ISNN 3030-3907

2026/4
VOLUME 8

DEVELOPMENT OF SCIENCE

ILMIY JURNAL



Development of science

Ilmiy jurnal

2026/4 VOLUME 8

ISSN 3030 -3907

Ilmiy jurnal OAK rayosatining 2024 yil 27 sentabrdagi 361-son qaroriga asosan 02.00.00 kimyo fanlari hamda 2025 yil 12 fevral 367- son qaroriga asosan 05.00.00 texnika fanlari bo‘yicha falsafa doktori (PhD) va fan doktori (DSc) ilmiy darajasiga talabgorlarning dissertatsiya ishlari yuzasidan dissertatsiyalari asosiy ilmiy natijalarini chop etish tavsiya etilgan milliy ilmiy nashrlar ro‘yxatiga kiritilgan.

BOSH MUHARRIR:
Temirov Alisher Hoshim o‘g‘li – texnika fanlari falsafa doktori (PhD),Dotsent.
TAHRIRIYAT KENGASH RAISI:
Fozilov Sadriddin Fayzullayevich – texnika fanlari doktori, professor
TAHRIRIYAT KENGASH A’ZOLARI

TEXNIKA FANLARI/ TECHNICAL SCIENCES/ ТЕХНИЧЕСКИЕ НАУКИ

Bozorov G‘ayrat Rashidovich
Buxoro Davlat Texnika Universiteti, professor
Abdurahmonov Olim Rustamovich
Buxoro Davlat Texnika Universiteti, professor
Adizov Bobur Zamirovich
O‘zbekiston Respublikasi Fanlar akademiyasi Umumiy va noorganik kimyo instituti, professor
Hayitov Ruslan Rustamjonovich
Buxoro Davlat Texnika Universiteti, professor
Jumayev Qayum Karimovich
Buxoro Davlat Texnika Universiteti, professor.
Berdiyev Dorob Murodovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor
Maxmudov Rafiq Amonovich
Buxoro Davlat Texnika Universiteti, professor.
Tilloyev Lochin Ismatilloyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Raxmonov Qahramon Sanakulovich
Buxoro Davlat Texnika Universiteti, dotsent.
Barakayev Nusratullo Rajabovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor.
Jo‘rayev Xayrullo Fayziyevich
Buxoro Davlat Texnika Universiteti, professor.
Panoyev Erali Rajabboyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Ataullayev Sherzod Nabiullyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Malik Negmurodovich
Buxoro Davlat Texnika Universiteti, dotsent.
Axmedova Ozoda Bahronovna
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti.
Safarov Bahri Jumayevich
Buxoro Davlat Texnika Universiteti, dotsent.
Xaydarov Axtam Amonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Safarov Jasur Alijon o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.
Асадова Раъно Дилмуратовна
Тошкент Давлат техника университети доценти

KIMYO FANLARI/ CHEMICAL SCIENCES/ ХИМИЧЕСКИЕ НАУКИ

Axmedov Voxid Nizomovich
Buxoro Davlat Texnika Universiteti, professor
Umarov Baqo Bafoyevich
Buxoro Davlat Universiteti, professor
Kodirov Abduaxad Abduraximovich
Qarshi davlat Universiteti, professor
Qurbonov Mingniqul Jumagulovich
Qarshi davlat Universiteti, dotsent
Turemuratov Sharibay Naurizbaevich
O‘zbekiston Respublikasi Fanlar akademiyasi Qoraqalpog‘iston bo‘limi Bosh ilmiy kotibi, professor
Tursunov Kaxor Shonazarovich
Qarshi davlat Universiteti, professor
Do‘stov Hamro
Buxoro Davlat Texnika Universiteti, professor
Panoyev Nodir Shavkatovich
Buxoro Davlat Texnika Universiteti, dotsent.
Olimov Bobur Bahodir o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.
Kasimov Sherzod Abduazimovich
Termiz Davlat Universiteti, professor.
Aliqulov Rustam Valiyevich
Termiz Davlat Universiteti, professor
Tropov Xamza Tursunovich
Samarqand Davlat Universiteti, professor

IQTISODIYOT FANLARI/ ECONOMICS/ ЭКОНОМИЧЕСКИЕ НАУКИ

Nizamov Aslitdin Badreddinovich
Buxoro Davlat Texnika Universiteti, professor.
Boboyev Akmal Choriyevich
Buxoro Davlat Texnika Universiteti, professor.
Ergashxojayeva Shaxnoza Djasurovna
Toshkent davlat iqtisodiyot universiteti, professor
Saidaxmedova Nodira Ilxomovna
Toshkent davlat iqtisodiyot universiteti, professor
Muxsinov Bekzod Toxirovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shakarov Qulmat Ashirovich
Renessans ta'lim universiteti,dotsent.
Jumaeva Zulfiya Qayumovna
Buxoro Davlat Texnika Universiteti, dotsent.
Norova Salomat Yusupovna
Buxoro Davlat Texnika Universiteti, dotsent.
Avezova Shaxnoza Maxmudjonovna
Buxoro Davlat Texnika Universiteti, dotsent.
Jalilov Jamshid G‘anijonovich
Toshkent davlat iqtisodiyot universiteti, dotsent
Xasanova Gulruh Djumanazarovna
Buxoro Davlat Texnika Universiteti, dotsent.

PEDAGOGIKA FANLARI/ PEDAGOGICAL SCIENCES / ПЕДАГОГИЧЕСКИЕ НАУКИ

Siddiqova Sadoqat G‘afforovna
Buxoro Davlat Texnika Universiteti, dotsent.
Zoyirov Erkin Xalilovich
Buxoro Davlat Texnika Universiteti, DSc, professor
Gaffarov Feruz Hasanovich
Puchon Universiteti, *professor*
Ruziyev Davron Yuldashevich
Buxoro Davlat Universiteti, professor
Muradova Firuza Rashidovna
Buxoro Davlat Texnika Universiteti, professor.
Yunusova Gulandon Samiyevna
Buxoro Davlat Texnika Universiteti, professor.
To‘xtayeva Zebo Sharifovna
Buxoro Davlat Texnika Universiteti, professor.
Navro‘zova Gulchixra Nigmatovna
Buxoro Davlat Texnika Universiteti, dotsent.
Uzoqova Laylo Polvonovna
Buxoro muhandislik – texnologiya instituti, dotsent.
To‘raqulova Marjona Qiyom qizi
Buxoro Davlat Texnika Universiteti, dotsent.
Muradova Zarina Rashidovna
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Sanjar Aslonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shodiyev Jahongir Jo‘raqulovich
Buxoro Davlat Texnika Universiteti, dotsent
Gaffarov Laziz Hasanovich
Buxoro muhandislik – texnologiya instituti, dotsent.

Tahririyat a’zolarning to‘liq ro‘yxati jurnalning www.devos.uz saytida keltirilgan.

Tahririyat hay’ati a’zolarining tarkibini o‘zgartirish hamda qo‘shimcha kiritish yoki tahririyat a’zoligidan chiqarish bosh muharrir tomonidan amalga oshiriladi.

ISSN 3030-3907

Development of science ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro‘yxatidan o‘tgan.

To‘plam elektron ko‘rinishda (pdf formatida) mualliflarga taqdim etiladi. To‘plamga kiritiladigan maqolalarning mazmuni, ulardagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligiga hamda har qanday fikr - mulohazalarga mualliflarning o‘zlari mas’ul hisoblanadilar. Talablarga javob bermaydigan maqolalar to‘plamga kiritilmaydi. Tashkiliy qo‘mita maqola matnini qisqartirish, qisman tuzatish kiritish, seksiyalarga joylashtirish huquqiga ega.

ISSN 3030-3907

MODERNIZATION OF EXCAVATOR SWING MECHANISMS: COMPARATIVE ANALYSIS OF THE OPERATING CHARACTERISTICS OF BALL AND ROLLER BEARINGS AND DEVELOPMENT OF AN OPTIMAL DESIGN

G‘aybulloyev Nusrat Sunatullo o‘g‘li
Design Engineer of the Design Department of JSC “NMMC” Navoi Machine-Building Plant.
Oripov Dostonjon Rustamjon o‘g‘li
Navoi State University of Mining and Technologies, Master’s student
Artikov Narmurad Nortajiyevich
Chief Designer of the Design Department of JSC “NMMC” Navoi Machine-Building Plant.
Shukurov Odil Erkinovich
Leading Engineer of the Machine-Tool Design Bureau of the Machine-Tool Manufacturing Workshop of JSC “NMMC” Navoi Machine-Building Plant.

Abstract. This article considers the modernization of excavator swing mechanisms based on a comparative analysis of the operating characteristics of ball and roller slewing bearings. The study examined the assembly drawing of the swing mechanism, the structural parameters of the base, cover, and internally toothed ring gear, catalogue data for roller slewing bearings, the GOST 3722–2014 standard for balls, and the results of spectral analysis of the ring gear material. The analysis showed that the considered swing mechanism is a large-sized unit operating under high-load conditions. The large number of mounting holes in the base and cover parts, the parameters of the internally toothed ring gear, namely **m = 14** and **z = 149**, as well as the manufacture of the ring gear from **40Kh steel**, confirmed that the structure is designed for severe operating conditions. The comparative assessment demonstrated that a significant difference in operating efficiency is caused by the method of load transmission: in ball bearings, the load is transmitted through point contact, whereas in roller bearings it is transmitted through line contact. Roller slewing bearings showed advantages due to their ability to distribute the load more uniformly and to effectively withstand axial, radial, and overturning moment loads. Based on the obtained results, it was substantiated that the use of a three-row cylindrical roller slewing bearing is the most appropriate optimal design solution for the modernization of excavator swing mechanisms. These results are of practical importance for improving the swing mechanisms of heavily loaded machines and increasing their reliability.

ISSN 3030-3907

Keywords. excavator, swing mechanism, modernization, slewing bearing, ball bearing support, roller bearing support, internal ring gear, structural analysis, 40Kh steel, load distribution.

Аннотация. В данной статье рассматривается вопрос модернизации механизмов поворота экскаваторов на основе сравнительного анализа эксплуатационных характеристик шариковых и роликовых опорно-поворотных подшипников. В ходе исследования были изучены сборочный чертеж механизма поворота, конструктивные параметры основания, крышки и внутреннего зубчатого венца, каталожные данные роликовых опорно-поворотных подшипников, стандарт ГОСТ 3722–2014 для шариков, а также результаты спектрального анализа материала зубчатого венца. Проведенный анализ показал, что рассматриваемый механизм поворота представляет собой крупногабаритный узел, работающий в условиях высоких нагрузок. Большое количество крепежных отверстий в деталях основания и крышки, параметры внутреннего зубчатого венца, а именно **m = 14** и **z = 149**, а также изготовление зубчатого венца из стали **40X** подтвердили, что конструкция предназначена для тяжелых условий эксплуатации. Сравнительная оценка показала, что существенное различие в эффективности работы обусловлено способом передачи нагрузки: в шариковых подшипниках нагрузка передается через точечный контакт, тогда как в роликовых подшипниках — через линейный контакт. Роликовые опорно-поворотные подшипники показали преимущества за счет способности более равномерно распределять нагрузку и эффективно воспринимать осевые, радиальные нагрузки, а также опрокидывающий момент. На основе полученных результатов обосновано, что применение трехрядного цилиндрического роликового опорно-поворотного подшипника является наиболее целесообразным оптимальным конструктивным решением для модернизации механизмов поворота экскаваторов. Полученные результаты имеют практическое значение для совершенствования механизмов поворота тяжелонагруженных машин и повышения их надежности.

Ключевые слова: экскаватор, механизм поворота, модернизация, опорно-поворотный подшипник, шариковая опора, роликовая опора, внутренний зубчатый венец, конструктивный анализ, сталь 40Х, распределение нагрузки.

Annotatsiya. Ushbu maqolada ekskavatorlarning aylanish mexanizmlarini modernizatsiya qilish masalasi sharikli va rolikli tayanch-burilish podshipniklarining ishlash xususiyatlarini taqqosiy tahlil qilish asosida ko‘rib chiqilgan. Tadqiqotda aylanish mexanizmining yig‘ma chizmasi, asos, qopqoq va ichki tishli venets detallarining konstruktiv parametrlari, rolikli tayanch-burilish

ISSN 3030-3907

podshipniklari katalog ma’lumotlari, shariklar uchun GOST 3722–2014 standarti hamda tishli halqa materiali bo‘yicha spektral tahlil natijalari o‘rganildi. Tahlil natijasida ko‘rib chiqilgan aylanish mexanizmi yirik gabaritli va yuqori yuklama ostida ishlovchi uzel ekani aniqlandi. Asos va qopqoq detallaridagi ko‘p sonli biriktirish teshiklari, ichki tishli venetsning **m = 14** va **z = 149** parametrlari, shuningdek tishli halqaning **40X po‘latdan** tayyorlangani konstruktsiyaning og‘ir ish sharoitiga mo‘ljallanganini tasdiqladi. Taqqosiy baholash natijasida sharikli podshipniklarda yuklama nuqtaviy kontakt orqali, rolikli podshipniklarda esa chiziqli kontakt orqali uzatilishi ularning ishlash samaradorligida muhim farq hosil qilishi ko‘rsatildi. Rolikli tayanch-burilish podshipniklari yuklamani yanada barqaror taqsimlashi, o‘qiy, radial va ag‘daruvchi moment yuklamalarini samarali qabul qilishi bilan ustunlik ko‘rsatdi. Olingan natijalar asosida ekskavator aylanish mexanizmlarini modernizatsiya qilishda optimal konstruktiv yechim sifatida uch qatorli silindrik rolikli tayanch-burilish podshipnigidan foydalanish maqsadga muvofiq ekani asoslandi. Mazkur natijalar og‘ir yuklangan mashinalarning aylanish mexanizmlarini takomillashtirish va ularning ishonchliligini oshirishda amaliy ahamiyatga ega.

Kalit so‘zlar: ekskavator, aylanish mexanizmi, modernizatsiya, tayanch-burilish podshipnigi, sharikli tayanch, rolikli tayanch, ichki tishli venets, konstruktiv tahlil, 40X po‘lat, yuklama taqsimoti.

INTRODUCTION.

Currently, the productivity, reliability, and long service life of excavators used in mining and construction machinery largely depend on the perfection of their main mechanical units. One of such critical units is the excavator swing mechanism. The swing mechanism ensures the rotation of the excavator upper platform in the required direction and withstands large axial, radial, and overturning loads generated during operation. Therefore, the components included in this mechanism, such as the slewing bearing, ring gear, base, and cover, must be structurally well designed. Any failure occurring in the swing mechanism negatively affects the operation of the entire machine and, in some cases, may cause the technological process to stop. For this reason, the modernization of excavator swing mechanisms is considered relevant from both practical and scientific points of view.

Slewing bearings used in excavator swing mechanisms are manufactured according to various structural schemes. In practice, ball and roller slewing bearings are the most common variants. Ball bearings are distinguished by their relatively simple design, ease of manufacture, and low friction. However, in large-diameter and highly loaded mechanisms, their capabilities may be limited. This is

ISSN 3030-3907

because point contact mainly occurs between the ball and the raceway, which leads to an increase in contact stresses under high loads. In roller bearings, the load is transmitted through line contact, resulting in distribution of the load over a wider zone. In particular, three-row cylindrical roller slewing bearings are characterized by their ability to withstand large axial forces, radial loads, and overturning moments simultaneously. Therefore, the transition from a ball bearing design to a roller bearing design in heavily loaded excavator mechanisms is of particular scientific interest.

The assembly drawing of the considered swing mechanism clearly shows the relative arrangement of the main components, mounting holes, supporting surfaces, and the general structural scheme operating together with the internally toothed ring gear. The base component included in the assembly drawing contains large-diameter annular supporting surfaces, numerous mounting holes, and mating installation dimensions. The cover component, together with the base, forms the internal support zone and ensures that the bearing elements remain in their operating position. The internally toothed ring gear contains one of the main parameters of the transmission, namely the module and the number of teeth, which makes it possible to evaluate the torque transmission characteristics of the mechanism. The geometrical dimensions shown in the drawings indicate that the swing mechanism is not a simple small unit, but a large-sized structure operating under heavy loads. Therefore, if the type of supporting element is selected incorrectly in such a unit, wear may accelerate, rotational accuracy may decrease, and service life may be reduced.

Another important factor determining the reliability of the swing mechanism is the selection of material. The results of spectral analysis carried out for the ring gear show that the material of the component is **40Kh steel** and that its chemical composition complies with regulatory requirements. The analysis determined that the carbon content is **0.40%**, silicon **0.29%**, manganese **0.76%**, chromium **0.92%**, phosphorus **0.017%**, and sulfur **0.015%**. These indicators are important for the mechanical strength of the material, its heat-treatment capability, and its wear resistance during service.

In swing mechanisms, the toothed ring and support raceways operate under high contact pressure. Therefore, improving the design requires not only changing the geometric form, but also considering the suitability of the selected material for the operating conditions. The fact that the material composition is within the standard range indicates that the modernized unit is being considered not only theoretically, but also under practical production conditions.

ISSN 3030-3907

Standard requirements play an important role in the evaluation of ball bearing supports. The **GOST 3722–2014** standard for steel balls clearly specifies the nominal diameter of balls, accuracy grades, sphericity, diameter deviations, surface roughness, and hardness requirements. According to the standard, balls are used in bearings or as separate components, and their quality indicators are controlled with high precision. Accuracy grades are defined from **G3 to G200**, which directly affects the operating quality and service life of the balls. In addition, the hardness of balls is also standardized depending on their diameter.

Thus, ball bearings are manufactured on the basis of highly precise and standardized elements. However, in the excavator swing mechanism, the problem is not only the accuracy of the ball, but also how it behaves under heavy loads. In other words, even if the balls are manufactured with high quality according to the standard, they are not always the optimal structural option for a large-diameter, heavily loaded swing unit.

The data on roller slewing bearings indicate that a more suitable solution exists for heavily loaded swing mechanisms. The catalogue of three-row cylindrical roller slewing bearings provides the main geometrical and mounting parameters for variants with internal gearing, external gearing, and without gearing. These data include the outside diameter, inside diameter, overall height, number of mounting holes, hole diameter, mounting threads, and other structural dimensions for large-diameter bearings.

In this type of support, the load is distributed between separate rows: one row mainly carries the axial load, another row carries the radial load, and the third row withstands the effect of the overturning moment. Such load distribution is very important for machines operating under severe working conditions, such as excavators. When a roller-type scheme is selected for a large-diameter swing unit, the contact area increases, load distribution improves, and deformations decrease. As a result, the reliability and service life of the mechanism increase. From this point of view, comparing roller bearings with ball bearing variants becomes a scientifically and practically justified task.

In the considered structure, the fact that the internally toothed ring gear has a tooth module of **m = 14** and a number of teeth of **z = 149** indicates that it is intended for transmitting high loads. The presence of numerous mounting holes in the base and cover components also serves to ensure mounting rigidity and uniform load distribution throughout the housing. Large-diameter supporting surfaces, heat-treatment indicators, and requirements for machining accuracy confirm that this swing mechanism is a highly responsible unit.

ISSN 3030-3907

Therefore, the development of an optimal design in this case is not limited to changing the shape of a single component. On the contrary, the support scheme of the entire swing unit, material selection, ring gear parameters, arrangement of mounting holes, and load-carrying capacity must be evaluated together. Only through such an approach can it be scientifically demonstrated which type of support will be more effective as a result of modernization.

The main idea of this study is to compare the operating characteristics of ball and roller slewing bearings in excavator swing mechanisms and to determine the optimal variant based on specific structural dimensions and material properties. In this case, the problem is not limited to a general theoretical description but is considered on the basis of the geometrical parameters of a real structure. Such an approach has practical importance because modernization of the excavator swing mechanism must be justified not only by calculation-based advantages, but also by manufacturing and assembly possibilities.

If the proposed solution improves load distribution, reduces wear, and ensures stable operation of the mechanism, such modernization will be technically and economically feasible. Based on this, the present article analyzes the updated design of the excavator swing mechanism, compares the operating principles and structural advantages of ball and roller supporting elements, and substantiates the optimal structural solution based on the ring gear material and the parameters of the main components. The research results serve to formulate scientific and practical recommendations that can be used to improve heavily loaded excavator swing mechanisms.

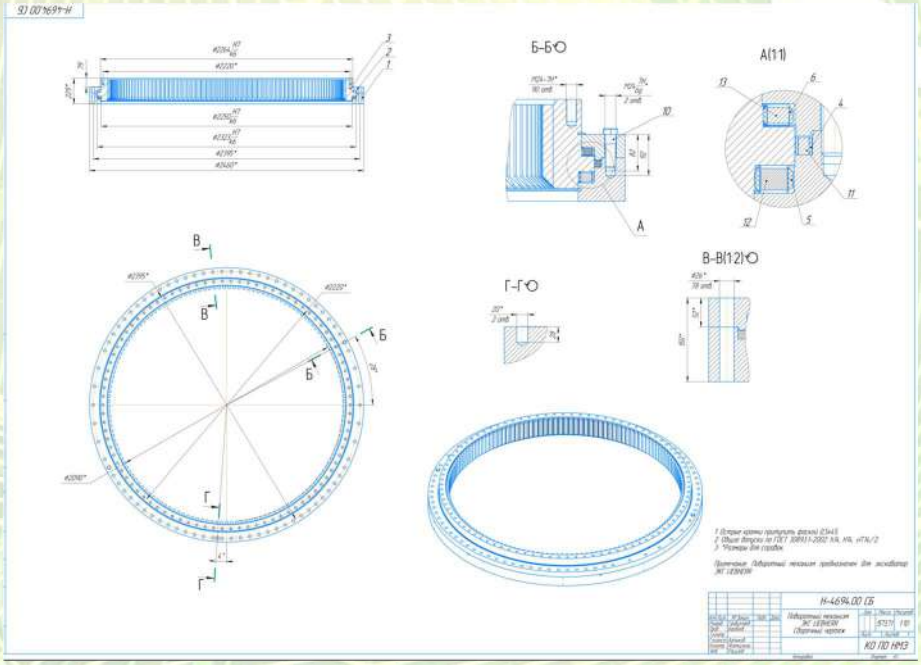


Figure 1. General assembly drawing of the excavator swing mechanism.

MATERIALS AND METHODS.

ISSN 3030-3907

In this study, the modernization of the excavator swing mechanism was investigated on the basis of a comparison of the operating characteristics of ball and roller slewing bearings. The main materials of the study included the assembly drawing of the swing mechanism, working drawings of the base, cover, and internally toothed ring gear, a catalogue of three-row cylindrical roller slewing bearings, the GOST 3722–2014 standard for balls, and the spectral analysis report of the ring gear material.

The research object was the excavator swing mechanism. The research subject was the structural and operational characteristics of ball and roller slewing bearings that can be used in this mechanism. During the study, first, the general structural scheme of the swing mechanism was analyzed; then, the geometrical dimensions, mating surfaces, mounting holes, and materials of its main components were examined. In this process, it was taken into account that the structure is a large-sized unit operating under high-load conditions.

In the structural analysis, it was considered that the outer diameter of the base component reaches **2460 mm**, that it contains **76 holes with a diameter of Ø26 mm**, and that **35KhML steel** is used as the material. The cover component contains **78 holes with a diameter of Ø26 mm** and was evaluated as an element that forms the support zone together with the base. For the internally toothed ring gear, the module was determined as **m = 14**, and the number of teeth as **z = 149**. These parameters were accepted as the main indicators for evaluating the torque transmission capacity of the swing mechanism.

In the materials science analysis, the chemical composition of the ring gear was studied on the basis of the laboratory report. According to the results of spectral analysis, the sample material corresponds to **40Kh steel**, containing **0.40% carbon**, **0.29% silicon**, **0.76% manganese**, and **0.92% chromium**. These results were used to demonstrate that the material complies with the standard composition and was selected in accordance with the operating conditions.

In evaluating roller supports, data from the catalogue of three-row cylindrical roller slewing bearings were used. The catalogue provides geometrical and mounting parameters for non-geared, externally geared, and internally geared variants. In the study, standard sizes close to the overall dimensions of the investigated structure were selected, and their diameters, height, number of holes, and mounting dimensions were compared. On this basis, the compatibility of the roller bearing scheme with the existing structure was assessed.

The analysis of ball supports was based on the **GOST 3722–2014** standard. This standard provides the nominal diameter, accuracy grades, sphericity, surface quality, and hardness indicators of steel balls. In the study, these data were used to

ISSN 3030-3907

evaluate the advantages and limitations of ball supports. In particular, the presence of **point contact** in ball bearings and **line contact** in roller bearings was accepted as the main comparison criterion.

In the structural analysis, it was considered that the outer diameter of the base component reaches **2460 mm**, that it contains **76 holes with a diameter of Ø26 mm**, and that **35KhML steel** is used as the material.

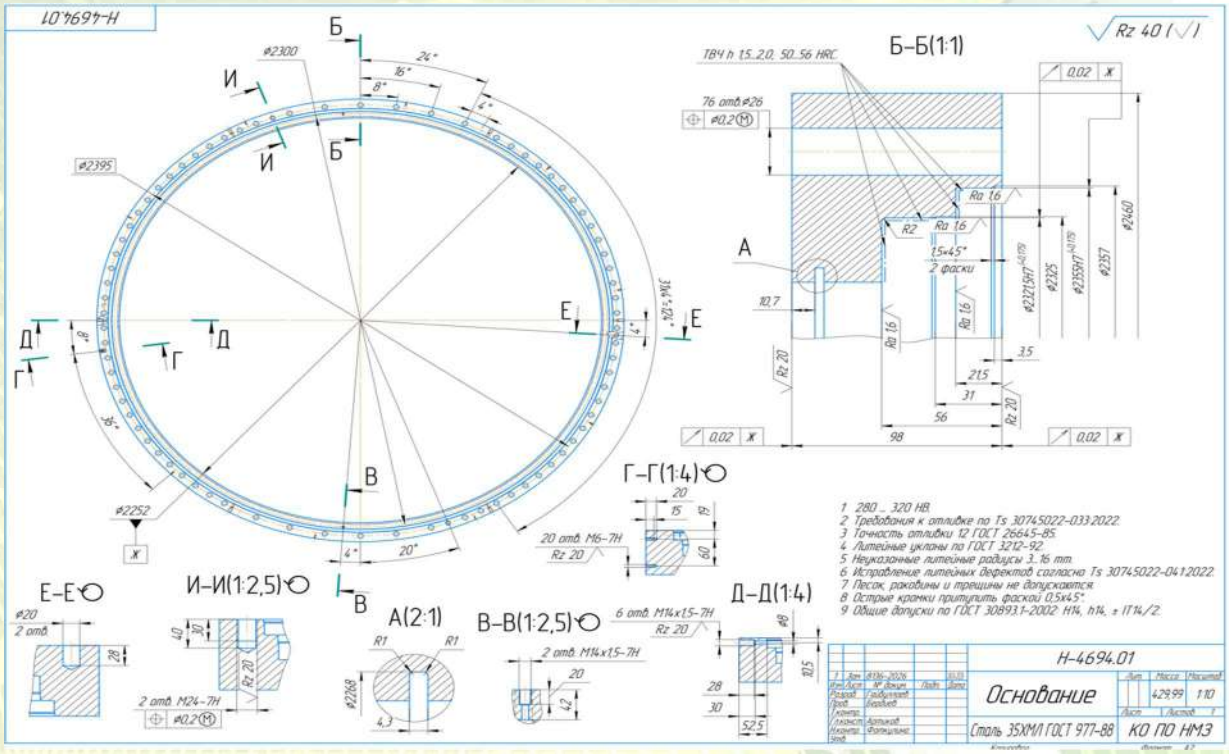


Figure 2. Structural drawing of the base component of the swing mechanism

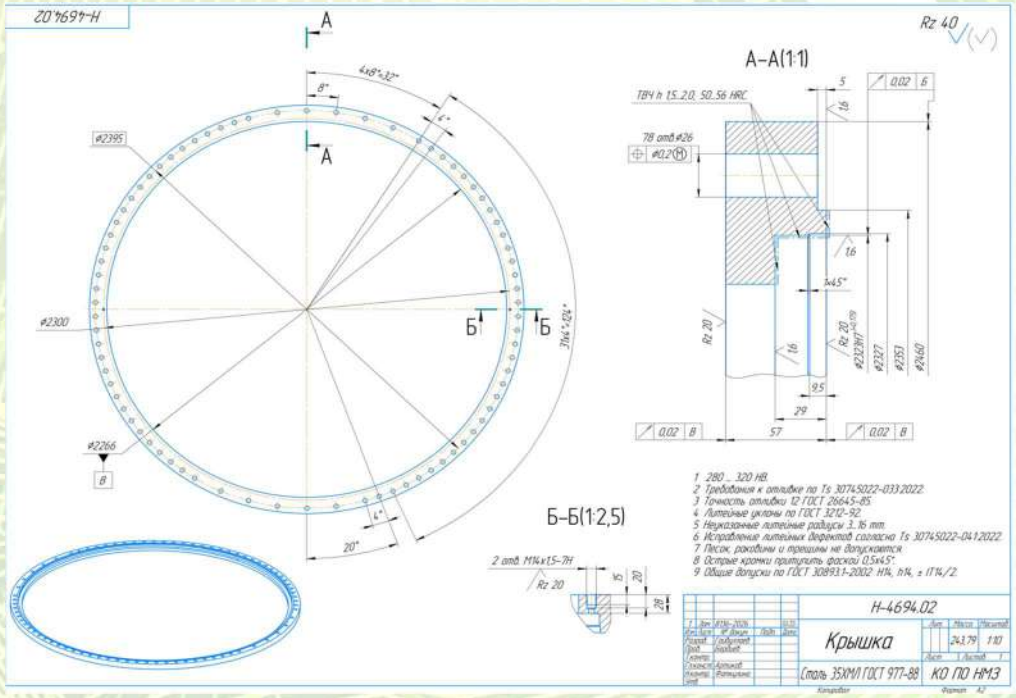


Figure 3. Structural drawing of the cover component of the swing mechanism.

ISSN 3030-3907

The cover component contains **78 holes with a diameter of Ø26 mm** and was evaluated as an element that forms the support zone together with the base.
The research methodology was carried out in the following sequence: at the first stage, the updated design of the swing mechanism was analyzed on the basis of drawings; at the second stage, the parameters of the main components were systematized; at the third stage, the operating principles of ball and roller supports were compared; at the fourth stage, the structural advantages of the roller support were evaluated on the basis of catalogue and standard data; and at the final stage, it was concluded which design is appropriate as the optimal variant for conditions of heavy loading, large diameter, and torque transmission.

Thus, the study used the methods of graphical material analysis, comparison, generalization, and analytical evaluation.

Table 1.

Main parameters of the updated swing mechanism design

Parameter	Value
Maximum diameter of the base component	2460 mm
Number of holes in the base	76 holes, Ø26 mm
Number of holes in the cover	78 holes, Ø26 mm
Module of the internally toothed ring gear	m = 14
Number of teeth	z = 149
Ring gear material	40Kh steel
Recommended support type	Three-row roller slewing bearing

RESULTS

The results of the conducted analysis showed that the updated design of the excavator swing mechanism is formed as a large-sized slewing unit operating under high-load conditions. In the assembly drawing, the swing mechanism is presented as an integrated system consisting of the base, cover, and internally toothed ring gear. It includes numerous mounting holes and large-diameter supporting surfaces intended to receive the load uniformly along the ring. The general scheme of the structure indicates that the load in the swing unit is designed to be distributed not locally, but along the annular zone. This is an important result for withstanding axial and radial forces, as well as the overturning moment generated during excavator operation.

As a result of the analysis of the base component drawing, it was determined that this part functions as a supporting element with high structural rigidity. The fact that the outer diameter of the component reaches **2460 mm**, while the internal

ISSN 3030-3907

functional zones include dimensions of approximately **2355H7, 2357, and 2325 mm**, indicates that the support unit has a large diameter. The presence of **76 holes with a diameter of Ø26 mm** in the base ensures uniform fastening along the ring. In addition, **35KhML steel** and a hardness range of **280–320 HB** are specified as the material, which indicates that the component has sufficient resistance to deformation under high loads. The presence of **78 holes with a diameter of Ø26 mm** in the cover component shows that, together with the base, it forms a closed and stable support zone. As a result, it was found that the housing part of the support unit has sufficient strength and mounting stability.

The analysis of the internally toothed ring gear drawing showed that it is the main torque-transmitting component in the swing mechanism. The drawing specifies a tooth module of **m = 14** and a number of teeth of **z = 149**, which confirms that the mechanism is intended for transmitting high torque. The parameters given for the ring gear indicate that the swing drive has a relatively large module, which is suitable for excavator units operating under heavy loads. Since the geometrical dimensions and supporting surfaces of the ring gear correspond to the assembly drawing, it was evaluated as the main load-transmitting element of the entire swing system. This result shows that, when selecting the type of slewing bearing, not only the contact element itself but also the general operating scheme with the ring gear must be taken into account.

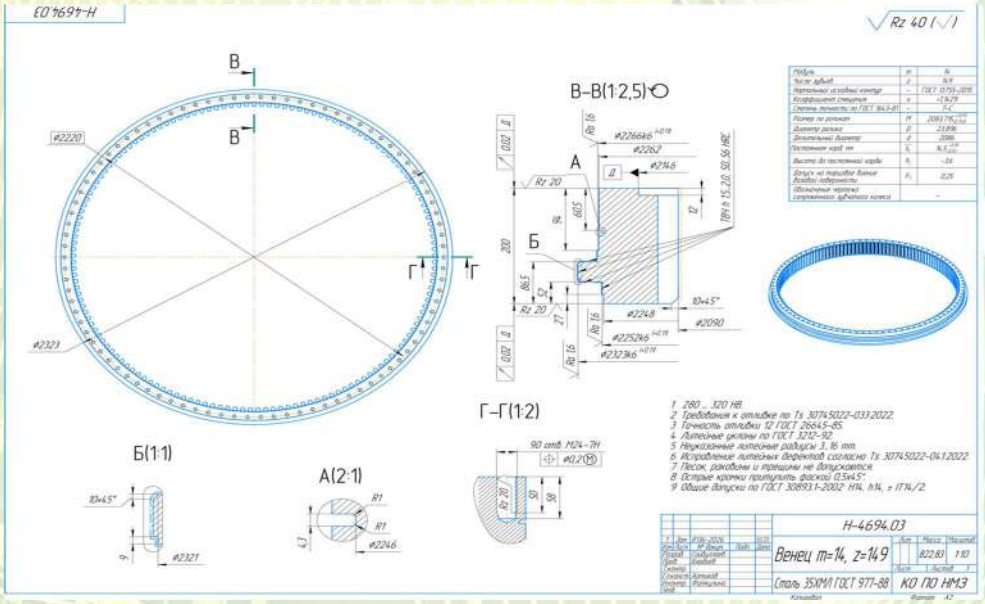


Figure 4. Structural drawing of the internally toothed ring gear (m = 14, z = 149).

The results obtained for the material showed that the ring gear was manufactured from a standard material. According to Spectral Analysis Report No. **447-25**, the sample referred to as **“Зубчатый кольцо”** was made of **40Kh steel**, with a carbon content of **0.40%**, silicon **0.29%**, manganese **0.76%**, chromium

ISSN 3030-3907

0.92%, phosphorus **0.017%**, and sulfur **0.015%**. In the report, these indicators were assessed as complying with the requirements of **GOST 4543–2016**.

This result shows that the material of the ring gear used in the structure was correctly selected in terms of mechanical strength and wear resistance. Therefore, it was confirmed that the modernization is justified not only by changing the geometrical form, but also by the proper selection of material.

The results of comparison with the catalogue of roller slewing bearings were especially important. Among the three-row cylindrical roller supports given in the catalogue, the **131.45.2000** and **131.45.2240** types were found to be the closest to the overall dimensions of the investigated structure. For example, in the **131.45.2240** type, the outside diameter is **D = 2461 mm**, the inside diameter is **d = 2019 mm**, the overall height is **H = 231 mm**, and **60 holes with a diameter of Ø33 mm** and **M30 mounting threads** are specified.

These parameters correspond to the external dimensions and annular support scheme shown in the swing mechanism drawings. On this basis, it was determined that the roller bearing variant is geometrically well compatible with the existing structure. This result shows that the application of a roller support is possible not only theoretically, but also from a practical point of view.

As a result of the comparative analysis, significant differences were identified between the operating characteristics of ball and roller supports. In a ball support, the load is mainly transmitted through point contact. Although this design is relatively simple and ensures easy rotation, under conditions of large diameter and high load, it leads to an increase in contact pressure. Although **GOST 3722–2014** strictly defines accuracy grades, diameter deviations, and hardness requirements for balls, this does not mean that they are always the optimal option for large-sized, heavily loaded swing mechanisms.

In a roller support, the contact is linear, the load is distributed over a larger area, and in a three-row arrangement, axial, radial, and moment loads are received separately in different directions. Therefore, the roller support design provides a more effective result for an excavator swing mechanism operating under high-load conditions.

Another result obtained is that the large diameter of the support rings and the multi-point fastening system in the updated design create favorable conditions for the application of a roller support. The large number of holes in the base and cover, their uniform arrangement along the ring, and the geometrical compatibility with the ring gear make it possible to successfully integrate a roller slewing bearing into the structure. As a result, load distribution improves, local stresses decrease, and

ISSN 3030-3907

the operational reliability of the mechanism increases. Such a structural scheme is especially important for heavy machinery requiring long service life.

In general, the results showed that the use of a roller slewing bearing in the considered updated swing mechanism is more effective than the ball bearing variant. The main reasons for this are load transmission through line contact, targeted distribution of forces in the three-row arrangement, good compatibility with the large-diameter structure, and the ability to ensure high reliability under severe operating conditions. Although ball supports have advantages in terms of accuracy and simplicity, the roller scheme proved to be more appropriate for this structure. Thus, the selection of a **three-row cylindrical roller slewing bearing** was substantiated as the optimal structural solution for the modernization of the excavator swing mechanism.

DISCUSSION.

The obtained results showed that the correct selection of the slewing bearing type is of decisive importance in the modernization of the excavator swing mechanism. As a result of the comparative analysis, it was determined that the roller support design is more effective under heavy-load conditions than the ball bearing variant.

The main reason for this is that, in roller bearings, the load is transmitted through line contact. In ball supports, however, the contact is point-based; therefore, under high-load conditions, an increase in local stresses is observed. This situation becomes especially important in large-sized excavator swing mechanisms.

Table 2.

Comparative characteristics of ball and roller slewing bearings

Indicator	Ball support	Roller support
Contact type	Point contact	Line contact
Load-carrying characteristic	Suitable for medium loads	More effective under heavy loads
Resistance to axial and radial loads	More limited	Higher
Ability to withstand overturning moment	Less stable	More stable
Application in large-diameter units	Not always optimal	More appropriate
Structural advantage	Simpler design	Better load distribution
Suitability for the excavator swing mechanism	Relatively lower	Higher

ISSN 3030-3907

Recommended variant	—	Three-row roller support

The structural analysis showed that the base and cover components of the swing mechanism form a large-diameter support zone and serve to distribute the load uniformly along the ring through numerous mounting holes. Such a structural solution creates favorable conditions for the use of a roller slewing bearing. This is because, in a roller-type scheme, the load is effectively received in several directions and is better compatible with this design. As a result, a reduction in deformation in the support zone and an increase in overall stability can be expected.

The parameters of the internally toothed ring gear also confirm that the modernized unit is intended for severe operating conditions. The fact that the module is equal to **14** and the number of teeth is **149** indicates that the swing mechanism has the ability to transmit high torque. Under such conditions, the load acting on the supporting element also increases. Therefore, the use of a roller bearing that receives the load over a wider contact surface is considered structurally justified.

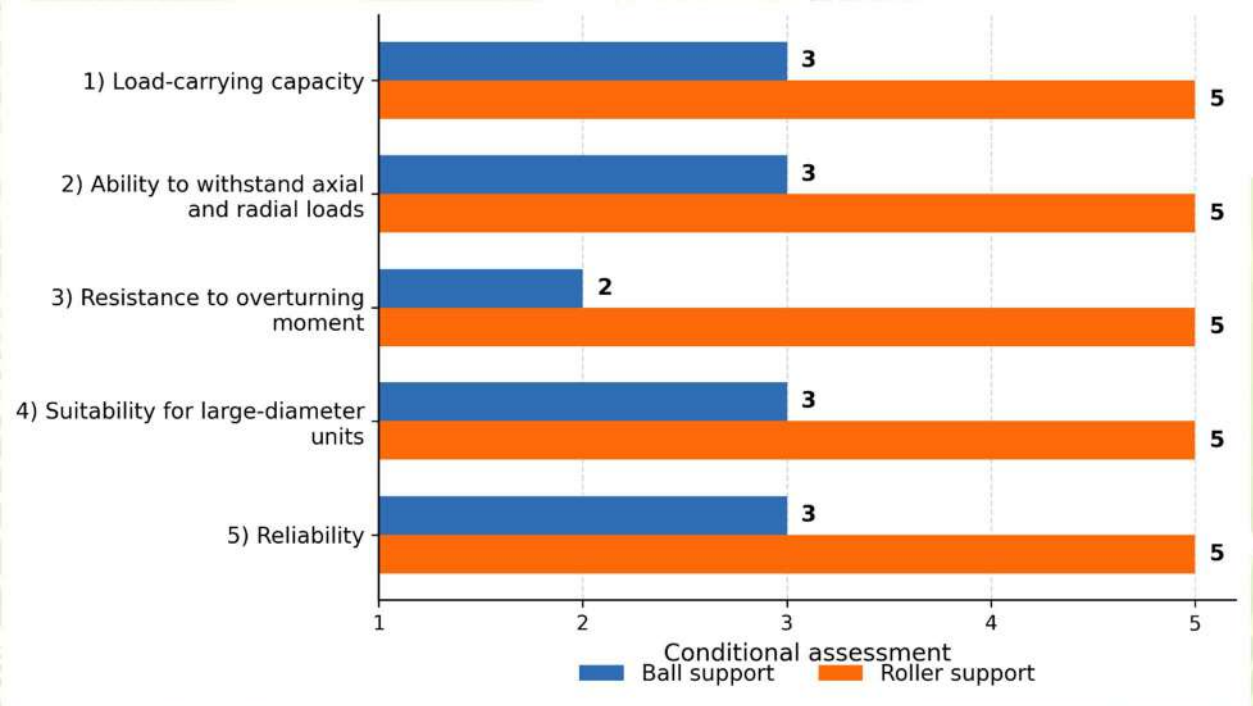


Figure 5. Comparative evaluation of ball and roller supports according to the main indicators

As can be seen from the diagram, the roller support has advantages over the ball support in terms of load-carrying capacity, ability to withstand axial and radial loads, resistance to overturning moment, suitability for large-diameter units, and reliability.

ISSN 3030-3907

The results of the material analysis also confirm the correctness of the selected solution. The fact that the ring gear material corresponds to **40Kh steel** shows that it meets the requirements for mechanical strength and operational reliability. This indicates that, in the modernized design, not only geometrical parameters but also the material factor were taken into account. Therefore, the proposed solution was developed on the basis of a comprehensive approach.

In general, the obtained results showed that the use of a roller slewing bearing in excavator swing mechanisms is more appropriate than the ball bearing variant. This solution can ensure more stable load distribution, reduced contact stresses, and an increased service life of the unit. From this point of view, the proposed modernization serves to improve the reliability and efficiency of excavator swing mechanisms.

CONCLUSION.

In conclusion, the correct selection of the slewing bearing type is of great importance in the modernization of excavator swing mechanisms. According to the results of the comparative analysis, the operating characteristics of ball and roller bearings differ significantly from each other. Although ball bearings are distinguished by their structural simplicity and relatively easy rotation, their capabilities are limited in large-sized swing mechanisms operating under heavy loads. Roller slewing bearings demonstrate advantages due to their ability to receive the load through line contact, effectively distribute forces in several directions, and ensure high reliability under severe operating conditions.

The results of the structural analysis showed that the elements of the swing mechanism, such as the base, cover, and internally toothed ring gear, are designed to operate under large-diameter and high-load conditions. The numerous mounting holes in the base and cover components, annular supporting surfaces, and the parameters of the ring gear, such as **m = 14** and **z = 149**, confirm that the entire unit was developed in accordance with severe operating conditions. Therefore, the use of a roller slewing bearing in such a structure was evaluated as structurally appropriate.

The materials analysis also confirmed the correctness of the selected modernization solution. According to the results of spectral analysis, the ring gear material corresponds to **40Kh steel**, has a standard composition, and is capable of withstanding operational loads. This indicates that not only a structural but also a materials science-based approach was applied in the modernized swing mechanism.

Thus, based on the results of the conducted research, it can be stated that the use of a **three-row roller slewing bearing** is appropriate as the optimal structural

ISSN 3030-3907

solution for improving excavator swing mechanisms. This solution can ensure more stable load distribution, reduced contact stresses, slower wear development, and an increased service life of the mechanism. As a result, the overall reliability and operating efficiency of the excavator are improved.

REFERENCES

1. Ataullaev A., Ataullaev O., Juraev N., Isaev D. Control Mechanism for the Rotational Support System of an Antenna // Proceedings of the IV International Conference on Advances in Materials, Earth Science, and Technology AIP Conf. Proc. 3390, 060030-1–060030-8; https://doi.org/10.1063/5.0322334.

2. Isaev D., Khamidov B., Ataullaev A., Ravshanov J., Juraev N. Comparative Analysis of Wear-Resistant Coating on Carbide end Mills Using Vibrodiagnostic Method // Proceedings of the IV International Conference on Advances in Materials, Earth Science, and Technology AIP Conf. Proc. 3390, 020016-1–020016-7; https://doi.org/10.1063/5.0322333

3. A.O. Ataullaev, O.X. Ataullaev, F.A. Ergashev Automated rectification of pulse response characteristics in radio engineering two-stage amplifiers //E3S Web of Conferences. – EDP Sciences, 2023. – T. 417. – pp. 05007

4. Sheina N. et al. Assessment of uncertainty and quality control in agricultural infrastructure //American Institute of Physics Conference Series. – 2024. – T. 3244. – №. 1. – C. 040014.

5. Ataullaev A. O., Kayumov B. B., Asadova M. A. Implementation of the Intelligent Tracking System With Wave Channels //International Scientific Journal Theoretical & Applied Science, Philadelphia, USA. – 2020. – №. 89. – C. 328-331.

ISSN 3030-3907