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ADAPTIVE TRANSMISSION FOR UNMANNED MOBILE 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 versatile variator speaks to the self-controlled adapt planetary prepare with the steady engagement of the toothed wheels. Who's that was made on the premise of an author's revelation «Effect of drive adjustment 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.

Introduction

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 taking after frictional components are utilized as variators: a size variator and a cone shaped variator with middle of the road rollers and a belt drive with composite wedge drive pulleys. Control of crown variator and conic variator is carried out by alter of position of intermediate roller. Control of the belt transmission is carried out by alter of breadth of wedge pulley. The most impediment of the grinding variator is its moo unwavering quality and control complexity. A more dependable instrument is the hydromechanical transmission (CVT), which combines a torque converter with a step transmission 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 thought of making a adapt variator is based on the utilize of a kinematic chain with two degrees of flexibility, which makes it conceivable, within the nearness of one input interface, to supply direction of the yield speed by implies of an intemperate limitation. The thought of the creation of the toothed variator has been based on the utilize of a kinematic chain with two degrees of opportunity allowing within the nearness of one input interface to supply direction of yield speed by implies of unnecessary imperative. 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. At that point, innovators, Crockett and Volkov attempted to make an adaptive hydromechanical framework CVT employing a planetary component with one degree of opportunity beside a hydrodynamic converter with two degrees of opportunity [6, 7]. The torque converter permits the framework to naturally adjust to the outside stack but inside limit limits. Therefore, the switched automatic multistage hydro mechanical transmissions got extension. The impediment of hydromechanical programmed gearboxes (CVT): the complexity of the plan, the complexity of the control framework, the complexity of support, the inconsistency of the control framework with all modes of development, tall taken a toll.

A adapt variator (equip variator) could be a on a very basic level modern instrument. The variator has two degrees of flexibility and as it were one input, which negates the condition for the presence of the component and the determinability of its movement. The definiteness of movement is given by a moving closed circle that circulates vitality. Endeavors of creators [4, 6, 7] to utilize well-known approaches to the examination of drive interaction, appropriate for frameworks with one degree of opportunity, did not clarify the definability of movement and contrasted altogether from reality.

The hypothetical prerequisites for the presence of a equip variator were created by K.S. Ivanov. [8 ... 11]. On the premise of these thinks about, Ivanov's licenses were made [12, 13]. The de-sign of an test model of an versatile adapt variator was made on the premise of satisfying the fundamental [8 ... 11] and adequate [14, 15] adjustment conditions (conditions for the nearness of a adapt variator). The reason of the show work is the improvement of hypothetical bases for the creation of a toothed variator.

Preconditions of creation of an adaptive gear 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 the creation of a equip variator, it is fundamental to utilize latest rule of the act of the component giving the variable exchange proportion. This guideline is based on the circulation of vitality in a kinematic chain with two degrees of flexibility. 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.

The necessary condition of force adaptation

The pith of the disclosure: the kinematic chain with two degrees of opportunity. The kinematic chain (Fig. 1, a) contains an outline 0, an input carrier H_1, closed contour with toothed wheels 1-2-3-6-5-4 and output carrier H_2. A closed form contains lackey 2, square of sun-oriented wheels 1-4, square of ring wheels 3-6 and disciple 5. Component has the parallel adapting 8-7 from carrier H_1 to the satellite 5. First, we assume that the kinematic chain has two degrees of freedom and two initial links H_1 and H_2.

The vital adjustment condition is based on the taking after theorem.

A versatile closed-loop with four poles in a kinematic chain with two degrees of opportunity forces a confinement on the development of the links. The kinematic chain has two degrees of freedom and two initial links H_1 and H_2. To illustrate the hypothesis, we'll calculate the stack of the component within the classical setting with the uniform development of the introductory links.

Initial information: superposed forces F_{H1} and F_{H2}, acting on the closed contour in points *B* and *K*, angular velocities of initial links ω_{H1}, ω_{H2} and linear speeds V_{H1} and V_{H2} of points *B* and *K* (Fig. 1*b*).

At the stack plan at to begin with, we'll consider four-link closed form 1-2-3-6-5-4 as a auxiliary bunch of Assur with zero portability. Closed form permits working out the conditions of statics for form input joins 2 and 5

$$R_{12} = 0.5F_{H1} \tag{1}$$

$$R_{32} = 0.5F_{H1} \tag{2}$$

Let's multiply the Eq. (1) by V_1 (speed of point of the disciple 2 or circular speed of wheel 1 by V_3 (speed of point C of the satellite 2 or circular velocity of wheel 3) and sum the received equations. We will get

$$R_{12}V_1 + R_{32}V_3 = 0.5F_{H1}(V_1 + V_3) \tag{3}$$

Concurring to the arrange of straight speeds of the component (Fig. 1*b*) $0.5(V_1 + V_3) = V_{H1}$. Then from equality (3) we obtain

$$R_{12}V_1 + R_{32}V_3 = F_{H1}V_{H1} \tag{4}$$

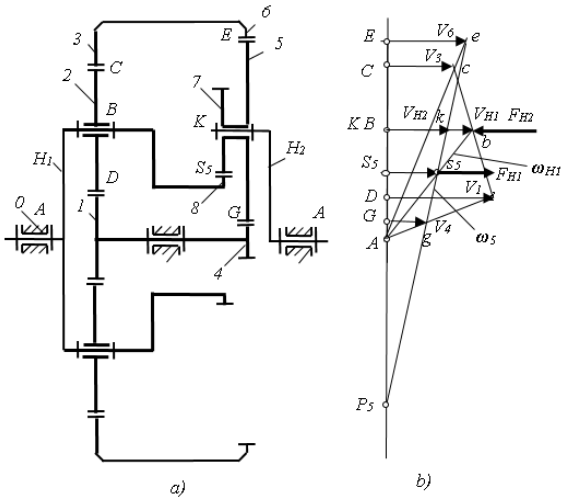

Figure 1 - A instrument with two degrees of flexibility and a arrange of straight speeds

In a similar way, we obtain the equilibrium condition for satellite 5.

$$R_{45}V_4 + R_{65}V_6 = F_{H2}V_{H2} \tag{5}$$

The balance conditions of the satellites contain all the drive parameters of the closed-loop. From these conditions, it is conceivable to get an condition for the interrelation of parameters for all closed circles, in case we whole up the conditions and utilize the uniformity of the precise speeds of the wheels in pieces 1-4 $\omega_1 = \omega_4$ and in the block 3-6 $\omega_3 = \omega_6$.

Summing up equations (4) and (5), we obtain

$$R_{12}V_1 + R_{32}V_3 + R_{45}V_4 + R_{65}V_6 = F_{H1}V_{H1} + F_{H2}V_{H2} \tag{6}$$

In condition (6), we change the straight speeds into precise ones by the equation $V = \omega r$ with matching indexes. For powers we'll utilize substitutions of satellites responses on the responses connected to the central wheels by guideline $R_{12} = -R_{21}$ etc. We will receive

$$\begin{aligned} &- R_{21}\omega_1 r_1 - -R_{23}\omega_3 r_3 - R_{54}\omega_4 r_4 - R_{56}\omega_6 r_6 = \\ &= F_{H1}\omega_{H1} r_{H1} + F_{H2}\omega_{H2} r_{H2} \end{aligned} \tag{7}$$

The item of the constrain and the sweep de-termines the minute utilizing the fitting indices. Condition (7) takes the shape

$$\begin{aligned} &-M_{21}\omega_1 - M_{23}\omega_3 - M_{54}\omega_1 - M_{56}\omega_3 = \\ &= M_{H1}\omega_{H1} + M_{H2}\omega_{H2} \end{aligned} \quad (8)$$

On the cleared outside of condition (8) there's a entirety of powers (correspondence to the whole of works) of inside powers of the form. The work (control) of inner powers on real displacements is zero

$$(M_{21} + M_{54})\omega_1 + (M_{23} + M_{56})\omega_3 = 0 \quad (9)$$

Note that with an subjective task of outside minutes, the harmony condition for each square of wheels 1-4 and 3-6 will not be satisfied. An unbalanced moment will occur on the wheel block 1-4. An unbalanced moment will occur on the wheel block 3-6. On the square of wheels 1-4 there will be unequal moments. $M_{1-4} = M_{21} + M_{54}$. On the block of wheels 3-6 there will be unbalanced moment $M_{3-6} = M_{23} + M_{56}$.

However, Eq. (9) consists of equalities (4) and (5). The balance must be maintained! From here follows the conclusion:: unbalanced separately the moments M_{1-4} и M_{3-6} are counterbalanced among themselves in the general equation

$$M_{1-4}\omega_1 + M_{3-6}\omega_3 = 0 \quad (10)$$

The right side of equation (8) is the sum of the powers (corresponding to the sum of the work) of the forces applied to the circuit. When conditions (9) are fulfilled, from equations (8) we obtain the fulfillment of the equilibrium conditions for the applied forces according to the action of the work (or the conservation law).

$$M_{H1}\omega_{H1} + M_{H2}\omega_{H2} = 0 \quad (11)$$

Extra imperative (11) diminishes the number of degrees of flexibility of the gadget and requires as it were one input connect. In this way, the condition for the interconnection of outside parameters (11) predetermines the nearness of powers with inverse signs on the outside joins of the chain (for illustration,) depending on the other. The association with the nearness of negative control cannot be an input association, since the minute acting on it is the minute of resistance.

This fundamental hypothetical result leads to an phenomenal conclusion: a kinematic chain with two starting joins associated by a closed-loop ought to have as it were one input connect.

Extra limitation (11) diminishes the number of a degree of flexibility on the unit and requests the nearness of as it were one input connect. Hence the condition of the interconnection of outside parameters (11) predetermines the nearness of powers with antithetic signs on outside chain joins (carriers H_1 and H_2). The connect with nearness of negative control can-not be an input connect since the minute act-ing on it could be a minute of resistance.

This fundamental hypothetical result leads to an un-precedented conclusion: the kinematic chain with two starting joins associated by the closed form ought to have as it were one input link.

The equation of additional constraint (11) will take on form

$$M_{H1}\omega_{H1} - M_{H2}\omega_{H2} = 0 \quad (12)$$

The condition (12) permits deciding an yield precise speed at the other set parameters.

$$\omega_{H2} = M_{H1}\omega_{H1} / M_{H2}. \quad (13)$$

Condition (13) communicates the most hypothetical result - the impact of constrain adjustment in mechanics: at the set consistent parameters of input control M_{H1}, ω_{H1} and output moment of resistance M_{H2} the output angular velocity ω_{H2} is inversely proportional the variable output moment of resistance M_{H2}.

The versatile instrument works without a control framework and is the self-controlled instrument.

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 lever» with an immovable support in the satellite 5 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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ҰШҚЫСЫЗ ҰЯЛЫ ЖҮЙЕГЕ АРНАЛҒАН АДАПТИВТІ ТРАНСМИССИЯ

Аннотация. Кез келген көлік құралдарының (құрлықтағы, ғарыштық және су астындағы) ұшқышсыз жылжымалы жүйесі жоғары сенімділік дәрежесіне ие және процесте ақаусыз жұмыс істеуі керек. Бұл қасиеттерді қарапайым механикалық жүйе элементар басқару жүйесімен үйлестіре алады. Сонымен қатар, ғарыш және су асты көлігінің ұшқышсыз жылжымалы жүйесі штаттан тыс жағдайлар туындаған кезде шағын өлшемдер мен салмақты және өзін-өзі реттеу мүмкіндігіне ие болуы керек. Қазіргі кездегі автоматты беріліс қораптары (CVT) ең күрделі механикалық жүйелер болып табылады және ең күрделі гидромеханикалық басқару жүйесі бар [1]. Мұндай берілістер ұшқышсыз мобильді жүйе үшін мүлдем жарамсыз, өйткені олардың сенімділігі төмен және өзгермелі айналаға сәйкес емес.

Соңғы уақытта адаптивті беріліс вариаторлары жасалды [2, 3, 4, 5]. Әмбебап вариатор тісті доңғалақтардың тұрақты қосылуы арқылы өздігінен басқарылатын бейімделген планетарлық дайындықты білдіреді. Бұл автордың «Механикадағы жетекті реттеудің әсері» тұжырымы негізінде жасалған. Автомобильдің адаптивті беріліс қорабы қарапайым қосымша бастапқы шектеулері бар екі жылжымалы кинематикалық тізбек түріндегі жаңа планетарлық беріліс вариаторын білдіреді. Адаптивті вариатор қозғалтқыштың тұрақты қуатында кері пропорционалды сыртқы жүктеме кезінде атқарушы құралды жылдамдықпен басқару мүмкіндігіне ие. Бейімделетін беріліс вариаторының негізгі артықшылықтары: басқару жүйесінің болмауы, конструкцияның қарапайымдылығы, жұмыс жағдайына толық сәйкестігі. Мобильді көлік жүйесін беруде адаптивті беріліс вариаторын қолдану орынды сияқты.

Тісті беріліс механизмін (теориялық негіздер, сынақтар, сипаттамалар және практикалық ұсыныстар) пайдалануға негізделген адаптивті жетектер жүйесі әзірленіп жатыр.

Түйінді сөздер: адаптивті беріліс, тісті вариатор, күшке бейімделу, қажетті шектеу, жеткілікті шектеу, орта беріліс.

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АДАПТИВНАЯ ТРАНСМИССИЯ ДЛЯ БЕСПРОВОДНОЙ МОБИЛЬНОЙ СИСТЕМЫ

Аннотация. Беспилотная мобильная система любых транспортных объектов (наземных, космических и подводных) должна иметь высокую степень надежности и безотказность в работе. Эти качества может обеспечить простейшая механическая система в сочетании с простейшей системой управления. Кроме того, беспилотная мобильная система космического и подводного транспорта должна иметь малые габариты и вес, а также возможность саморегулирования при возникновении внештатных ситуаций. Существующие автоматические коробки передач (CVT) являются наиболее сложными механическими системами и имеют наиболее сложную гидро-механическую систему

управления [1]. Такие трансмиссии абсолютно не пригодны для беспилотной мобильной системы из-за их низкой надежности и неадекватности изменяющимся условиям окружающей среды.

В последнее время разработаны адаптивные зубчатые вариаторы [2, 3, 4, 5]. Универсальный вариатор говорит с самоуправляемой адаптивной планетарной подготовкой с устойчивым зацеплением зубчатых колес. Кто это сделал на основе авторского откровения «Эффект регулировки привода в механике». Адаптивная коробка передач автомобиля представляет собой принципиально новый планетарный редуктор-вариатор в виде двух подвижных кинематических цепей с элементарными дополнительными оригинальными связями. Адаптивный вариатор имеет возможность приводить исполнительный орган в движение с обратной скоростью - пропорциональной внешней нагрузкой при постоянной мощности двигателя. Основные преимущества адаптивного зубчатого вариатора: отсутствие системы управления, простота конструкции, полная адекватность условиям работы. Представляется целесообразным использование адаптивного зубчатого вариатора в трансмиссии мобильной транспортной системы.

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

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

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