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SELF-ADJUSTING ADAPTIVE SPACECRAFT CONTROL SYSTEM

Abstract. The unmanned mobile system of any transport facilities (land, space and underwater) should have high extent of reliability and non-failure operation in process. The elementary mechanical system in a combination to the elementary control system can provide these qualities. Besides the unmanned mobile system of space and underwater transport should have small sizes and weight and self-regulation possibility at origination of non-staff situations. Automatic gearboxes existing now (CVT) are the most complicated mechanical systems and

have the most complicated hydro mechanical control system [1]. Such transmissions are absolutely unsuitable for unmanned mobile system because of their low reliability and inadequacy to a changing circumambient.

Recently adaptive gear variators are developed [2, 3, 4, 5]. The adaptive variator represents the self-controlled gear planetary train with the constant engagement of the toothed wheels. Who's that was created on the basis of an author's disclosure «Effect of force adaptation in mechanics». The adaptive gear box of the automobile represents a brand-new planetary gear variator in the form of two mobile kinematic chain with the elementary additional original constraints. The adaptive variator has ability to drive the executive tool with a speed which is back - proportional external loading at constant power of an engine. The basic advantages of an adaptive gear variator: absence of the control system, simplicity of a design, full adequacy to working conditions. It seems expedient to use an adaptive gear variator in the transmission of a mobile transport system.

Adaptive drivetrain based on usage of a gear variator (theoretical bases, tests, characteristics and practical recommendations) is in-process presented.

Keywords: adaptive transmission, toothed variator, force adaptation, necessary constraint, sufficient constraint, mid gear.

Аннотация. Беспилотная мобильная система любых транспортных средств (наземных, космических и подводных) должна обладать высокой степенью надежности и безотказной работы в процессе эксплуатации. Элементарная механическая система в сочетании с элементарной системой управления может обеспечить эти качества. Кроме того, беспилотная мобильная система космического и подводного транспорта должна иметь небольшие размеры и вес и возможность саморегулирования при возникновении внештатных ситуаций. Существующие в настоящее время автоматические коробки передач (вариаторы) являются наиболее сложными механическими системами и имеют самую сложную гидромеханическую систему управления [1]. Такие передачи абсолютно непригодны для беспилотных мобильных систем из-за их низкой надежности и неадекватности изменяющейся окружности.

В последнее время разрабатываются адаптивные вариаторы передач [2, 3, 4, 5]. Адаптивный вариатор представляет собой саморегулирующуюся зубчатую планетарную передачу с постоянным зацеплением зубчатых колес. Кто это был создан на основе раскрытия автора «Эффект адаптации силы в механике». Адаптивная коробка передач автомобиля представляет собой совершенно новый планетарный вариатор в виде двух подвижных кинематических цепей с элементарными дополнительными оригинальными ограничениями. Адаптивный вариатор имеет возможность управлять исполнительным инструментом со скоростью, обратно пропорциональной внешней нагрузке при постоянной мощности двигателя. Основные преимущества адаптивного вариатора: отсутствие системы управления, простота конструкции, полная адекватность условиям работы. Представляется целесообразным использовать адаптивный вариатор передач в трансмиссии мобильной транспортной системы.

Представлена адаптивная трансмиссия, основанная на использовании зубчатого вариатора (теоретические основы, тесты, характеристики и практические рекомендации).

Ключевые слова: адаптивная передача, зубчатый вариатор, адаптация силы, необходимое ограничение, достаточное ограничение, средняя передача.

Аңдатпа. Кез келген көлік құралдарының (жер үсті, ғарыш және су асты) пилотсыз мобильдік жүйесі пайдалану процесіндегі сенімділік пен үздіксіз жұмыстың жоғары дәрежесіне ие болуы тиіс. Қарапайым механикалық жүйе қарапайым басқару жүйесімен бірге осы қасиеттерді қамтамасыз ете алады. Бұдан басқа, ғарыштық және су асты көлігінің пилотсыз мобильді жүйесі шағын көлемде және салмақта болуы және штаттан тыс жағдайлар туындаған кезде өзін-өзі реттеу мүмкіндігіне ие болуы тиіс. Қазіргі уақытта автоматты беріліс қораптары (вариаторлар) ең күрделі механикалық

жүйелер болып табылады және басқарудың ең күрделі Гидромеханикалық жүйесіне ие [1]. Мұндай берілістер ұшқышсыз мобильді жүйелер үшін мүлдем жарамсыз, өйткені олардың сенімділігі төмен және өзгеретін шеңбердің жеткіліксіздігі.
Жақында адаптивті беріліс вариаторлары жасалды[2, 3, 4, 5]. Адаптивті вариатор-бұл өздігінен реттелетін тісті планетарлық беріліс, редукторлар үнемі ілініп тұрады. Бұл автордың"механикадағы күштің бейімделу әсері" атты нәсіліне негізделген. Ұялы телефонның адаптивті беріліс қорабы-бұл қарапайым қосымша бастапқы шектеулері бар екі түрлі кинематикалық тізбек түріндегі мүлдем жаңа планетарлық вариатор. Адаптивті вариатор қозғалтқыштың тұрақты қуаты кезінде сыртқы жүктемеге кері пропорционалды жылдамдықпен жетек құралын басқара алады. Адаптивті вариатордың негізгі артықшылықтары: басқару жүйесінің болмауы, дизайнның қарапайымдылығы, жұмыс жағдайларына толық сәйкестік. Мобильді көлік жүйесінің берілісінде адаптивті беріліс вариаторын қолдану орынды болып көрінеді.
Тісті вариаторды қолдануға негізделген адаптивті беріліс ұсынылған (теориялық негіздер, тесттер, сипаттамалар және практикалық ұсыныстар).

Түйінді сөздер: адаптивті беріліс, тісті вариатор, күштің бейімделуі, қажетті шектеу, жеткілікті шектеу, орташа беріліс.

Adaptive Transmission for unmanned mobile system is based on use an adaptive toothed variator. A variator is a friction mechanism with an adjustable gear ratio [1]. The following frictional mechanisms are used as variators: a girth variator and a conical variator with intermediate rollers and a belt drive with composite wedge drive pulleys. Control of crown variator and conic variator is carried out by change of position of intermediate roller.

Control of the belt transmission is carried out by change of diameter of wedge pulley. The main disadvantage of the friction variator is its low reliability and control complexity. A more reliable mechanism is the hydromechanical transmission (CVT), which combines a torque converter with a step transmission. In this transmission, the torque converter performs a smooth change in gear ratio within a narrow range of each gear step. Disadvantages of a hydromechanical variator: a complex design, a complex and inadequate gear shift control system, as well as breaks in the transmitted power flow, leading to shocks.

Attempts of use of double coupling step transfers for advance of smoothness of motion at switching of steps [2] lead to essential complication of a design.

The gear variator is a completely new wheel train with constant mesh and variable gear ratio. The idea of creating a gear variator is based on the use of a kinematic chain with two degrees of freedom, which makes it possible, in the presence of one input link, to provide regulation of the output speed by means of an excessive limitation.

The idea of creation of the toothed variator has been based on use of a kinematic chain with two degrees of freedom allowing in the presence of one input link to provide regulation of output speed by means of superfluous constraint. So Ivanov's drives with dynamic self-regulation [3] have been created. Later for the purpose of scheme simplification the two-row planetary mechanism has been used in Harris's [4] and Ivanov's [5] patents. Then inventors Crockett and Volkov tried to create an adaptive hydromechanical system CVT using a planetary mechanism with one degree of freedom together with a hydrodynamic converter with two degrees of freedom [6, 7]. The torque converter allows the system to automatically adapt to the external load but within narrow limits. Therefore, the switched automatic multistage hydro mechanical transmissions got extension. The disadvantage of hydromechanical automatic gearboxes (CVT): the complexity of the design, the complexity of the control system, the complexity of maintenance, the incompatibility of the control system with all modes of movement, high cost.

A gear variator (gear variator) is a fundamentally new mechanism. The variator has two degrees of freedom and only one input, which contradicts the condition for the existence of the mechanism and the determinability of its motion. The definiteness of motion is provided by a moving closed loop that circulates energy. Attempts of inventors [4, 6, 7] to use well-known approaches to the analysis of force interaction, suitable for systems with one degree of freedom, did not explain the definability of motion and differed significantly from reality.

The theoretical prerequisites for the existence of a gear variator were developed by K.S. Ivanov. [8 ... 11]. On the basis of these studies, Ivanov's patents were created [12, 13]. The design of an experimental prototype of an adaptive gear variator was created on the basis of fulfilling the necessary [8 ... 11] and sufficient [14, 15] adaptation conditions (conditions for the presence of a gear variator).

The purpose of the present work is the developing of theoretical bases of creation of a toothed variator.

The variator is a frictional mechanism that maintains a variable gear ratio. The main disadvantage of the variator is its low load capacity depending on friction. The wheelwork has considerably higher load-carrying capacity as it does not depend on a friction. But the wheelwork has the constant transfer ratio and cannot provide variator function (continuous smooth change of the transfer ratio).

For creation of a gear variator it is necessary to use brand new principle of act of the mechanism providing the variable transfer ratio. This principle is based on the circulation of energy in a kinematic chain with two degrees of freedom. Energy circulation is provided by gear wheels forming a movable closed-loop located between the input and output links of the mechanism. Intensity of circulation of energy depends on variable output loading. This key property of the closed contour defines additional constraint which will neutralize superfluous mobility of the closed contour. As a result, the variable transfer ratio is provided with variable output loading. Thus, the gear variator will provide not only the variable transfer ratio but also adaptation to a variable load. Adaptation is brand new property of the mechanism allowing to work without a control system. The gear variator is the adaptive self-controlled mechanism.

Presence of the closed contour defines a necessary condition of the adaptation, giving the chance to be accommodated for a variable power regime of motion.

The sufficient condition of power adaptation consists in implementation of possibility of transfer of force from the input link of a mechanism to a output link. For force transfer concept performance «moment lever» or «support on the case» is required. «Moment lever» is the certain link having a motionless datum point, with the input to these link input and output forces which create the counterbalanced moments.

The design of a gear variator looks like a planetary kinematic chain which has only one motionless axis - the central axis. This axis is not capable to provide a support on the case (an additional support) and to create «moment lever». However, the planetary kinematic chain of a gear variator possesses unique property - presence of some point of coincidence of speeds of links on an entry and an exit (the center of coincidence of speeds). This center allows connecting the input carrier and the output satellite the parallel gearing which transforms the output satellite in «moment lever» with an immovable support in the instant center of speeds.

Constant input force and variable output force on the output satellite are connected by the equation of the moments concerning a datum point. As a result, in a gear variator «moment lever» is presented in the form of a link with a datum point having a variable position.

Necessary and sufficient conditions provide performance of operating conditions of motion. However, on start the motion regime in essence differs from motion in operating condition.

On start an output link of a gear variator is motionless. The kinematic chain of a variator has one degree of freedom. Therefore, force transfer on an output link is impossible. Start from a place (the motion beginning) provides the mid gear of the kinematic chain created by a design of the mechanism at the moment of start. The mid gear provides the beginning of motion of the kinematic chain in the chocked position. At the moment of start the gear variator is rotated as a single whole without internal mobility of links. A parallel transfer transferring input force on the output satellite is creating a "moment lever" which is linking the gear variator after the motion beginning.

Presented in Fig. 1a the scheme of a two-mobile mechanism with a movable closed contour allows you to create equilibrium conditions. (In a mechanism with two degrees of freedom, it is impossible to create equilibrium conditions without a closed contour). The equilibrium of the system leads to the implementation of the law of conservation of energy in the mode of steady motion.

Closed-contour theorem 1.

A kinematic chain with two degrees of freedom, containing an input link, an output link, and a movable closed chain placed between them, can exist in a steady-state mode of motion.

For the scheme (Fig. 1a), it is necessary to prove that the work (or power) on the input link H_1 is equal to the work (power) on the output link H_2, that is,

$$M_{H1} \cdot \omega_{H1} = M_{H2} \cdot \omega_{H2} \qquad (1)$$

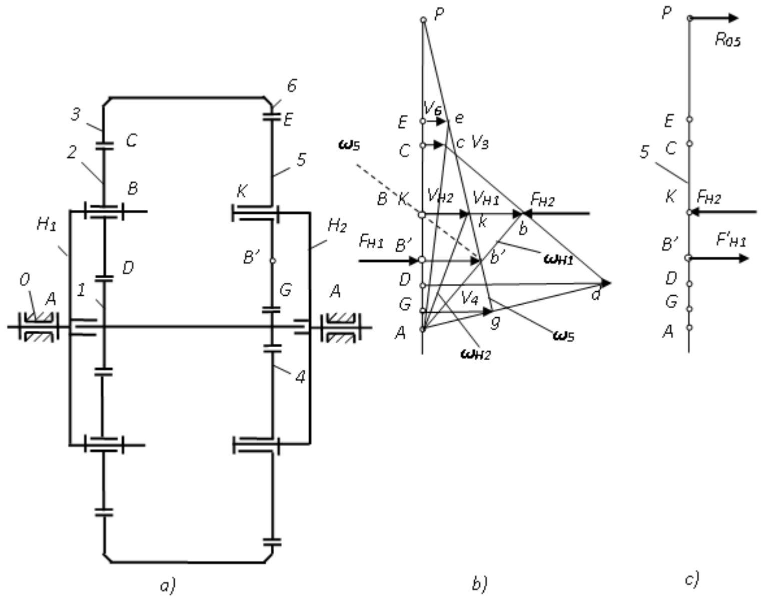

Fig. 1. (a) Kinematic chain of the mechanism with two degrees of freedom, (b) the plan of linear velocities of the chain, (c) link 5 with applied forces

We will assume that with the steady motion of the system in the form of a gear planetary mechanism, all the links move uniformly, and there are no inertia forces.

To prove the theorem, we transfer all the acting forces to satellite 5 (Fig. 1c). - A movable closed contour allows you to perform this transfer.

According to Fig. 1a the force $F_{H1} = M_{H1} / r_{H1}$ acting at the point B is transmitted to the link 5 from the carrier H_1 to the satellite 2 through the wheel blocks 3-6 and 1-4 in the form of reactions $R_{65} = 0.5F_{H1}r_3 / r_6$ and $R_{45} = 0.5F_{H1}r_1 / r_4$. The input force reduced to link 5 is equal to the sum of these reactions $F'_{H1} = 0.5F_{H1}(r_3r_4 + r_1r_6) / r_4r_6$.

Here r_i is the radius of the wheel i.

The position of the point of application B' of the reduced force F'_{H1} is determined by the formula $KB' = r_5(r_1 - r_4)/r_4$. Reduction of force F_{H1} to a link 5 corresponds to the condition of equality the power of these forces $F_{H1}V_{H1} = F'_{H1}V'_{H1}$. The force F_{H2} is applied at the point K.

Next, consider the equilibrium of link 5 (Fig. 1c). The sum of the moments relative to the instantaneous center P of the link velocities is zero $\sum M_P = 0$. Or

$$F'_{H1} \cdot (PK + KB') - F_{H2} \cdot PK = 0 \tag{2}$$

Here $KB' = e$ is the eccentricity. From here, the position of the instantaneous velocity center P (distance PK) can be determined from the given forces.

$$PK = F'_{H1}\, e / (F_{H2} - F'_{H1}) \tag{3}$$

Taking into account the motion of link 5 around a point P with an angular velocity ω_5, you can use the substitutions in equation (2)

$PK + KB' = V'_B / \omega_5, \quad PK = V_K / \omega_5$. Then equation (2) will take the form

$F'_{H1} \cdot V'_B - F_{H2} \cdot V_K = 0$. Subject will receive $F_{H1} \cdot V_B = F_{H2} \cdot V_K$.

Substituting the values of the velocities $V_B = \omega_{H1} r_{H1}, \quad V_K = \omega_{H2} r_{H2}$ into this equation, we obtain the equation of equilibrium of the entire mechanism according to the law of conservation of energy

$$M_{H1} \cdot \omega_{H1} = M_{H2} \cdot \omega_{H2} \tag{4}$$

which was required to be proved.

At the same time, formula (4) corresponds to the principle of virtual work (capacity) but with a significant difference – using real speeds instead of virtual ones.

From equation (4) follows the expression of force adaptation

$$\omega_{H2} = M_{H1} \cdot \omega_{H1} / M_{H2} \tag{5}$$

At a given constant input power on the link H_1, the output angular velocity ω_{H2} adapts to the variable output resistance torque M_{H2}.

Thus, a movable closed chain in a two-mobile kinematic chain with one input and one output creates the possibility of power adaptation.

SUFFICIENT CONDITION OF ADAPTATION AND MID GEAR AT START

The design of a gear variator looks like a planetary kinematic chain which has only one motionless axis - the central axis A. This axis is not capable to provide a support on the case (an additional support) and to create « the moment lever». However the planetary kinematic chain of a gear variator possesses unique property - presence of some point S_5 of coincidence of speeds of input link H_1 and output satellite 5 [14, 15]. This centre allows connecting the input carrier H_1 and the output satellite 5 by the parallel gearing 8-7 which transforms the output satellite in «the moment satellite 5 lever» with an immovable support in the instant centre of speeds P_5 (Fig. 1 *b*). Constant input force F_{H1} and variable output force F_{H2} on the output satellite 5 (on line

egP_5) are acting in points s_5 and k. These forces are connected by the equation of the moments concerning the point P_5.

$$F_{H1} \cdot P_5S_5 - F_{H2} \cdot P_5K = 0 . \quad (14)$$

As a result, in a gear variator «the moment lever» is presented in the form of a link with a datum point having a variable position.

The condition of independent start is defined by equality of lengths of the input and output carriers $r_{H1} = r_{H2}$.

CONCLUSIONS

Novelty of researches consists in creation the mechanism of brand new design realizing the author's discovery "Effect of force adaptation in the mechanics". The toothed variator performances the necessary and sufficient conditions of adaptation and provides the start by mid gear that provides transfer of all energy from the engine on the output shaft of a variator both at start-up, and in operating conditions. The adaptive gear variator is the highly effective self-controlled connecting gear which can be used for machines with variable technological resistance in all branches of engineering from motor industry to a robotics.

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АНАЛИЗ ПОМЕХОУСТОЙЧИВОСТИ АМПЛИТУДНО- И ЧАСТОТНО-МОДУЛИРОВАННЫХ СИГНАЛОВ

Аңдатпа. Қазіргі қоғамдағы ақпараттың едәуір бөлігі әртүрлі мақсаттағы байланыс жүйелерінде радиотехникалық құралдарды қолдана отырып, электр сигналдарымен беріледі. Сондықтан байланыс жүйелері адамдардың өмірінде маңызды рөл атқарады. Модуляция негізінде пайда болған сигналдар, шуылға қарсы және аз әсер етеді. Себебі модуляция тасымалдаушы сигналдың амплитудасы және жиілік компоненті мен олардың ерекшеліктерін өзгерту арқылы қарастырылады. Осциллографпен өлшеу мысалдарында амплитудалық пен жиіліктік модуляцияланған сигналдарды талдау негізінде деректер келтірілген.

Түйін сөздер. Сигнал амплитудасы, радиоарна, жиіліктік модуляция, фазалық модуляция, амплитудалық модулятор, тасымалдаушы сигнал, үздіксіз модуляция.

Аннотация. Значительная часть информации в современном обществе передается электрическими сигналами с помощью радиотехнических средств в системах связи различного назначения. Поэтому системы связи играют все большую роль в жизни людей. Сигналы, сформированные по средством модуляций более помехозащищённые и меньше подвержены угасанию. Рассмотрена модуляция по средством изменения амплитудной и частотной составляющей несущего сигнала и их особенности. Приведены данные по анализу амплитудно и частотно модулированных сигналов на примерах измерения осциллографом.

Ключевые слова. Амплитуда сигнала, радиоканал, частотная модуляция, фазовая модуляция, амплитудный модулятор, несущий сигнал, непрерывная модуляция.

Abstract. A significant part of the information in modern society is transmitted by electrical signals using radio equipment in communication systems for various purposes. Therefore, communication systems are playing an increasingly important role in people's lives. Signals generated by modulation are more noise-proof and less susceptible to fading. Modulation by changing the amplitude and frequency components of the carrier signal and their features are considered. The data on the analysis of amplitude and frequency modulated signals are presented using examples of measurement by an oscilloscope.