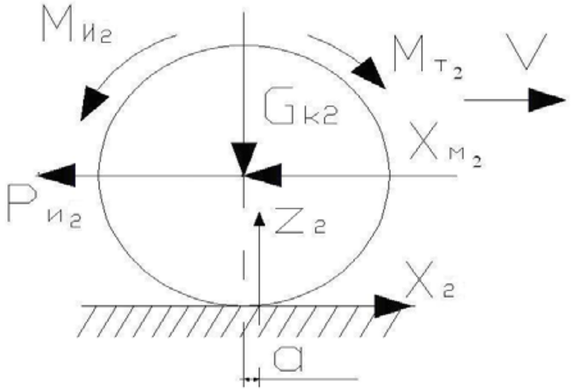
Solving equations (1) and (2) we obtain /5,6,7/:

$$X_{м1} = P_{T1} - z_1 f - \frac{j}{r^2}(J_Я i_{TP}^2 \eta_{TP} + 2J_1) - jm_1 = P_{T1} - z_1 f - jm_1\left(1 + \frac{(J_Я i_{TP}^2 \eta_{TP} + 2J_1)}{m_1 r^2}\right), \quad (4)$$

$$X_1 = P_{T1} - P_{f1}\frac{j}{r^2}(J_Я i_{TP}^2 \eta_{TP} + 2J_1)\ , \quad (5)$$

$\delta_{вр1} = 1 + \frac{(J_Я i_{TP}^2 \eta_{TP} + 2J_1)}{m_1 r^2}$ - attached to the front wheels coefficient accounting rotating masses; P_{f1} - rolling resistance of front wheels, H; G_{k1} - the weight falls on the front wheels, H.

Consider the interaction of the rear driving wheel of the machine with the road (picture 2).



Picture 2 – The interaction of the rear driving wheel with the road

According to the calculation scheme, we obtain equations:

$$X_2 = X_м + P_{и2} = X_м + jm_2\,, \quad (6)$$

$$z_2 a + X_2 r + M_{и2} = M_{T2}\,, \quad (7)$$

$$X_2 = P_{T2} - z_2 f - \frac{j}{r^2}(J_Я i_{TP}^2 \eta_{TP} + 2J_2)\,, \quad (8)$$

$$P_{и2} = jm_2\,, \qquad \varepsilon = \frac{j}{r}\,, \qquad M_{и2} = J_2 \varepsilon\,,$$

X_2 – the tangential reaction of the road to the rear wheels, H; $X_{м2}$ – reaction of the front of the car to the rear wheels, H; z_2 – normal reaction of the road to the rear wheel, H; $M_{и2}$ – inertia of the rear wheels, Hм; M_{T2} – traction moment on the rear wheels, Hм; $P_{и2}$ – inertia force of the forward-moving rear wheels, H; P_{T2} – tractive power of the rear wheels, H; $J_Я$ – moment of inertia of the motor rotor, *kgm²*; J_2 – moment of inertia of the rear wheel, *kgm²*; m_2 – weight to the rear wheels, *kg*; j – acceleration, *м/s²*; f – rolling resistance coefficient; ε – angular acceleration; r – wheel radius, *м*.

Solving equations (6) and (7), we obtain /5, 6, 7/:

$$X_{м2} = P_{T2} - z_2 f - \frac{j}{r^2}(J_Я i_{TP}^2 \eta_{TP} + 2J_2) - jm_2 = P_{T2} - z_2 f - jm_2\left(1 + \frac{(J_Я i_{TP}^2 \eta_{TP} + 2J_2)}{m_2 r^2}\right), \quad (9)$$

$$X_2 = P_{T2} - P_{f2} - \frac{j}{r^2}(J_Я i_{TP}^2 \eta_{TP} + 2J_2)\ , \qquad (10)$$

$\delta_{вр2} = 1 + \frac{(J_Я i_{TP}^2 \eta_{TP} + 2J_2)}{m_2 r^2}$ - attached to the rear wheels coefficient accounting rotating masses; P_{f2} – The rolling resistance of the rear wheels, H.

LIST OF USED SOURCES

1 Бекенов Т.Н, Нусупбек Ж.Т., Тасыбеков Ж.Т. К разработке модели работы модульных колес транспортного средства дорог // Вестник КГУСТА (по мат. межд. научно-практ. конф.). – Бишкек, 2012.

2 Бекенов Т.Н., Нусупбек Ж.Т.,Тасыбеков Ж.Т. К обоснованию модели работы модульных колес транспортного средства//Сб. науч. тр.(по мат. конф. «Науч. иссл. и их прак. прим. Совр. сос. и пути разв. 2012».- Одесса, 2012.- Т.2.

3 Анкудинов Д.Т. Шахтные пневмоколесные самоходные машины. Динамика, устойчивость, управляемость. – М.: Недра, 1984. – 252 с.

4 Петрушов В.А., Щуклин С.А., Московкин В.В. Сопротивление качению автомобилей и автопоездов. - М.: Машиностроение, 1975. - 222 с

5 Бекенов Т.Н., Нусупбек Ж.Т. Определение коэффициентов учета вращающихся масс колес автомобиля // Материалы III межд.народ. конф.: Научное пространство Европы – 2007. – Днепропетровск, 2007. – с. 55–57.

6 Бекенов Т.Н., Нусупбек Ж.Т. Методика расчета силового баланса переднего и заднего колес транспортного средства // Вестник КГУСТА.- Бишкек, 2009.- С.82–84.

7 Бекенов Т.Н, Нусупбек Ж.Т. Разработка модели расчета тяговой проходимости передних и задних приводных колес самоходных машин / В кн.: Теория и расчет тяговой и опорно-сцепной проходимости самоходных машин и их приложения (Бекенов Т.Н.).- М.:ООО «Буки Веди»,2012.- 112с.