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KINEMATIC STRUCTURE OF THE 1M63MF101 LATHE: A REVIEW AND EDUCATIONAL ANALYSIS

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Abstract. This paper presents a review and educational analysis of the kinematic structure of the 1M63MF101 lathe. The aim is to systematically describe and explain the fundamental kinematic principles underlying the operation of this widely used machine tool, making the material accessible to engineering students and practitioners. Drawing on established methods of kinematic synthesis, the paper describes the main kinematic groups of the machine, their functions, interrelations, and adjustment mechanisms. The educational value of the paper lies in its structured presentation of kinematic group classification, motion transmission principles, and the role of adjustment mechanisms, supported by relevant formulas and explanatory discussion.

Keywords: CNC lathe, kinematic structure, machine tool design, turning process, feed motion, cutting motion, kinematic groups, spindle drive, 1M63MF101 lathe, machining accuracy.

Annotatsiya. Ushbu maqolada 1M63MF101 tokarlik stanogining kinematik strukturasini ishlab chiqish va tahlil qilish masalasi ko‘rib chiqilgan. Mavzuning dolzarbligi zamonaviy mashinasozlikda ishlov berish aniqligi va unumdorligini oshirish zarurati bilan belgilanadi. Tadqiqotda kinematik sintez usullari asosida stanokning asosiy kinematik guruhlari, ularning bog‘lanishi va sozlash mexanizmlari o‘rganildi. Natijada stanokning samarali kinematik strukturasi taklif etildi. Muallifning ilmiy hissasi kinematik guruhlar tahlili va ularning amaliy qo‘llanilishiga oid tavsiyalar ishlab chiqilganidadir.

Kalit so‘zlar: 1M63MF101 tokarlik stanogi, kinematik struktura, kinematik guruhlar, bosh harakat, surish harakati.

Аннотация. В статье рассмотрена разработка и анализ кинематической структуры токарного станка 1М63МФ101. Актуальность темы определяется необходимостью повышения точности и производительности обработки в современном машиностроении. На основе методов кинематического синтеза исследованы основные кинематические группы станка, их взаимосвязи и механизмы настройки. В результате предложена эффективная

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кинематическая структура станка. Научный и практический вклад автора заключается в анализе кинематических групп и разработке рекомендаций по их применению.

Ключевые слова: токарный станок 1М63МФ101, кинематическая структура, кинематические группы, главное движение, движение подачи.

INTRODUCTION.

Machine tools play a crucial role in modern manufacturing, ensuring high precision and productivity in machining various parts. Among them, lathes are widely used due to their versatility and ability to perform different turning operations.

The 1M63MF101 lathe is designed for machining external and internal cylindrical surfaces, threading, facing, and other turning operations. The efficiency and accuracy of such machines largely depend on their kinematic structure, which determines how motion is generated, transmitted, and controlled.

The kinematic structure of a machine tool represents a system of interconnected mechanical elements responsible for generating working motions, adjusting their parameters, and ensuring the required relationship between the cutting tool and the workpiece. Proper design of the kinematic structure makes it possible to achieve optimal machining conditions, improve productivity, and increase processing accuracy.

The development of rational kinematic structures is an important task in machine tool engineering, since the arrangement and interaction of kinematic groups directly influence machining performance. For this reason, analysis and synthesis of kinematic structures remain relevant in the design and improvement of metal-cutting machines.

This paper provides a review and educational analysis of the kinematic structure of the 1M63MF101 lathe, systematically describing its kinematic groups, their functions, and the principles of their interaction. The goal is to offer a clear and structured explanation of well-established kinematic principles as applied to this machine, serving as a reference for students and engineers seeking to understand lathe design.

Kinematic Structure and Main Motions.

The kinematic structure of the 1M63MF101 lathe is determined by the technological requirements of turning operations and the need to ensure accurate interaction between the cutting tool and the workpiece. The machine is intended to perform a wide range of operations, including external and internal turning, facing, thread cutting, and machining of shaped surfaces. These operations require a

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properly organized system of working motions, realized through the machine's kinematic structure.

Based on the methodological principles of kinematic synthesis, all working motions of the machine can be divided into several main groups. Each group performs a specific function and is responsible for generating a particular motion required in the machining process.

The primary group is the main cutting motion group, generated by spindle rotation and responsible for material removal. This motion determines the cutting speed and has a decisive influence on machining productivity and surface quality.

The second important group is the feed motion group, which provides relative movement between the cutting tool and the workpiece. It includes longitudinal and transverse feed motions necessary for forming the required surface geometry.

In addition, the machine contains auxiliary and setup motions, which are used for positioning, adjustment, and supporting machining operations. The coordinated interaction of these groups forms the complete kinematic structure of the lathe.

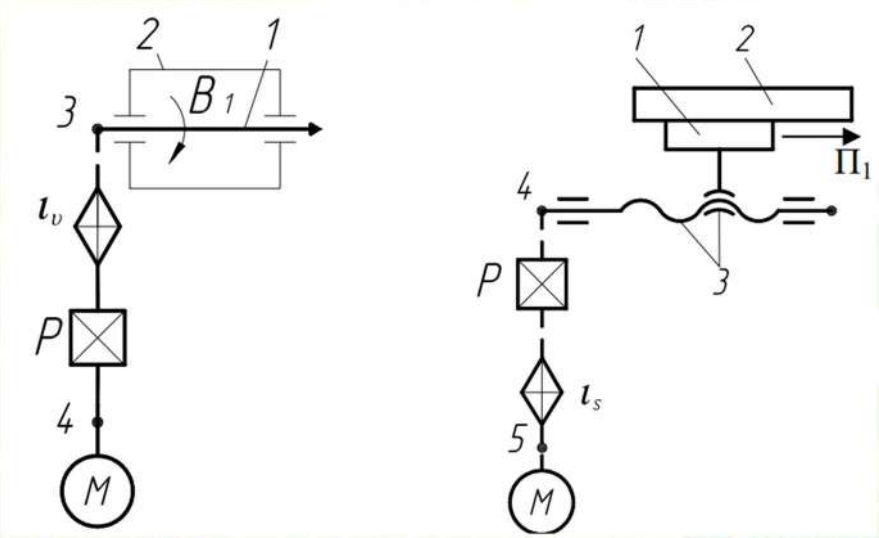


Figure 1. Structural schemes of simple kinematic groups: (a) rotational motion group; (b) translational motion group.

As shown in Figure 1, the structure of simple kinematic groups consists of internal and external kinematic links. In the rotational motion group, the spindle and housing form a rotational kinematic pair that provides the trajectory of motion, while the external kinematic chain includes the drive motor, reversing mechanism, and speed adjustment mechanism. Such a structure ensures the generation and regulation of cutting motion.

For the translational motion group, the internal link is represented by a translational pair formed by the movable and fixed members of the machine. The

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external chain includes the motor, feed control mechanism, and reversing device, ensuring generation of linear feed motion. These structures illustrate the fundamental principles used in the synthesis of machine tool kinematic groups and can be applied in the analysis of the 1M63MF101.

The motion is adjusted according to speed and direction, while its trajectory (circular motion) is provided by a rotational kinematic pair. The internal link of this group is represented by a rotational pair between spindle 1 and housing 2.

To provide rotational motion to spindle 1, a motor M is used, which is connected to the spindle through the external kinematic chain 4–3. For adjusting the spindle rotational speed, the external link is equipped with the corresponding adjustment mechanism iv, while the spindle rotation direction is controlled by the reversing mechanism R.

Thus, the external link of the kinematic group is represented by the kinematic chain 4–R–iv–3 between motor M and spindle 1.

The cutting speed can be determined by the expression:

$$V = \frac{\pi D n}{1000}$$

where V is the cutting speed, D is the workpiece diameter, and n is the spindle rotational speed.

The second important group is the feed motion $\varphi_s(P_2, P_3)$, which ensures the relative movement of the cutting tool with respect to the workpiece. In turning machines, this motion is usually performed by the carriage system, including longitudinal and transverse slides. Compared with the cutting motion, the feed motion is more complex, since it may include several coordinated elementary movements depending on the machining operation.

For example, during thread cutting, the feed motion must be synchronized with spindle rotation in order to ensure the required thread pitch. For this reason, the feed motion is classified as a complex kinematic group. The feed rate may be expressed as

$$S = s \cdot n$$

where S is the feed rate, s is the feed per revolution, and n is spindle speed.

The feed motion in the 1M63MF101 lathe is realized through the feed gearbox, lead screw, and apron mechanism, which provide accurate transmission of motion from the drive system to the carriage. This kinematic relationship is especially important in thread cutting and precision turning operations.

In addition to the main working motions, the machine includes auxiliary motions, which do not directly participate in material removal but are essential for efficient operation. These motions include rapid positioning of the tool, return

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movements, engagement and disengagement of mechanisms, and other supporting operations. Although auxiliary motions do not directly affect the geometry of the machined surface, they significantly influence machining productivity.

Another important category is setup (adjustment) motions, which are used to prepare the machine for operation. These motions include setting the initial position of the tool and workpiece, adjusting cutting parameters, and configuring the machine for a specific machining operation. In conventional lathes, these adjustments are performed through mechanical settings and operator control.

The interaction between all these kinematic groups forms a unified system that ensures the proper functioning of the machine tool. The cutting motion provides the necessary energy for material removal, while the feed motion defines the geometry of the machined surface. Auxiliary and setup motions support the process by improving operating efficiency and reliability.

The design of the kinematic structure must ensure not only the correct generation of motions but also their precise coordination. Any deviation in motion parameters can lead to machining errors, reduced surface quality, or increased tool wear. Therefore, the synthesis of kinematic structure is a critical stage in machine tool design.

In conventional lathes such as the 1M63MF101, motion regulation is achieved through mechanical transmission systems, including gearboxes, feed mechanisms, and kinematic chains. These systems provide the required ranges of speed, feed, and coordination necessary for machining different surfaces.

Determination of Kinematic Groups and Their Characteristics.

The determination of kinematic groups is a key stage in the design of the kinematic structure of a machine tool. It is based on the analysis of required machining operations, the type of surfaces to be processed, and the principles of motion generation within the machine. For the 1M63MF101 lathe, the kinematic structure must ensure the execution of turning operations with high accuracy and stable operation.

According to the general methodology of kinematic synthesis, each working motion is generated by a corresponding kinematic group. These groups are classified as simple or complex depending on the number and type of elementary motions involved.

The first and most important group is the cutting motion group $\varphi_v(B_1)$. This group is responsible for spindle rotation together with the workpiece. It is classified as a simple kinematic group, since it produces a single rotational motion about a fixed axis. The trajectory of this motion is circular and is ensured by a rotational

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kinematic pair formed between the spindle and the machine frame. The main function of this group is to provide the required cutting speed, which directly affects machining quality and productivity. The second group is the feed motion group $\varphi_s(P_2, P_3)$, which is responsible for the relative displacement of the cutting tool with respect to the workpiece. This group is classified as a complex kinematic group, since it includes at least two elementary motions: longitudinal feed and transverse feed. These motions are realized through the carriage mechanism of the lathe, including the saddle and cross-slide. Their combination makes it possible to machine cylindrical, conical, and threaded surfaces.

During thread-cutting operations, the feed motion must be synchronized with spindle rotation to ensure the required thread pitch. This synchronization establishes a precise kinematic relationship between the feed group and the cutting motion group.

In addition to the main working groups, the machine includes auxiliary kinematic groups responsible for supporting operations such as tool positioning, return motions, and engagement of mechanisms. Although these groups do not directly influence the cutting process, they improve operating efficiency and reduce non-productive time.

Another important category is setup (adjustment) kinematic groups, which are used to prepare the machine for operation. These groups provide adjustment of the initial position of the tool and workpiece, setting of machining parameters, and mechanical regulation according to technological requirements.

The classification and proper organization of kinematic groups play a crucial role in the overall performance of the machine tool. Each group must be designed so that it performs its function while maintaining proper interaction with other groups. This ensures stable operation, machining accuracy, and reliability.

Furthermore, the number and type of kinematic groups influence the complexity of the machine structure. A rational design minimizes unnecessary elements while ensuring all required motions are accurately generated. This improves reliability, simplifies maintenance, and increases machine performance.

In the case of the 1M63MF101, the kinematic structure effectively combines a simple cutting motion group with a more complex feed motion system, supported by auxiliary and setup groups. Such a configuration allows the machine to perform a wide range of turning operations with high accuracy and stable performance.

Connection of Kinematic Groups.

An important stage in the synthesis of the kinematic structure of a machine tool is determining the method of connection between kinematic groups. The type

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of connection directly affects the functional capabilities of the machine, the complexity of its design, and the accuracy of motion transmission.

In the 1M63MF101 lathe, the connection of kinematic groups is determined by the nature of turning operations and the relationship between working motions. The cutting motion group $\varphi_v(B_1)$, and the feed motion group $\varphi_s(P_2, P_3)$, not have common executive links, but they are functionally interconnected through the machining process. Spindle rotation generates the cutting motion, while the feed motion forms the geometry of the machined surface. These groups operate simultaneously and maintain a kinematic relationship through the machine transmission system.

The connection between these groups is realized through mechanical coordination typical for conventional lathes. The main motion is transmitted through the spindle drive, while the feed motion is generated through the feed gearbox, lead screw, and feed mechanisms. Their coordinated interaction ensures proper execution of turning operations.

Within the feed motion group itself, different elementary motions, such as longitudinal and transverse feeds, are combined into a single complex kinematic group. These motions are internally connected through the machine structure and kinematic chains to generate the required tool movement.

Auxiliary and setup motion groups are connected to the main kinematic groups through intermediate elements and mechanical linkages. These connections ensure correct positioning of the tool and workpiece and support the overall functioning of the machine.

From a structural point of view, the connection of kinematic groups in the 1M63MF101 lathe may include both independent and sequentially connected groups. In thread-cutting operations, for example, the feed motion group and spindle motion group are connected through a kinematic relationship that ensures the required thread pitch.

In conventional machine tools, such connections are realized through gear trains, change gears, couplings, and other transmission mechanisms. This approach ensures reliable motion transmission, structural simplicity, and stable machine performance.

Thus, the adopted method of connecting kinematic groups in the 1M63MF101 provides effective interaction of all machine elements and enables accurate and efficient machining of various parts.

Kinematic Chain Analysis and Motion Transmission.

The analysis of kinematic chains is an important stage in understanding how motion is transmitted within a machine tool. In the 1M63MF101 lathe, kinematic

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chains connect the motion source (electric motor) with the working elements of the machine, such as the spindle and carriage system.

Each kinematic chain consists of a sequence of interconnected elements transmitting motion and power. These elements may include shafts, gears, couplings, lead screws, feed rods, and gear trains. The structure of the chain determines the efficiency, accuracy, and reliability of motion transmission.

The kinematic chain responsible for the cutting motion begins with the main drive motor, which generates rotational motion. This motion is transmitted through the spindle drive system and gearbox to the spindle. The gearbox provides the required speed ranges for different cutting conditions and forms an essential part of the kinematic chain.

The kinematic chain of the feed motion is more complex, since it involves several transmission elements. Motion is transmitted through the feed gearbox, lead screw, and apron mechanisms to the carriage and cross-slide. These mechanisms convert rotational motion into linear displacement and ensure the required feed motions of the cutting tool.

An important feature of the feed kinematic chain is the maintenance of the required relationship between spindle rotation and feed motion, especially during thread cutting. This relationship is ensured through the kinematic chain and change gears, which provide the necessary thread pitch.

The transmission ratio in the kinematic chain can be expressed as

$$i = \frac{n_1}{n_2}$$

where i is the transmission ratio and n_1, n_2 are rotational speeds of the connected links.

Optimization of kinematic chains is essential for improving machine performance. A properly designed chain minimizes backlash, reduces vibration, and ensures smooth motion transmission. This directly affects machining quality and durability of machine components.

In the case of the 1M63MF101, the combination of mechanical transmission elements provides an efficient and reliable kinematic structure. The rational arrangement of gears, shafts, and feed mechanisms ensures high accuracy, stable operation, and effective execution of turning processes.

CONCLUSION.

This paper has presented a review and educational analysis of the kinematic structure of the 1M63MF101 lathe, based on established principles of kinematic synthesis. The main kinematic groups responsible for generating working motions were systematically described, including the cutting motion group, the feed motion

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group, as well as auxiliary and setup motion groups. The analysis showed that the cutting motion group is a simple kinematic group, while the feed motion group is complex due to the combination of several elementary motions. The adjustment mechanisms of these motions were examined, including regulation of speed, direction, and kinematic relationships required for machining operations.

Special attention was given to the connection of kinematic groups, which in the machine is achieved through mechanical coordination and transmission systems. This approach ensures reliable operation, machining accuracy, and stable performance of the machine tool.

The reviewed kinematic structure illustrates how all machine components interact to enable accurate machining of various surfaces. The educational material presented in this paper may serve as a reference for students and engineers engaged in the study, operation, or improvement of similar metal-cutting machine tools.

REFERENCES

1. Журавлёв В. Ф. *Системы управления металлорежущими станками.* — Санкт-Петербург: БХВ-Петербург, 2021. – 400 с
2. Куликов В. И. *Механообрабатывающие технологии: учебник.* – Москва: Издательство Лань, 2020. – 385 с.
3. Кудрявцев В. В. *Технология машиностроения. Современные методы обработки.* – Санкт-Петербург: Питер, 202. – 416 с.
4. Попов А. П. *Проектирование металлорежущих станков: учебное пособие.* —Москва: Машиностроение, 2018. – 352 с.
5. Кулагин В. А. *Кинематика металлорежущих станков и приводов.* — Москва: Изд-во МГТУ им. Баумана, 2019. — 296 с.
6. Фролов И. Н. *Автоматизация металлообработки и станков с ЧПУ.* — Москва: Форум, 2022. — 408 с.
7. Скоков В. С. *Основы технологии машиностроения: учебное пособие.* — Ростов н/Д: Феникс, 2017. —368 с.
8. Труханов А. И. *Металлорежущие станки и автоматические линии.* — (Санкт-Петербург: Профессия, 2016. —340 с.
9. Шаров А. Г. *Станки: конструкция, эксплуатация и обслуживание.* — Москва: Академический проект, 2020. —384 с.
10. Потапов С. А. *Механика резания и формообразование поверхностей.* — Москва: Машиностроение, 2018. —312 с.

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