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Research Article

Theoretical Determination of Changes in Chain Networks Lengths

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Abstract

The article presents the results of theoretical studies conducted to determine the change in the length of the free strand of a chain drive with a variable center distance. In the research, the engagement of the chain with the driving and driven sprockets was considered as a 3-vector type, 5-link lever mechanism. During operation, in addition to natural wear in chain drives, elongation and changes in wrap angles due to vibration or oscillation are observed. This, in turn, leads to a decrease in traction capacity and uneven distribution of loads in the chain strands. Therefore, it is important to take into account the free strands of chain drives. The vector contour method is considered convenient for the analytical study of planar mechanisms. For this reason, this method is used in the geometric analysis of the equivalent 5-link lever mechanism. As a result of the conducted theoretical research, an analytical expression was obtained that allows determining the length of the chain strands, and based on its numerical solution, a graph showing the dependence of the chain strand length on the rocker rotation angle was constructed.

Keywords

Chain Drive, Distance Between Axles, Chain Network, Length, Vector, Contour, Angle, Equation, Asterisk

1. Introduction

Chain transmissions operate by meshing, like gear transmissions, while belt transmissions have the leading and driven sprockets interconnected by a flexible link (chain). The simplicity of the structure of chain transmissions, high efficiency, absence of slippage compared to belt transmissions, small overall dimensions, constant number of gears, ease of adjustment and replacement, and the ability to transmit motion to several shafts other than the drive shaft ensure their wide application in technological machine drives. At the same time, chain transmissions are used as the main transmission in all areas of mechanical engineering due to their ability to transmit high-value power, flexibility, large center distance, and ease of maintenance and installation [1-4]. In recent years, based on technical and technological innovations, a number of resource-saving transmission designs have been developed, and their unique kinematic and dynamic characteristics have been created.

2. Experimental Procedures

As is known, the main factor determining the performance

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of chain transmissions is the resistance of chain elements to wear. In addition to natural wear in chain transmissions during operation, changes in the extension and angle of engagement are observed as a result of vibration or shaking. This, in turn, leads to a decrease in the tensile strength and uneven distribution of loads in the chain links [5-7]. Therefore, it is important to take into account the free links of chain transmissions. In the analytical study of smooth mechanisms, it is convenient to use the vector contour method. Therefore, we use this method in the geometric analysis of an equivalent five-link lever mechanism [8, 9].

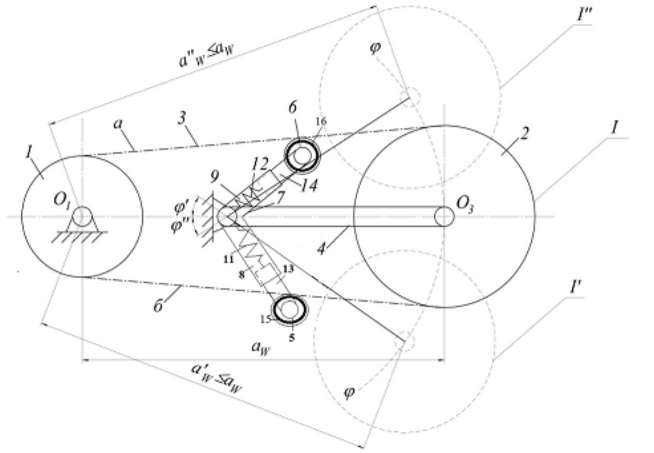

Figure 1. *Chain transmission with variable distance between axles.*

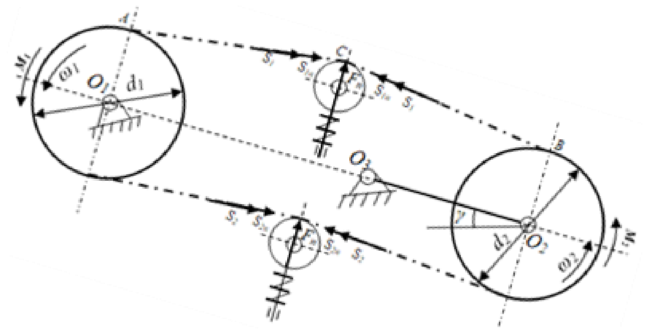

Figure 2. *Chain transmission scheme with variable distance between axles.*

Since the recommended chain transmission chain links are equal and their characteristics of change are the same, we consider the change in the length of one link. In this case, we use the closed-loop vector method. The closed-loop contour $O_1ABO_3O_2$, consisting of the radius of the leading and driven sprockets, the chain link and the distance between the axes, is shown in *Figure 3*. To determine the length of the chain link, we divide the closed-loop contour $O_1ABO_3O_2$ into three closed-loop vector sections O_1AO_2, O_2BO_3 and O_2AB [10, 11].

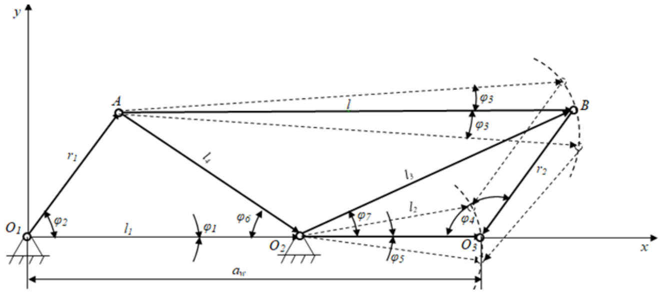

Figure 3. *A scheme of a five-link lever mechanism with three vector contours.*

We construct the vector equations for the vector contours given above [12, 13]:

for contour O_1AO_2

$$\vec{r}_1 + \vec{l}_4 - \vec{l} = 0, \qquad \left(\vec{r}_1 < \vec{l}_1\right) \tag{1}$$

for contour O_2BO_3

$$\vec{l}_3 + \vec{r}_2 - \vec{l}_2 = 0, \qquad \left(\vec{l}_4 \prec \vec{l}_5\right) \tag{2}$$

for contour O_2AB

$$\vec{l}_4 + \vec{l}_3 - \vec{l} = 0 \qquad \left(\vec{l}_4 \prec \vec{l}_5\right) \tag{3}$$

We project the vector equation (1) onto the coordinate axes O_1x and O_1y

$$\vec{r}_1 \cos\varphi_2 + \vec{l}_4 \cos\varphi_6 - \vec{l}_1 = 0 \tag{4}$$

and

$$\vec{r}_1 \sin\varphi_2 + \vec{l}_4 \sin\varphi_6 = 0 \tag{5}$$

From equations (4) and (5) we get the following

$$\vec{l}_4 \cos\varphi_6 = \vec{l}_1 - \vec{r}_1 \cos\gamma \tag{6}$$

and

$$\vec{l}_4 \sin\varphi_6 = -\vec{r}_1 \sin\gamma \tag{7}$$

To determine φ6, we divide equation (7) by (6).

$$tg\,\varphi_6 = \frac{-\vec{r}_1 \sin\varphi_2}{\vec{l}_1 - \vec{r}_1 \cos\varphi_2}, \varphi_6 = arctg\left(\frac{-\vec{r}_1 \sin\varphi_2}{\vec{l}_1 - \vec{r}_1 \cos\varphi_2}\right) \tag{8}$$

We determine the value of l4 from equation (7) as follows

$$l_4 = \frac{-\vec{r}_1 \sin \varphi_2}{\sin\left(arctg\left(\frac{-\vec{r}_1 \sin \varphi_2}{\vec{l}_1 - \vec{r}_1 \cos \varphi_2} \right)\right)} \quad (9)$$

(2) project the vector equation onto the coordinate axes O_1x and O_1y

$$\vec{l}_3 \cos\varphi_7 - \vec{r}_2 \cos\varphi_4 - \vec{l}_2 \cos\varphi_5 = 0 \quad (10)$$

and

$$\vec{l}_3 \sin \varphi_7 - \vec{r}_2 \sin \varphi_4 - \vec{l}_2 \sin \varphi_5 = 0 \quad (11)$$

From equations (10) and (11) we get the following

$$\vec{l}_3 \cos\varphi_7 = \vec{r}_2 \cos\varphi_4 + \vec{l}_2 \cos\varphi_5 = 0 \quad (12)$$

and

$$\vec{l}_3 \sin \varphi_7 = \vec{r}_2 \sin \varphi_4 + \vec{l}_2 \sin \varphi_5 = 0 \quad (13)$$

To determine φ_7, we divide equation (13) by (12).

$$tg\varphi_7 = \frac{\vec{r}_2 \sin\varphi_4 + \vec{l}_2 \sin \varphi_5}{\vec{r}_2 \cos\varphi_4 + \vec{l}_2 \cos \varphi_5}, \quad \varphi_7 = arctg\left(\frac{\vec{r}_2 \sin\varphi_4 + \vec{l}_2 \sin \varphi_5}{\vec{r}_2 \cos\varphi_4 - \vec{l}_2 \cos \varphi_5} \right) \quad (14)$$

We determine the value of l3 from equation (13) as follows

$$\vec{l}_3 = \frac{\vec{r}_2 \sin\varphi_4 + \vec{l}_2 \sin \varphi_5}{\sin\left(arctg\left(\frac{\vec{r}_2 \sin\varphi_4 + \vec{l}_2 \sin \varphi_5}{\vec{r}_2 \cos\varphi_4 - \vec{l}_2 \cos \varphi_5} \right)\right)} \quad (15)$$

From the vector equation (3), we express the length of the vector corresponding to the chain network as follows.

$$\vec{l} = \vec{l}_4 + \vec{l}_3 \quad (16)$$

To determine the unknowns from the expression (16), we perform several operations on the vector equations (1) and (2).

$$\vec{l} = \frac{\vec{r}_2 \sin\varphi_4 + \vec{l}_2 \sin \varphi_5}{\sin\left(arctg\left(\frac{\vec{r}_2 \sin\varphi_4 + \vec{l}_2 \sin \varphi_5}{\vec{r}_2 \cos\varphi_4 - \vec{l}_2 \cos \varphi_5} \right)\right)} - \frac{-\vec{r}_1 \sin \varphi_2}{\sin\left(arctg\left(\frac{-\vec{r}_1 \sin \varphi_2}{\vec{l}_1 - \vec{r}_1 \cos \varphi_2} \right)\right)} \quad (17)$$

If we take into account the angle of inclination of the chain network with respect to the transmission axis [14], then

$$\varphi_2 = 90 - \theta \quad (18)$$

$$\varphi_4 = 90 + \theta \quad (19)$$

where θ is the slope relative to the axis of the chain network, degrees.

According to [15], we express the angle of inclination of the chain network with respect to the extension axis as follows

$$\theta = \arcsin\left[\frac{t}{2A_0} \left(\frac{1}{\sin \tau_2} - \frac{1}{\sin \tau_1} \right) \right] \quad (20)$$

where t is the chain pitch, m; A0 is the distance between the initial axes, m; τ_2 and τ_1 are the angles corresponding to half the pitch of the sprockets, degrees.

Taking into account (20), we write (18) and (19) as follows

$$\varphi_2 = 90 - \arcsin\left[\frac{t}{2A_0} \left(\frac{1}{\sin \tau_2} - \frac{1}{\sin \tau_1} \right) \right] \quad (21)$$

$$\varphi_4 = 90 + \arcsin\left[\frac{t}{2A_0} \left(\frac{1}{\sin \tau_2} - \frac{1}{\sin \tau_1} \right) \right] \quad (22)$$

Taking into account expressions (18) and (19), we write expression (17) as follows

$$\vec{l}=\frac{\vec{r}_2\cos\left[\arcsin\left(\frac{t}{2A_0}\left(\frac{1}{\sin\tau_2}-\frac{1}{\sin\tau_1}\right)\right)\right]+\vec{l}_2\sin\varphi_5}{\sin\left(arctg\left(\frac{\vec{r}_2\cos\left[\arcsin\left(\frac{t}{2A_0}\left(\frac{1}{\sin\tau_2}-\frac{1}{\sin\tau_1}\right)\right)\right]+\vec{l}_2\sin\varphi_5}{-\vec{r}_2\sin\left[\arccos\left(\frac{t}{2A_0}\left(\frac{1}{\sin\tau_2}-\frac{1}{\sin\tau_1}\right)\right)\right]-\vec{l}_2\cos\varphi_5}\right)\right)}-\frac{\vec{r}_1\cos\left[\arcsin\left(\frac{t}{2A_0}\left(\frac{1}{\sin\tau_2}-\frac{1}{\sin\tau_1}\right)\right)\right]}{\sin\left(arctg\left(\frac{\vec{r}_1\cos\left[\arcsin\left(\frac{t}{2A_0}\left(\frac{1}{\sin\tau_2}-\frac{1}{\sin\tau_1}\right)\right)\right]}{\vec{l}_1+\vec{r}_1\sin\left[\arcsin\left(\frac{t}{2A_0}\left(\frac{1}{\sin\tau_2}-\frac{1}{\sin\tau_1}\right)\right)\right]}\right)\right)} \qquad (23)$$

To determine the regularity of the chain network change, the numerical solution of equation (23) was carried out in the Microsoft Office Excel program. The numerical solution was carried out for the following values of the parameters as an example: l 1=250 mm; r 1=r2=760 mm; l 2=150 mm; φ 5=0º, 10º, 20º.

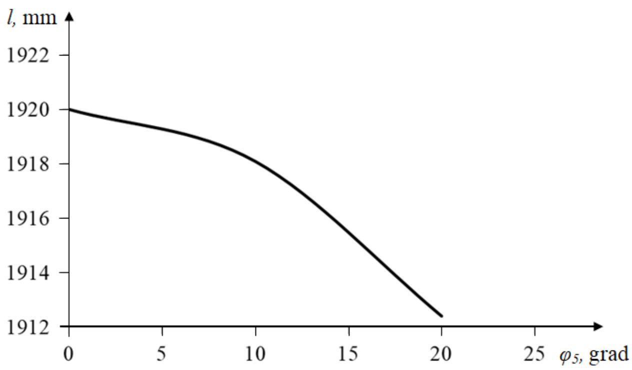

Figure 4*. The law of variation of the length l depending on φ5.*

It can be seen from Figure 4 that when the angle of rotation of the lever is 0º, the length of the chain link *l* is 1920 mm, when the angle of rotation of the lever is 10°, the length of the chain link *l* is 1918,09 mm, and when the angle of rotation of the lever is 20°, the length of the chain link *l* is 1912,41 mm. Therefore, from the above data, it can be concluded that as the angle of rotation of the lever increases, the length of *l (AB)* changes, that is, decreases.

3. Conclusions

In the geometric analysis of a chain transmission, it is convenient to use the vector contour method, as in the analysis of smooth lever mechanisms. In this study, a five-link lever mechanism equivalent to a transmission was used to determine the changes in the lengths of the chain links. The results of the studies show that with an increase in the angle of rotation of the lever, one of the chain links increased and the other decreased. In this case, the changes followed a curvilinear pattern.

Abbreviations

$ABO_1O_3O_2$	Sides of a 3-vector Type, 5-link Lever Mechanism

Author Contributions

Turdaliyev Voxidjon Maxsudovich: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Methodology, Resources, Software, Validation, Writing – original draft, Writing – review & editing

Akbarov Abdurahmon Iminjon Ogli: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Validation, Writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] The Complete Guide to Chain. © 1997 by U. S. Tsubaki, Inc. First English- language edition, 1997. ISBN 0-9658932-0-0. P: 240. Djuraev A Dj, and others. Theory of machines and mechanisms. Publishing house named after Gafur Gulam, Toshken-2004.

[2] Krasnov A. A. Development of the fundamentals of designing systems for transporting threads and fabrics of textile machines as mechanisms with flexible links: Diss. for academic competition step. Doctor of Technical Sciences Ivanova. 2010. 357 p.) J Kh Beknazarov, Sh Sh Kenjabayev, Development of an Effective Resourceving-Saving Design and Methods for Calculating the Parameters of Gears with Compound Wheels 2019.

[3] Turdaliev V. M. Akbarov. A. I. Olmasov S. A. Calculation of tension in the leading branch of the chain of a chain transmission with a variable center distance.

[4] Turdaliev V. M. Akbarov. A. I. Olmasov S. A. Study of tension change in the leading branch of the chain of a chain transmission with variable center distance // PROBLEMS OF DEVELOPMENT OF MODERN SOCIETY January 23-24, 2024 ML-08 Vol. 3. - Russia, - P. 392 -396. Dj, D. A., Abduvakhobov, D. A., Khabibullaev, D. H., & Gofurjanov, I. I. (2023). Helical Cylindrical Gear with Elastic Elements. Doctrines, Schools, and Concepts of Sustainable Development of Science in Modern Conditions, 163.

[5] Patent. Res. Uzbek FAP No. 01974. Zanzhirli uzatma V. M. Turdaliev, A. A. Kosimov, A. I. Akbarov, S. R. Komilov. Bulletin No. 6 2022.

[6] E. Aliev. Development of efficient construction of seed supply drum and justification of parameters. 05.02.03-"Technological machines. Robots, mechatronics and robotics systems" scientific dissertation, Namangan-2025y 148 p.

[7] Mamakhanov A. A. Development of constructions and calculation methods of belt element-chain transmissions of technological machines: Tech. science. dr. diss. (02.05.02) Namangan, 2021. - 200 p.

[8] Komilov S. R. Development of construction and calculation method of chain transmission with variable distance between axles. Tex. science. fake doctor. diss. (02.05.02) Namangan, 2022. - 136 p.

[9] Patent RUz No. FAP 2021 0047. Chain transmission / Turdaliev V., Kasimov A., Akbarov A., Komilov S. 30.06.2022.

[10] Kasimov A. A. Improvement of toothed belt transmission design and calculation methods. Tex. science. false on dr. diss. autoref. - Namangan, 2020. - 44 p.

[11] Mukhamedov Z., Turdaliyev V. M., Kosimov A. A. Kinematic Nonuniformity of the Rotation of a Toothed Belt Transmission with a Composite 118 Pulley // Russian Engineering Research, 2020. – Volume 40. – P. 705–709.

[12] Kasimov A. A. Improvement of toothed belt transmission design and calculation methods. Tex. science. false on dr. diss. autoref. - Namangan, 2020. - 44 p.

[13] Shvedov I. A. Povyshenie rabotosposobnosti tsepnyx peredach konstruktorskimi i tekhnologicheskimi metodami // Dissertation kand. technical science -Krasnodar: KGTU, 2004. -241 p.

[14] Komilov S. R. Development of construction and calculation method of chain transmission with variable distance between axles. Tex. science. fake dr. diss. (02.05.02) Namangan, 2022. - 136 p.

[15] Gotovtsev A. A., Stoblin G. B., Kotenok I. P. Design of chain drives: Handbook. - M.: Mechanical Engineering, 1973. - 376 p.

Biography

Turdaliyev Voxidjon Maxsudovich is a highly respected Doctor of Technical Sciences and a professor, renowned for his extensive contributions to the field of machine details. He has authored numerous articles and books, which are considered fundamental references in the industry. His expertise and profound knowledge have earned him recognition both locally and internationally. Currently, he serves as a department professor at the prestigious Tashkent Institute of Textile and Light Industry, where he imparts his valuable knowledge to the next generation of engineers. Throughout his distinguished career, Professor Djuraev has mentored numerous students, many of whom have gone on to achieve great success in their professional fields. His dedication to research, education, and the advancement of machine design has made him a key figure in his field, with a lasting impact on both academia and industry.

Akbarov Abdurahmon Iminjon Ogli is a PhD candidate and a junior lecturer at the Department of Mechanics. He is currently working on his doctoral research and contributing to the field through teaching and academic involvement. He graduated Namangan Engineering-Construction Institute in 2020, and his Master of Ground vehicles and systems (by mode of transport) from the same institution in 2022. He has participated in multiple international research collaboration projects in recent years.

Research Field

Turdaliyev Voxidjon Maxsudovich: Theory of Machines and Mechanisms, Mechanical Engineering, Elastic Elements in Gear Transmissions, Dynamics and Kinematics of Technological Machines, Vibration Analysis in Gear Systems, Reliability and Efficiency of Machine Components.

Akbarov Abdurahmon Iminjon Ogli: Helical Gear Transmission with Elastic Elements, Applied Mechanics, Machine Design and Analysis, Dynamic Behavior of Mechanical Systems, Torsional and Axial Vibration Analysis, Structural Optimization in Mechanical Drives.