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## NamMTI ILMIY-TEXNIKA JURNALI TAHRIR HAY'ATI A'ZOLARI

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## ROTATIONAL AUTO-OSCILLATIONS OF RIBBED CYLINDERS IN A PNEUMATIC PRESSURE SUPPLY SYSTEM

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**Abstract:** In modern textile production, improving yarn quality while increasing spinning machine speed remains challenging. The drafting system, particularly the fluted cylinders, largely determines yarn quality. Vibrations and self-excited oscillations of these cylinders increase product irregularity and reduce quality. The dynamics of delivery cylinder interactions involve time-dependent transitions, vibrations, and other complex behaviors, which are not well-studied due to their complexity and resource requirements. Yarn quality, process stability, productivity, and material efficiency also depend on the drafting components. Therefore, studying the rotational self-oscillations of fluted cylinders in pneumatic systems is crucial for enhancing spinning efficiency and maintaining stable yarn quality.

**Keywords:** Fiber; corrugated cylinder; yarn; yarn breakage; geometric errors; dynamic characteristics; torsional vibrations, spinning machine, drafting device, pneumatic pressure system.

**Introduction.** The occurrence of rotational self-oscillations of the cylinders of the drafting device negatively affects the quality of the yarn, in particular leading to an increase in product unevenness.

Self-oscillations of the cylinders of the drafting device arise during the operation of roving and spinning machines.

The occurrence of rotational self-oscillations of the cylinders is caused by several factors [1]:

- when the diameter of the drafting cylinders is not small and their width is large (10–36 meters);
- increase in friction between the cylinders and the supports due to untimely lubrication of the bearings in the supports of the drafting device;
- a large number of supports, which leads to misalignments and the occurrence of additional loads;
- low rotational speed, resulting in a more pronounced nonlinear nature of friction;
- the presence of pressure exerted by rollers on the cylinders;
- the presence of multi-stage gear transmissions for transmitting motion from the motor to the cylinders of the drafting device.

Many scientific studies have been conducted on investigating the rotational self-oscillations of fluted cylinders of the drafting device, as well as on improving the efficiency and quality of yarn production.

For the first time, the self-oscillations of delivery cylinders were studied by Ya.I. Koritysskiy [1]. He identified the negative impact of self-oscillations on the technological process. In this work, Ya.I. Koritysskiy showed that torsional relaxation self-oscillations of fluted cylinders may arise as a result of wear of the elements of the delivery cylinder. He also emphasized that the largest part of the total unevenness occurs due to fluctuations (pulsations) in the speed of the fluted delivery cylinders.

Prof. Ya.I. Koritysskiy was the first to conduct an in-depth theoretical study of torsional self-oscillations of delivery cylinders. In his monograph, methods for calculating the main parameters of vibration processes characteristic of yarn production machines are presented, and ways to eliminate other vibrations are also indicated.

Ya.I. Koritysskiy experimentally investigated quasi-harmonic self-oscillations on a special test stand. In particular, he established that by increasing the manufacturing accuracy of the cylinders of the support-type drafting device, the amplitude of self-oscillations decreases significantly.

The test results revealed the following:

- the main cause of self-oscillations is the presence of friction in the sliding support;
- the amplitude of self-oscillations depends on the flexibility and inertia of the system's masses, the manufacturing accuracy of the fluted cylinder, its rotational speed, the friction in the roller pair, lubrication, and the material coating;
- the geometric accuracy of the mold shape has a significant impact on self-oscillations.

In the studies [2], the researcher identified that one of the causes of torsional vibrations is errors in gear transmissions that have kinematic and cyclic characteristics, and methods to reduce or eliminate these vibrations were proposed.

As indicated in the studies [3], these factors can be the main reasons for the occurrence of forced torsional vibrations of the cylinders.

The positive effect of the damper installed at the end of the cylinder line and its investigation are presented in works [4,5].

A damper is a device used to reduce vibrations and shocks. Its positive effect is expressed in reducing vibrations, increasing system stability, and improving efficiency. Research has studied the effectiveness of the damper and its impact on the system.

The parameters of relaxation self-oscillations, particularly, strongly affect the rigidity of acceleration and deceleration of the cylinders. This phenomenon can significantly deteriorate the performance of fluted cylinders and increase yarn breakage.

Prof. M.I. Khudykh [6] noted that wear of the necks of fluted cylinders leads to their breakage, which results in the unfitness of the cylinders and increases yarn breakage and unevenness. Therefore, timely detection and prevention of this is considered important.

Since the supports of the fluted cylinders are open, they are easily contaminated by dust. This creates conditions for the rapid wear of all necks and supports. The fluted cylinders are not sufficiently long, have a small diameter, and lack adequate rigidity. As a result, they bend, which causes the necks to contact the supports in all directions and wear out quickly. This, in turn, increases the amplitude of self-oscillations of the delivery drafting cylinders.

The drafting cylinders consist of joints connected to each other and installed strictly parallel to the cylinder stands. These stands are spaced at a certain distance. The length of the joints depends on the distance between the spindles in the spinning machine.

At the same time, the dynamics of the connections between the delivery fluted cylinders have not been sufficiently studied.

The dynamics of the connections between the delivery fluted cylinders include the time variation during the transition of the system from one state to another, vibrations, and other dynamic characteristics. The insufficient study of these aspects may be explained by the complexity of the topic or the limited resources required for the research.

Although many studies exist beyond the analysis mentioned above, it cannot yet be considered that a unified scientific basis for the components of the drafting device has been established, especially regarding dynamic phenomena, which have become a limiting factor in the development of these designs.

In the modern K-46 model spinning machine of the "Rieter" (Switzerland) company, there are 1,824 spindles, with a spacing of 70 mm between them. The length of the drafting cylinders is 63.84 meters, and each consists of 114 joints, each 0.56 meters long [7].

Ensuring simultaneous rotation at the beginning and end of the cylinders is one of the most important conditions for obtaining high-quality spun products. Therefore, the joints must be carefully prepared and accurately connected.

One of the innovations of advanced ring spinning machines is the introduction of a semi-electronic system for driving the drafting device, which allows the number of yarn twists to be set directly from the control panel. In addition, all functions of the machine are controlled via a central panel. The computer memory of the machine can store all parameters of 18 articles, which can be selected using the MEMOset system.

It should be emphasized that in the 1,824-spindle machine, due to the introduction of the new system for driving the drafting device, the accuracy of cylinder speed has increased, ensuring the consistency of yarn quality. For this purpose, each drafting cylinder is driven in two or three separate segments.

The pressure system of the Ri-Q-Draft drafting device, in which the drafting rollers are pneumatically loaded via the Ri-Q-Bridge lever, is an important element that ensures the stable and uniform drafting of the fibrous sliver during the spinning process. Its main function is to create optimal compression force between the top roller and the bottom cylinder, which is necessary for drafting the product by effectively pulling the fibers without slipping or damage. For the middle and delivery cylinders in spinning machines, an additional transmission is installed between the machines. This reduces the twisting force acting on the delivery cylinder and maintains uniform product quality along the entire machine length. This machine is suitable for almost all types of materials, which makes it widely applicable. After the drafting device completes its operation, the drafting mechanism is activated evenly across all spinning positions, preventing delays caused by twists and breaks.

The pressure system of the Ri-Q-Draft drafting device, in which the drafting rollers are pneumatically loaded via the Ri-Q-Bridge lever, is a key element ensuring the stable and uniform drafting of the fibrous sliver. Its main function is to create optimal compression force between the top roller and the bottom cylinder, allowing fibers to be pulled efficiently without slipping or damage.

The top rollers of the drafting device are pressed onto the bottom cylinder by pneumatic cylinders, which create the required force through compressed air. The pressure in the system is regulated via a pneumatic main line and, in modern machines, is controlled either by a pressure-reducing (regulating) valve or electronically. When the machine starts, compressed air is supplied to the cylinders acting on the lever mechanism that presses the top rollers.

The pressing force must be carefully dosed: too little pressure causes fiber slippage and uneven drafting, while excessive pressure leads to roller deformation and overload of the mechanisms. In some designs, mechanical springs can be used instead of pneumatics, but the pneumatic system provides smoother and more precise adjustment.

The pneumomechanical system that applies pressure to the top rollers of the drafting device requires regular monitoring and precise adjustment depending on the material being processed. Proper adjustment ensures stable yarn quality, reduces equipment wear, and lowers energy consumption.

To achieve the correct adjustment parameters, it is necessary to refer to the technical documentation of a specific model of ring spinning machine, as the machine's design features may affect the recommended values of pressure and compression force.

Advances in science and technology have significantly increased the efficiency of machines and equipment across all sectors of production, especially in the textile and light industry. This is mainly due to the faster movement of spindles and working parts

in spinning machines. Therefore, equipment manufacturers must consider not only static loads but also dynamic loads acting on moving parts and mechanisms.

Although many studies exist beyond the analysis presented above, it cannot yet be considered that a unified scientific basis has been established for the components of the drafting device, especially regarding dynamic phenomena, which remain a limiting factor in the development of these designs.

**Methods.** Practical research was carried out in the yarn production department of the “Iftihor Kiyim Sanoat” LLC enterprise. The use of pneumatic pressure systems on the rollers of drafting pairs in spinning machines is gradually spreading. When pneumatic pressure systems are used, maintenance of the drafting devices is simplified, and most importantly, the constant pressure of the roller on the cylinder is ensured both over time and along the length of a series of cylinders [8].

In our study, the rotational self-oscillations of the fluted cylinders of the drafting device were practically investigated.

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The instrument designed to measure the rotational self-oscillations of the fluted cylinders in the drafting device measures vibration, that is, vibration velocity, acceleration, and displacement.



**Figure 1.** Instrument for measuring rotational self-oscillations

### Measurement of Vibration Parameters

During the research, the following main vibration parameters were evaluated:

- Variation of the vibrating acceleration: horizontal axis (X) — angular acceleration of the cylinder  $\omega$  (rad/s) or  $n$  (revolutions/min), measurement range 0–199.9  $m/s^2$ ;
- Velocity of the vibrating object: vertical axis (Y) — rotational (torsional) self-oscillation amplitude  $A\varphi$  or dynamic moment (RMS), measurement range 0–19.99  $cm/s$ ;

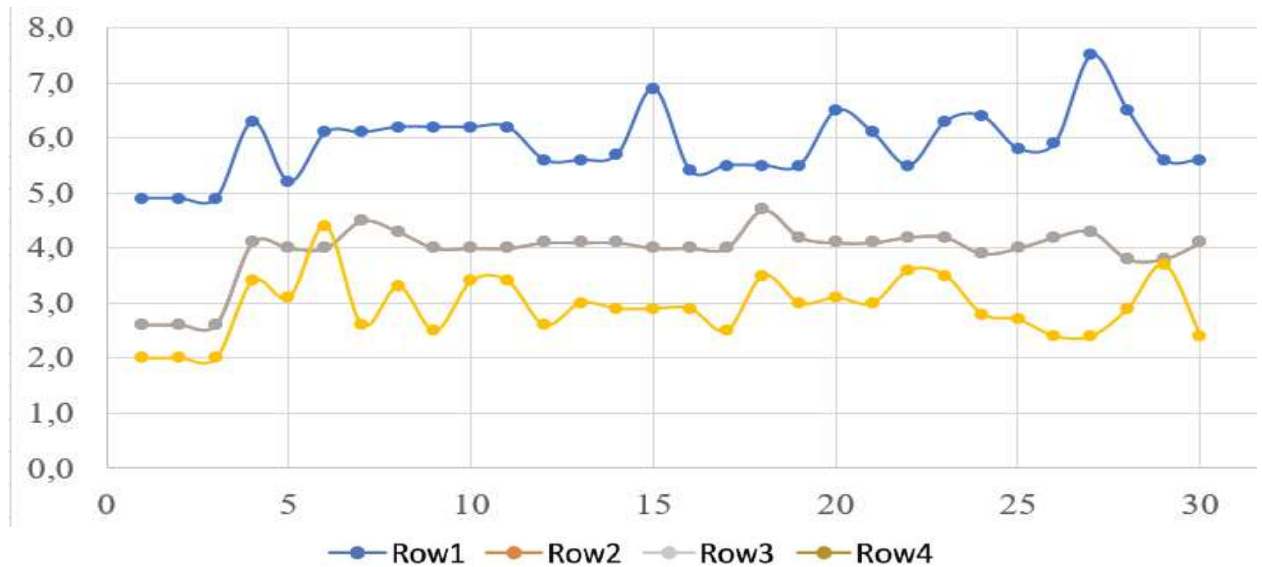
- Maximum displacement of the vibrating object (P-P): 1–1.999 mm.

$T_{\text{yarn}} = 30/1$  – linear density of the yarn ( $N_e = 20/1$  - in English count).

$V = 23.0$  m/min – speed of the front cylinder.

$n = 17500$  rpm – rotational speed of the spindle.

In addition, during the experiment, results were recorded for the following conditions:



**Figure 2.** Vibration acceleration along the X-axis

From the graph, it is clearly observed that vibration is not the same at different points of the shaft. The highest vibrations are observed in the middle of the shaft (blue line) – in some places, the values increase quite sharply. This condition usually indicates that the load is more concentrated in this part or that the balance at the center of the shaft is slightly disturbed. During operation, the stretching of the material may also have a greater effect on the middle, so the increase in vibrations here is natural; however, some peaks may also indicate a mechanical problem.

The beginning of the shaft (yellow line) shows relatively lower values, but there are still some fluctuations in certain places. This indicates that there may be minor faults in the transmission or bearings at the starting section. The end part (gray line), on the other hand, appears to be operating almost stably – the values do not fluctuate significantly, which suggests that this part is well-fixed or that the load is evenly distributed.

Overall, the system is operating, but the high vibrations in the middle of the shaft require attention. If not inspected in time, this may lead to wear, noise, or even авария situations in the future. Therefore, it would be useful to balance the middle section and inspect the mechanical elements.

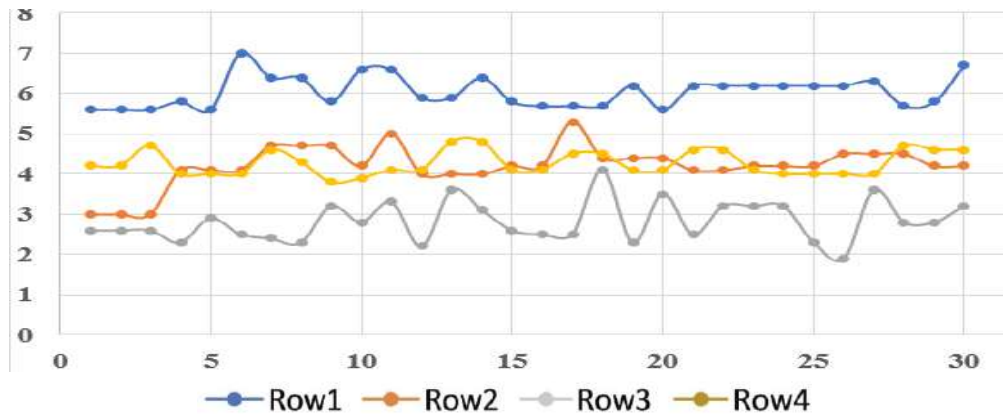


Figure 3. Vibration acceleration along the Y-axis

In this graph, vibration accelerations are shown along the Y-axis, and here as well, different behavior is observed at various points of the shaft. The highest values are again seen in the middle of the shaft (blue line), fluctuating approximately in the range of 5.5–7. This indicates that transverse (lateral) forces are stronger in the central part of the shaft. The presence of sharp increases at certain points suggests uneven loading in the system or the occurrence of minor resonance conditions.

The beginning of the shaft (yellow line) appears somewhat more stable this time, with values mainly in the range of 4–5. This means that although vibration is present in this part, it is not sharp, and the operation process is relatively smooth. The end part (gray line) shows the lowest values (in the range of 2–3.5), but even here there are some sudden drops and rises – this indicates that attention should be paid to the fastening or the condition of the bearings.

Overall, in the Y-direction as well, the main load and potential issues are concentrated in the middle of the shaft. This shows that the forces acting on the shaft are related not only to rotation but also to lateral deformations. From a practical point of view, inspecting this particular area, balancing it, and diagnosing the mechanical components will ensure reliable operation of the system.

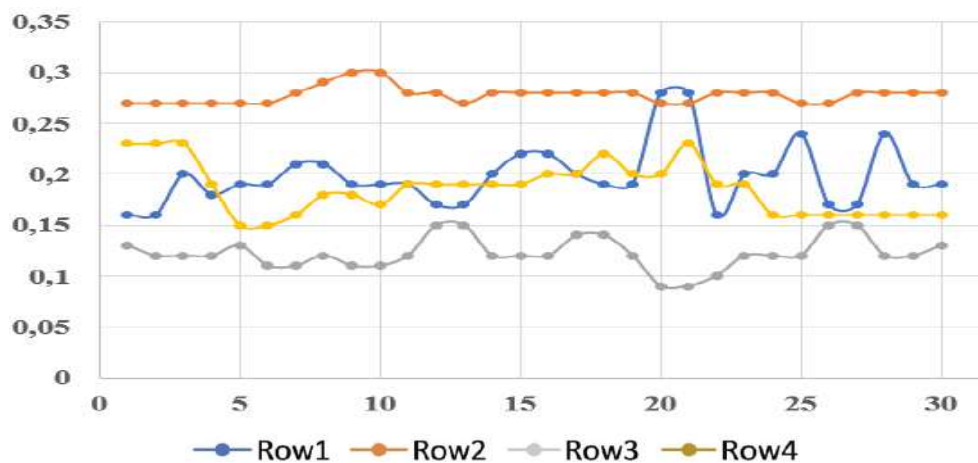


Figure 4. Vibration velocity along the X-axis

In this graph, the vibration velocity is shown along the X-axis, and it can be seen that the overall condition is much more stable compared to the previous acceleration graphs. The highest values are again observed in the middle of the shaft (blue line), but this time the vibrations are not sharp; instead, they change smoothly (approximately in the range of 0.16–0.28). This indicates that, although there is a dynamic load in the middle, the system has not yet reached a critical level and is operating relatively steadily.

The beginning of the shaft (yellow line) is at an average level, with slight increases in some areas, but the overall trend is smooth. This indicates that the operation in the initial transmission section is proceeding normally. The lowest and most stable values are observed at the end of the shaft (gray line) – in this section, the vibration velocity changes very little, showing that it is operating in a mechanically good condition.

Overall, based on the vibration velocity, the system can be assessed as “operating normally.” The sharp peaks observed in the accelerations are somewhat softened here, indicating that there is damping or energy dissipation in the system. Nevertheless, the slightly higher values remaining in the middle of the shaft suggest that monitoring should continue in the future.

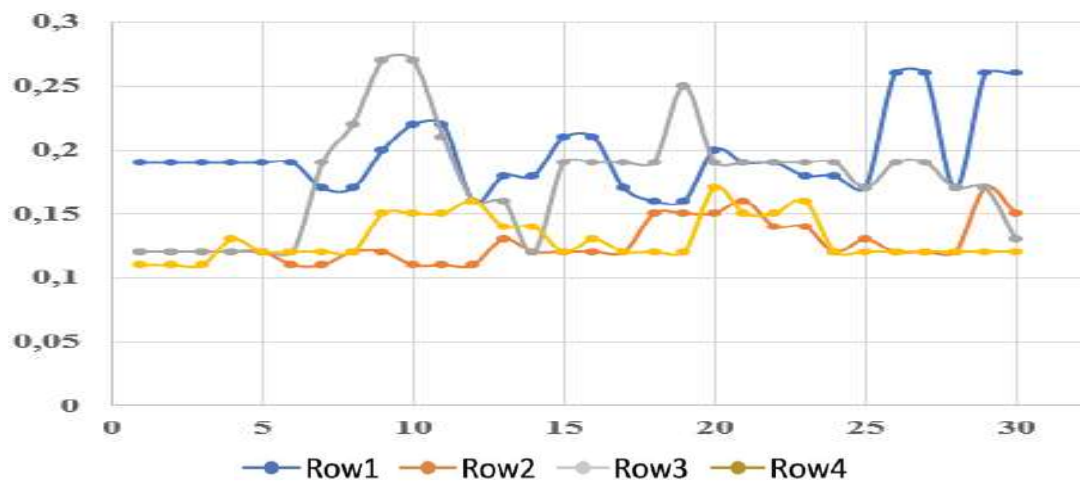


Figure 5. Vibration velocity along the Y-axis

In this graph, the vibration velocity along the Y-axis is shown, and observing the overall condition, the values are quite low and relatively stable. The highest values are recorded in the middle of the shaft (blue line), reaching up to 0.25–0.27 at certain points. This indicates that the main dynamic load is also concentrated in the central part in the lateral direction. At the same time, these changes are not abrupt but occur gradually, meaning that the system is currently operating stably.

The end of the shaft (gray line) shows sharper increases in some areas, for example around points 10 and 18, where considerably higher values are observed. This may indicate occasional looseness or temporary irregularities in the support elements. The beginning of the shaft (yellow line), on the other hand, has the lowest and almost flat

values — this section shows minimal vibration and that the operation is proceeding steadily.

Overall, the vibration velocity in the Y direction indicates that the system’s operating condition is not poor. However, the consistently higher values in the middle section and the presence of some peaks at the end suggest that these points should be given particular attention during future maintenance.

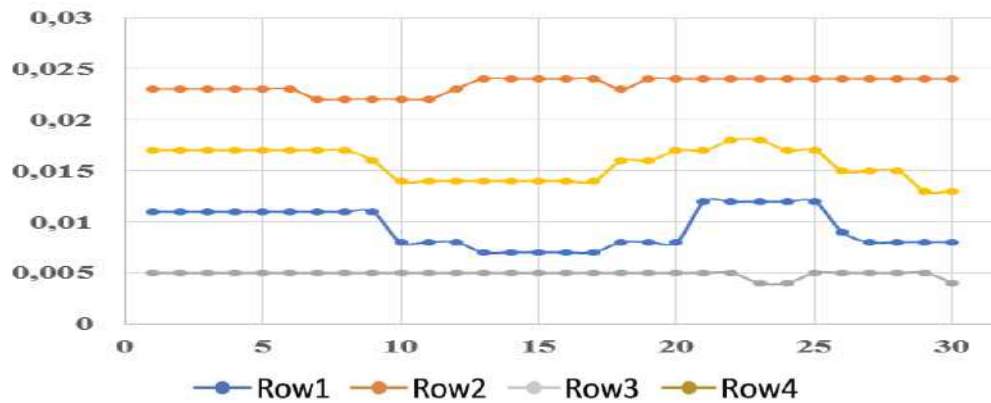


Figure 6. Vibration displacement along the X-axis

In this graph, vibration displacement along the X-axis is shown, and overall, the values appear to be within a very small range (approximately 0.005–0.025). The largest displacements are not in the middle of the shaft (blue line) this time, but they are also noticeable at other points, although some changes are still observed in the middle section. For example, between points 10–15, the displacement decreases and then slightly increases again — this indicates that the elastic deformation of the shaft is changing under the influence of the load.

The head of the shaft (yellow line) shows average values and changes relatively smoothly, meaning no sharp issues are noticeable in this section. The highest displacement values, however, correspond to another point (dark yellow line) — here, the displacement remains almost constant and at a higher level (around 0.022–0.024). This indicates the presence of a constantly acting force or a geometric feature in the structure.

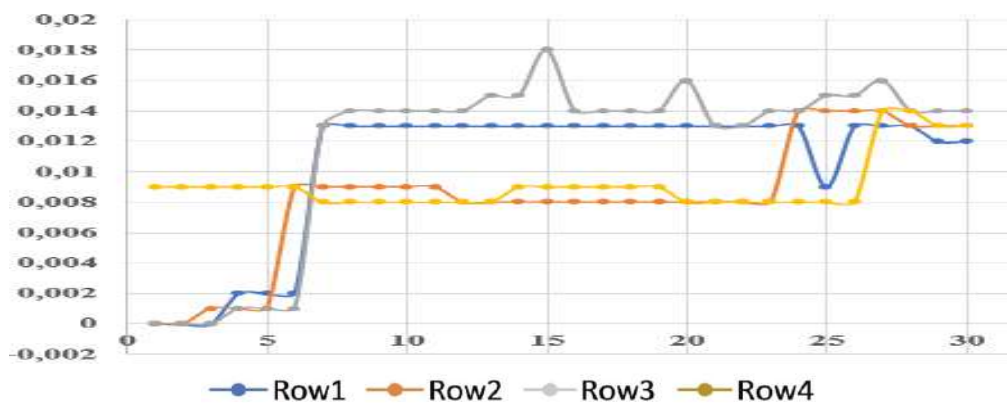


Figure 7. Vibration displacement along the Y-axis

The end of the shaft (gray line), on the other hand, has the lowest displacement values and changes very little, indicating that this section is well-fixed and undergoes almost no deformation. Overall, since the vibrational displacements are small, the system is operating in a mechanically satisfactory condition; however, it is beneficial to continue monitoring at the midsection and at certain points with higher values.

This graph shows the vibrational displacement along the Y-axis. At the initial points (in the range of 1–5), all the lines are close to zero, indicating that the shaft experiences almost no displacement during the initial start-up phase. Subsequently, a sharp increase is observed — particularly at the middle of the shaft (blue line) and the end (gray line), where the displacement suddenly rises and then stabilizes at a certain level. This behavior indicates that, after the load is applied during operation, the shaft begins to undergo elastic deformation.

The middle of the shaft (blue line) remains relatively stable around 0.013, but at certain points (for example, in the range of 23–25) short-term decreases are observed. This indicates the presence of temporary uneven loading or external influences. The end of the shaft (gray line), on the other hand, exhibits the highest displacements (up to 0.014–0.018), particularly the peaks in the middle, which implies that this section is more sensitive to vibrations.

The beginning of the shaft (yellow and dark yellow lines) remains at relatively low and stable values. In this section, the displacement is small, meaning it is structurally rigid or experiences lower loading. Overall, although the displacements in the Y direction are within a small range, there is a stable level forming during operation. The greatest attention should be paid to the end and partially the middle of the shaft, since it is in these areas that deformation and vibrations are most pronounced.

**Results.** The obtained data indicate the presence of dynamic vibrations during the rotation of the fluted cylinders and their direct impact on the stability of the technological process. In particular, it was observed that changes in acceleration, velocity, and displacement parameters in the interaction between cylinders and rollers are associated with defects in the yarn formation process.

Rotational self-oscillations manifest depending on the structural accuracy of the cylinders, the quality of their connections, the stability of the pressure system, and the rotational speed. If the kinematic alignment between cylinders is disturbed or the pressure force is not distributed evenly enough, this leads to an increase in vibration amplitude.

Maintaining normative and stable pressure in the pneumatic system allows the fibers in the drafting zone to be held uniformly. This, in turn, improves the contact condition between cylinders and rollers, reduces slippage, and enhances product quality. From this perspective, monitoring self-oscillations serves not only as a means of assessing mechanical condition but also as a tool for optimizing the technological process.

By performing a comprehensive analysis of parameters such as vibration acceleration, vibration velocity, and vibrational displacement, an objective assessment of the operating mode of the fluted cylinders can be made. In particular, comparing the

measurements along the X and Y axes helps to determine the direction in which dynamic loads are stronger.

### Discussion.

Based on the practical research conducted, it was determined that rotational self-oscillations of the fluted cylinders in the pneumatic pressure system have a significant impact on the quality of the spinning process. Vibrations occurring in the fluted cylinders can lead to increased yarn unevenness, decreased stability of the technological process, and deterioration of the interaction between the working elements.

The results of the study indicate that by regularly monitoring vibration parameters—specifically acceleration, velocity, and displacement—it is possible to assess the technical condition of the drafting device. This is crucial for early detection of malfunctions, improving the motion accuracy of the cylinders, and ensuring stable yarn quality.

At the same time, maintaining optimal pressure in the pneumatic system, ensuring high-quality contact surfaces between rollers and cylinders, and the accuracy of structural connections were identified as the main factors in reducing self-oscillations.

In the future, it is advisable to mathematically model the dynamics of the fluted cylinders, develop a real-time vibration monitoring system, and conduct a more in-depth study of the patterns of self-oscillations under various technological modes.

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