INVESTIGATION OF CONVEYER CHAIN RESISTANCE TO WEAR

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Abstract. The aim of the research is to estimate a disassembled conveyor chain with rolling friction hinges and sliding friction pivots wear in the laboratory for two types of test benches. The experimental results showed that the chain of the rolling friction hinges is much durable than the chain with the sliding friction hinges. The experiments were carried out on the full chain circuit bench at 3500 N load and the speed of 0.34 $m \cdot s^{-1}$. For hastened chain research the chain was loaded with a smoothly varying load force within 1600 and 3200 N. The rolling friction hinge chain parts were heat treated. The chains were not lubricated.

Keywords: conveyor chain, rolling friction hinges, resistance to wear.

Introduction

Last few decades, the efficiency of the production purposes is rapidly modernized production and introduction of mechanized work performance. In a range of industries, including agriculture, there is widespread use of chain conveyors.

Currently, in all standardized conveyor chains sliding friction hinges are used. Considering that the chain is produced in a large-scale, the idea of rolling friction introduction of the chain joints can be regarded as a modern and actual problem for chain safety and lifetime enhance.

Approximately 35 % of all types of chains are traction chains. The most used are plate chains, welded chains and dismountable chains.

The main attention of the researchers is on the transmission chain and conveyor chain equipment theory associated with gearing, kinematics, dynamics, strength and wear resistance issues.

Materials and methods

The **closed chain loop experiment bench** is depicted in Figure 1. The force from the electric engine 1 is applied to the chain 18 by means of belt pulleys 6 and 7, the belt 11, the reducer 2 and the driving chain sprocket 4. To simulate the operation of the chain under load, the bench has a hydraulic pump and an adjustable throttle valve installed. The hydraulic pump is operated by means of the chain sprocket 5, the reducer 3, the belt pulleys 8 and 9 and the belt 10. The alterations of passage through the throttle valve 13 cause the load applied to the chain 18.

Determining the durability using a closed chain loop takes a lot of time. In general, just one research on the regularities of the increase in the average chain pitch may take dozens of hours. The forced chain research bench (Fig. 2) has been developed to allow a faster determination of the optimal chain design and the necessary hardness of the component effective surfaces without having to manufacture a lot of chain components beforehand. Such a bench ensures smooth, persistent oscillatory (there and back) movement or the rotary movement (including backwards) of the chain under different workload conditions, which is typical for chain conveyors. Reversible sliding friction regime intensifies the wear [1; 2] (refers to sliding friction).

The operational principles of the bench are shown in Figure 2. The rollers 13 are driven by the electric engine 1 with a single degree worm reduction unit 2, the chain drive 3 and the chain drive 23 (for rotary movement) or the crank gear for oscillatory movement (Fig. 2). The rotary moment form the sprockets and cardans II is transmitted to the rollers 13 being researched.

Cardan drive allows transmitting rotation, even when the pivot shift 13 moves longitudinal because of the step extension of the chain. The test piece of the chain 14 contains five components and one end attached to the test bench frame, but with the other end to the moving slider of the loading mechanism 13. The chain section loading with axial force is caused with moving the slider guides 13 in the frame guides 16 with a cylindrical compression spring 11. From the reduction gear 2 the torque through the transmission chain 3 transmits to the eccentric disk 8 and shaft 7. From the eccentric 8 the force, through the bearings, is transmitted to the slider 10, which moves to the left and compresses the spring 11. The spring 11 transmits the force to the slider 13 and loads the chain section 14. The eccentric disk 8 and shaft 7 is based on bearings, which can be moved by screws 7, in that way the chain loaded force amplitude could be adjusted. The spring 11 is tarred and from the deformation range the load with accuracy 0.14 ... 0.18 kN can be calculated. The pivot fluctuation speed is 5760 movements per hour, which corresponds to 5.6 hours of the study on the test bench No. 1.

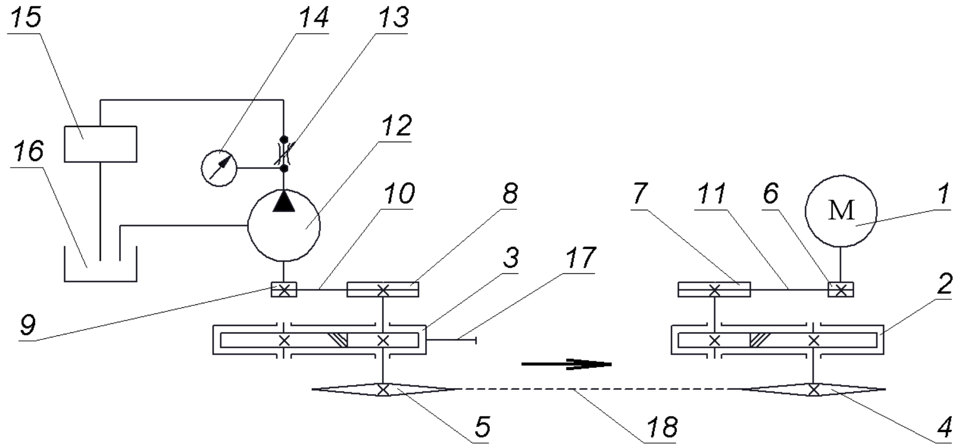

Fig. 1. **Closed chain loop experiment bench (experiment bench No. 1)**

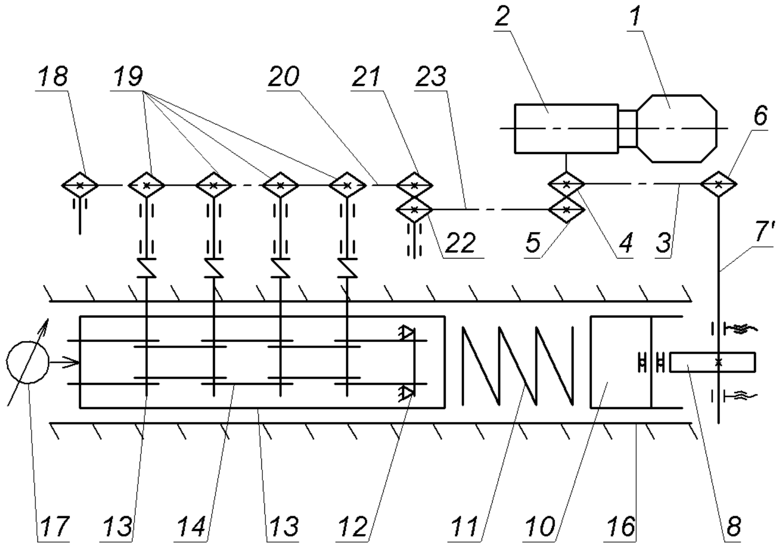

Fig. 2. **Forced chain research bench (experiment bench No. 2)**

Methods of research

One of the main parameters of a chain is the chain pitch t, which changes under the influence of the chain hinge component deterioration. In order to evaluate the deterioration of the components of a chain in a certain period of being operated under certain workload, the chain is loaded with the force of ≈3500 N. The duration of the load is also recorded. During the experiment, the deterioration (and therefore the chain pitch t) is measured at two different chain links, every link consisting of 16 plates and 8 rollers.

The investigated rolling friction chain (patent no. 13695) plate ends interact in gear with the chain asterisk, which improves the accuracy of the pivoting movement of parts, thus increasing the range of the rolling hinge.

Before the experiment all components of both studied chain test pieces are measured. For plate the distance between the active surfaces is measured: size b (Fig. 3. for rolling friction hinge chain and Fig. 4. for sliding friction hinge chain). The size b is determined by using specific peripheral devices the accuracy of which is 0.01 mm. For the pivot four dimensions are measured: a_1, a_2, a_3 and a_4 (Fig. 5. and Fig. 6.). Identical measurements are carried out after completion of the experiment. The chain pitch measuring schema is shown in Fig. 7.

The chain pitch is measured with vernier callipers, and the rollers and plates are measured with a micrometer. In order to ensure precision of the measurements, a special auxiliary device was used to fix the plates in place. The precision of the measurements for the chain pitch t is 0,1 mm. The precision of the measurements for the roller size a_i and the plate size b is 0.01 mm.

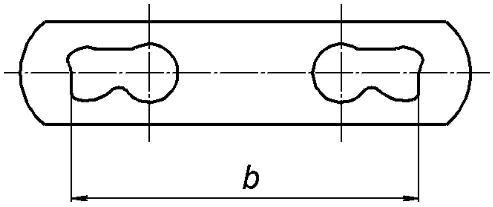

Fig. 3. **Plate of the rolling friction hinge chain:** b – gap between the straight effective surfaces of the plate

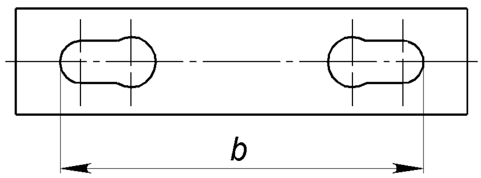

Fig. 4. **Plate of the sliding friction hinge chain:** b – gap between the straight effective surfaces of the plate

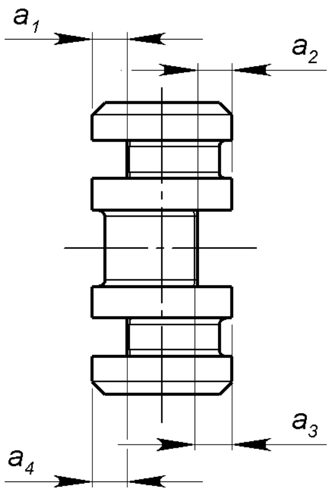

Fig. 5. **Roller of a rolling friction hinge:** a – measurements of the deterioration of the roller effective surfaces

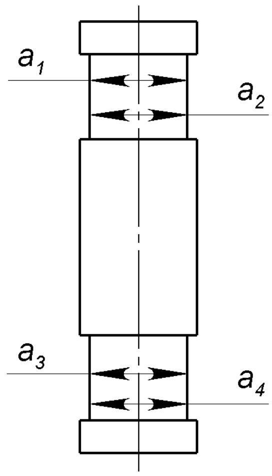

Fig. 6. **Roller of a sliding friction hinge:** a – measurements of the deterioration of the roller effective surfaces

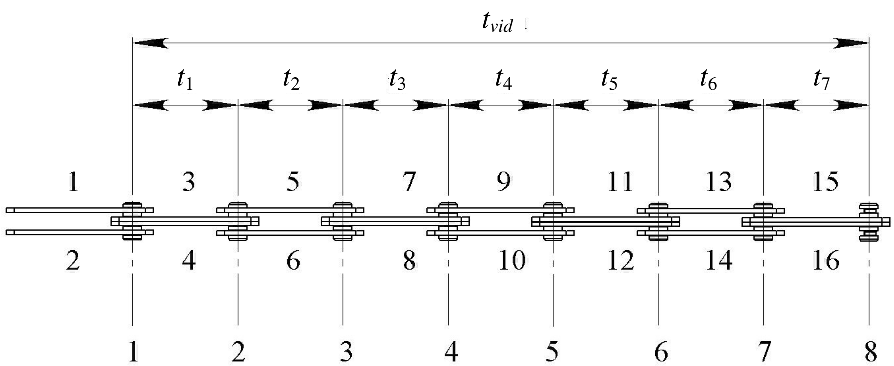

Fig. 7. **Layout of measuring the chain link pitch: applicable to the links 1 and 2 of both rolling friction hinges and sliding friction hinges**

Results and discussion

The results which are obtained with the experiments on the test bench No.1. are shown in Fig. 8, Fig. 9 and Fig. 10, they show the pitch changes, plate and roller wear of a sliding friction hinge chain and a rolling friction hinge chain operated under the same circumstances.

Figure 8 shows that after having experimentally tested the chain pitch t_{vid} changes, these were 4.4 times bigger in the sliding friction hinge chain than in the rolling friction hinge chain.

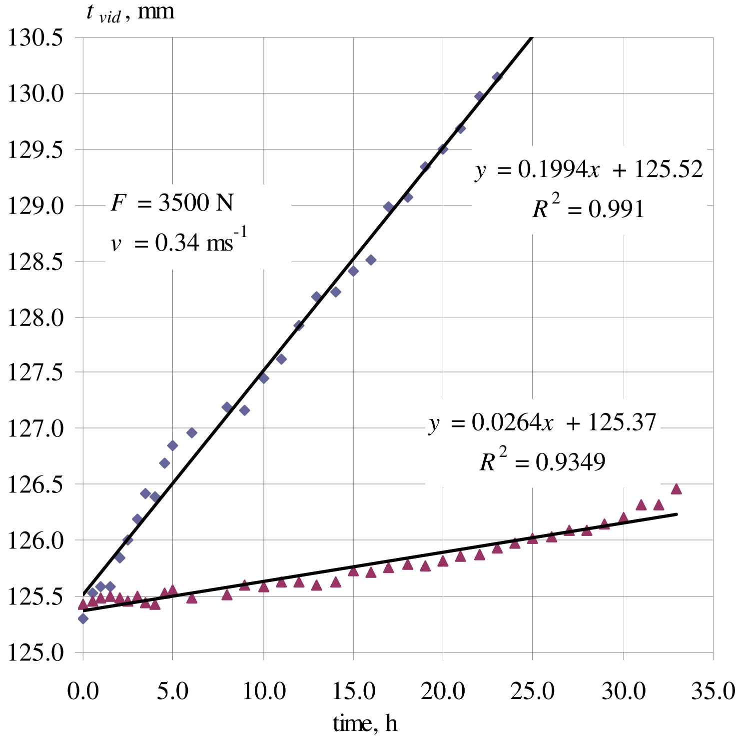

Fig. 8. **The average chain pitch angle t_{vid} (experiment bench No. 1):**
◆ – sliding friction hinge chain; ▲ – rolling friction hinge chain

Figure 9 shows that the deterioration of the rollers in the sliding friction hinge chain is 9.4 times bigger than that in the rolling friction hinge chain.

The deterioration of the chain plates is shown in Figure 10. As the diagram shows, the deterioration of the plates in the sliding friction hinge chain is 1.9 times bigger than that in the rolling friction hinge chain.

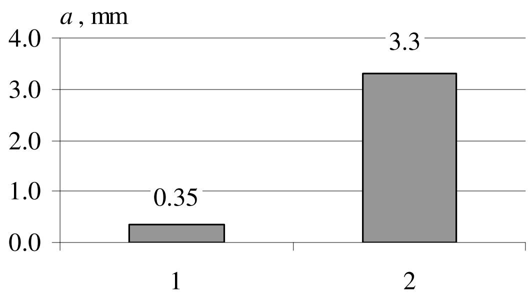

Fig. 9. **The deterioration of chain plates Δ*a* (experiment bench No. 1):**
1 – rolling friction hinge chain; 2 – sliding friction hinge chain

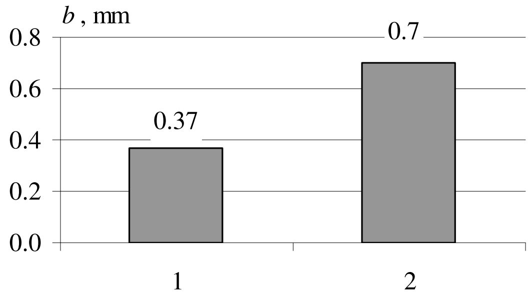

Fig. 10. **The deterioration of chain plates Δ*b* (experiment bench No. 1):**
1 – rolling friction hinge chain; 2 – sliding friction hinge chain

The results which are obtained with the experiments on the test bench No.2. are shown in Fig. 11, Fig. 12 and Fig. 13.

The forced research of the rolling friction hinges and sliding friction hinges showed the chain pitch extension of the sliding friction chain being 3.4 times bigger than that of the rolling friction hinge chain. The ratio of durability of the rollers and plates in the rolling friction hinge chain to that in the sliding friction chain was, respectively, 6.8 and 1.7.

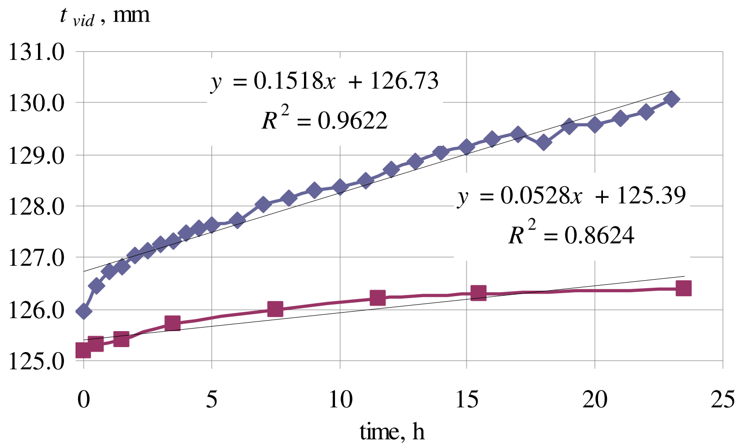

Fig. 11. **The average chain pitch angle t_{vid} (experiment bench No. 2):**
◆ – sliding friction hinge chain; ■ – rolling friction hinge chain

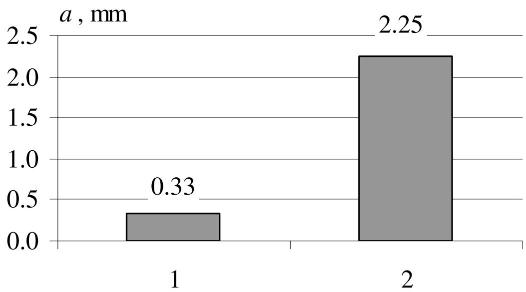

Fig. 12. **The deterioration of chain plates Δ*a* (experiment bench No. 2):**
1 – rolling friction hinge chain; 2 – sliding friction hinge chain

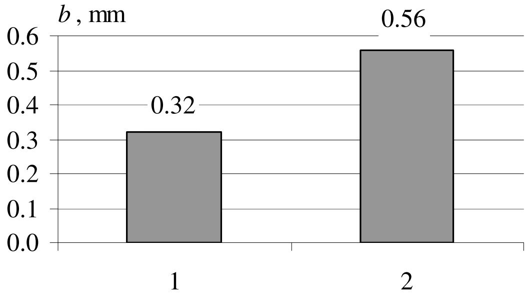

Fig. 13. **The deterioration of chain plates Δ*b* (experiment bench No. 2):**
1 – rolling friction hinge chain; 2 – sliding friction hinge chain

Conclusions

The comparative experimental research on the full chain loop bench and on the forced chain research bench has proven that the durability of a rolling friction hinge chain was about 3.4 – 4.4 times bigger than that of a sliding friction hinge chain. The hardness of the plates in the rolling friction hinge chain has been 42 HRC, the rollers were 30 HRC hard.

References

1. Васильев И. В. Исследование процесса изнашивания и заедания материалов при трении в шелочной среде. - В кн: Коррозия и износ конструкционных материалов химического машиностроения/ Информ. - изд. отд. М.: 1958, цб. 25.
2. Васильев И. В. Некоторые зависимости процесса изнашивания металлов при трении в шелочных средах. - В кн.: Коррозия и износ металлов. Тр. НИИХИММАШ, 1959, вып. 27.