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Danchenko V.M., Dobrov I.V., Semichev A.V.

Roll drive mechanism with planetary gearbox for cold pilger pipe rolling mills

Данченко В.М., Добров І.В., Сьомічев А.В.

Механізм приводу валків з планетарним редуктором для трубопрокатних станів холодної пілігримової прокатки труб

Abstract. Purpose. *Creation and study of a roll drive mechanism with a planetary gearbox, which will ensure a reduction in axial forces in the production of thin-walled pipes and it will expand the range of pipes obtained on cold pilger rolling mills.* ***Methodology.*** *The work includes research on determining the parameters of the roll drive of cold pilger rolling mills using the graph-analytical method of studying the kinematics of mechanisms.* ***Results.*** *The roll drive mechanism with a planetary gearbox will ensure regulation of the angular speed of rotation of the rolls and a reduction in axial forces.* ***Scientific novelty.*** *The influence of the geometric parameters of the roll drive on the value of the angular speed of the rolls, which ensure a reduction in axial forces, has been determined.* ***Practical significance.*** *The roll drive mechanism with a planetary gearbox allows obtaining high-quality thin-walled pipes with the possibility of expanding the range.*
Keywords: *roll drive, planetary gearbox, cold pilger rolling, axial forces, thin-walled pipes.*

Анотація. Мета. *Створення та дослідження механізму приводу валків з планетарним редуктором, який забезпечить зменшення осьових зусиль при виробництві тонкостінних труб та розширить сортамент труб, що отримуються на станах холодної пілігримової прокатки.* ***Методологія.*** *Робота включає дослідження з визначення параметрів приводу валків станів холодної пілігримової прокатки труб з використанням графоаналітичного методу дослідження кінематики механізмів.* ***Результати.*** *Механізм приводу валків з планетарним редуктором забезпечить регулювання кутової швидкості обертання валків та зменшення осьових зусиль.* ***Наукова новизна.*** *Визначено вплив геометричних параметрів приводу валків на величину кутової швидкості валків, що забезпечують зменшення осьових зусиль.* ***Практичне значення.*** *Механізм приводу валків з планетарним редуктором дозволяє отримувати високоякісні тонкостінні труби з можливістю розширення сортаменту.*
Ключові слова: *привід валків, планетарний редуктор, холодна пілігримова прокатка, осьові зусилля, тонкостінні труби.*

Introduction. The use of various methods and technologies for metal processing using plastic deformation has ensured the production of a wide range of metal products.

At the present stage of development of production technology of thin-walled long metal products are in greatest demand, in particular thin-walled and especially thin-walled pipes. Thin-walled cold-deformed long pipes are the basis for further technical progress.

Analysis of published data and problem statement. The existing mechanism for driving rolls on cold pilger rolling mills leads to the appearance of axial forces, which is the cause of corrugations and other defects. When rolling thin-walled pipes, these defects are more significant. Obtaining high-quality thin-walled pipes is impossible without reducing the magnitude of axial forces [1-2].

To reduce axial forces, it is proposed to use replaceable parts for each rolling route. Adjusting the angular speed of rotation of the rolls will allow for each range of pipes to ensure compliance between the forced rolling radius and the natural one [1-5].

The purpose of the development is to create and study a mechanism for driving rolls with a planetary gearbox, which will ensure a reduction in axial forces in the production of thin-walled pipes and expand the range of pipes produced on cold pilger rolling mills.

Materials and methods. A mechanism for driving rolls of cold pilger rolling mills with a planetary gearbox is proposed. The kinematic diagram of this roll drive is shown in Fig.1.

Wheel 10 is driven by an electric motor. Wheel 8, which is engaged with wheel 10, rotates. Wheel 7 drives connecting rod 5, which is fixed to the roller. The electric motor for driving the working stand rotates crank 2.

To determine the number of degrees of mobility of the mechanism, a structural diagram was constructed (Fig. 2). The structural diagram indicates the links of the mechanism consisting of the working stand mechanism and the roller drive. Crank 1 and wheel 10 are driving, therefore they are indicated by solid lines. Other links have the form of various geometric figures with corners in the form of a circle. For example, a stationary frame contains four vertices. The first circle (from left to right) means the connection of the frame with the gear wheel 10 using a rotational kinematic pair of the first kind (fifth class), the second - the connection

© Danchenko V.M. – Doctor of Technical Sciences, Professor, Ukrainian State University of Science and Technologies;
Dobrov I.V. – Doctor of Technical Sciences, Ukrainian State University of Science and Technologies;
Semichev A.V. – Candidate of Technical Sciences, Associate Professor, Ukrainian State University of Science and Technologies

with the carrier 9 using a kinematic pair of the fifth class, the third - with the gear wheel 7 (pair of the 5th class), the fourth - the connection with the working stand 4 (pair of the 5th class), the fifth - the connection with the crank of the roller drive 2. The class of the pair indicates the number of connection conditions that are determined by it. That is, a pair of the fifth class provides one degree of mobility. The working cage 4 contains four vertices. The first circle (from left to right) connects the working cage with the connecting rod 5, the second - connects with the roller 6, the third - connects with the fixed frame 1, the fourth - with the connecting rod 3. All kinematic pairs that connect the working cage with other links are of the fifth class and provide one degree of mobility. The crank 2 is connected by means of kinematic pairs of the fifth class with the fixed frame 1 and the connecting rod 3. The connecting rod 5 is connected by only two kinematic pairs of the fifth class with the working cage 4, the wheel 7 and by means of a kinematic pair of the fourth class with the roller (one link with a gear wheel) 6.

On the upper and lower rollers there are synchronizing gears. The lower roller forms one link with the synchronizing gear (the link is designated by the number 6 and conventionally called the roller). The upper roller forms one link with the synchronizing gear and the connecting rod (the link is shown by the number 5 and it is called the connecting rod). The roller 6 and the working stand 4 are interconnected by a kinematic pair of the fifth class. The wheel 10 is connected to the frame using a kinematic pair of the fifth class, and to the wheel 8 using a gear pair of the fourth class. The wheel 8 is connected to the carrier 5 using a kinematic pair of the fifth class, and to the wheel 7 using a pair of the fourth class. The wheel 7 is connected to the frame using a kinematic pair of the fifth class, and to the wheel 8 using a pair of the fourth class.

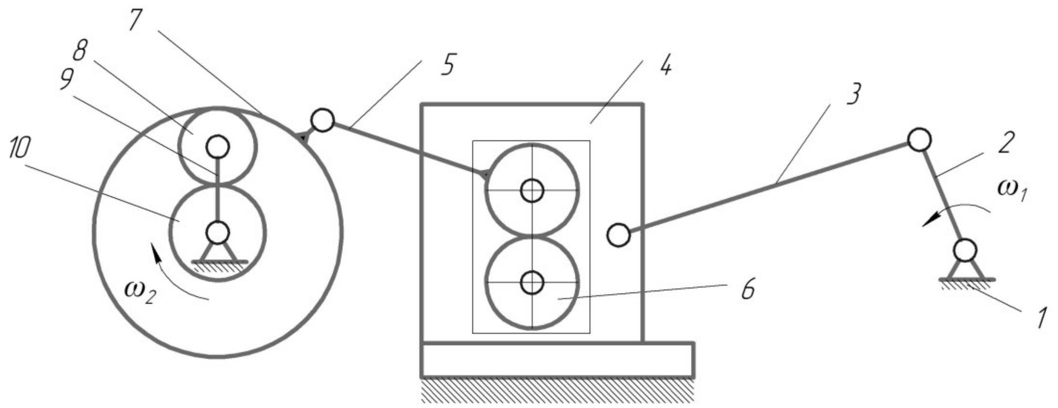

Fig. 1. Roller drive mechanism with planetary gearbox: 1 - fixed frame; 2 - crank drive of the working stand; 3 - connecting rod; 4 - working stand; 5 - connecting rod, upper roller, gear wheel (one link); 6 - roller; 7, 8, 10 - gears; 9 – carrier.

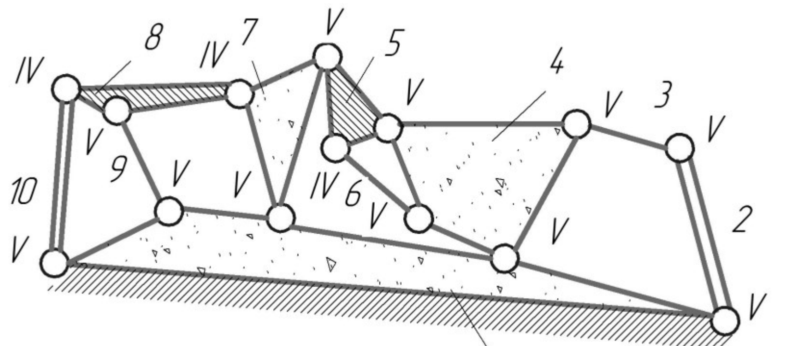

Fig. 2. Structural diagram of the roller drive mechanism with planetary gearbox.

Using the structural diagram, the number of kinematic pairs and their class, as well as the number of links, were obtained. The number of degrees of mobility of the mechanism (consists of the working stand drive mechanism and the roll drive mechanism) [1]:

$$W = 3(n-1) - 2p_1 - p_2 = 3 \cdot 10 - 2 \cdot 11 - 3 = 2 \quad (1)$$

where n - total number of mechanism links; p_1 - number of single-moving links of the mechanism, p_2 - number of two-moving links of the mechanism.

The number of mobility degrees corresponds to the number of engines (one for the stand drive, the other for the roll drive). This will provide the ability to adjust the angular speed of the roll depending on the rolling route.

So, it is possible to formulate requirements for the drive of the rolls of cold pilger rolling mills. The drive mechanism must provide the required angle of rotation of the roll, and the angular speed must change according to the law that ensures the maximum reduction of axial forces.

Using kinematic analysis, it is shown the change in the angle of rotation of the rolls depending on the time of rotation of the crank of the working stand drive (Fig. 4).

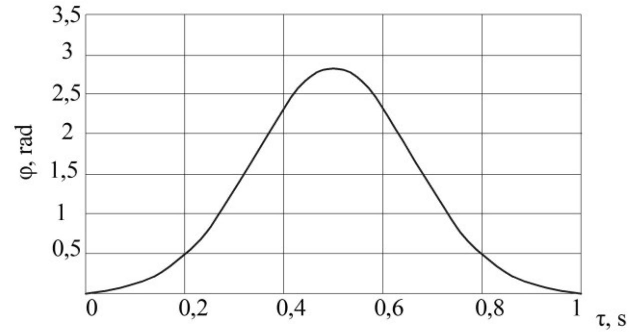

Fig. 4. Change in the angle of rotation of the roll depending on the time of rotation of the crank drive of the working stand

The simulation shows that the nature of the change in torque on the electric motor shaft corresponds to the change in torque on the roll.

It is also important that the direction of rotation of the rotor of the gear drive motor 10 does not change when the direction of movement of the working cage changes. This has a positive effect on the efficiency of the mechanism.

Conclusions

1. A roller drive mechanism with a planetary gearbox has been developed. Based on the structural analysis of the mechanisms, it was shown that this mechanism can work.

2. A separate roller drive mechanism with a planetary gearbox allows you to adjust the speed of rotation of the rollers regardless of the speed of the working stand. The parameters of this drive can be determined using kinematic analysis.

3. The roller drive mechanism with a planetary gearbox will provide adjustment of the angular speed of rotation of the rollers and reduce axial forces. This will allow you to obtain high-quality thin-walled pipes with the possibility of expanding the range of pipes produced by these mills.

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