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Redesign a planetary gear belonging to a model МПОZМ-10 gearmotor

Rediseño de un engranaje planetario perteneciente a un motorreductor modelo МПОZМ-10

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Abstract: The redesign of the planetary gear train of the Soviet gearmotor МПОZМ-10, that is located at Commander Ernesto Che Guevara Nickel and Cobalt-producing Company (ECG), Yagrumaje, Punta Gorda, Moa City, Cuba, was developed using the dimensional analysis of its mechanical components, such as the central gears, the planetary gears and the ring gears. The geometric parameters were determined through precision calibrators, applying profile corrections, with factors ranging between -0.400 and +0.100, depending on the mechanical components. The 18X and 40X steels were selected according to their chemical compositions and the required specific heat treatments, were determined for each mechanical part. The results include the module calculation (1.5 mm), pitch (4.71 mm), tooth thickness (2.35 mm) and the characteristic diameters of all the mechanical components, providing full technical documentation for their manufacture. The resulting design, allows for recovery of the industrial equipment which, have been out of service.

Key Words: machine design, mechanical device, industrial equipment, electric motors, mechanical technology

Resumen: Se desarrolló el rediseño del tren planetario del motorreductor soviético МПОZМ-10 ubicado en la empresa productora de níquel Ernesto Che Guevara de Moa, mediante análisis dimensional de sus componentes: piñón solar, satélites y coronas dentadas. Se determinaron los parámetros geométricos mediante mediciones con calibradores de precisión, aplicando corrección de perfiles con factores entre -0,400 y +0,100 según el componente. Se seleccionaron aceros 18X y 40X según su composición química y se establecieron los tratamientos térmicos específicos para cada pieza. Los resultados incluyen el cálculo de módulo (1,5 mm), paso (4,71 mm), espesor de diente (2,35 mm) y los diámetros característicos de todos los componentes, proporcionando la documentación técnica completa para su fabricación. El diseño obtenido permite la recuperación de equipos industriales fuera de servicio.

Palabras clave: diseño de máquinas, dispositivo mecánico, equipo industrial, motores eléctricos, tecnología mecánica

1. Introduction

Gearmotors are mechanical devices that regulate the driving speed by integrating an electric motor with a speed reducer. This adaptation is achieved through gears that adjust speed and power (Bermúdez *et al*., 2011).

Gears are essential mechanisms for mechanical power transmission and they are the most common mechanical parts that are used to transmit power from one rotating shaft to another one (Kailuke and Yenarkar, 2013; Mott *et al*., 2018; Xu *et al.,* 2023; Ghorashi, 2025). Most gear drives result in a change in the speed of the output gear relative to the input gear (Zamora-Hernández *et al.,* 2023; Arana *et al.,* 2025). Planetary gears offer superior gear ratios, high load-carrying capacity, and greater compactness (Huo *et al.*, 2023), making them widely used in industry (Cooley *et al*., 2014; Hu *et al.,* 2019).

Due to their multiple force transmission paths, planetary gear systems are efficient, but they are sensitive to their manufacturing variations, elasticity, and dynamic excitation. They are susceptible to transmission failures, arising from multiple factors, including assembly faults, eccentricity, and dynamic effects (Verucchi *et al.,* 2015; Huo *et al.,* 2023; Iglesias *et al*., 2025; Letsela *et al*., 2026).

Tooth deformations have also been reported (Mena-Chavarrea *et al.,* 2023; Guerra *et al.,* 2025), causing dynamic overload, noise as well as vibrations.

The Soviet МПОZМ-10 planetary gearmotors, are essential mechanical components of the electrostatic precipitator systems at Ernesto Che Guevara Nickel and Cobalt-producing plant (ECG) (Figure 1). Currently, several of these units have been out of service, due to their advanced wear or faults of the gears in their planetary gear trains, resulting in production downtime and impairing of the industrial filtration process efficiency.

Figure 1. Gearmotor model МПОZМ-10.

The planetary gear train of the МПОZМ-10 consists of the following items: a two-section sun gear (18 and 36 teeth), three planet gears with two sections each (47 and 48 teeth), and two ring gears (140 teeth). The complexity of this system and the impossibility of obtaining original spare parts due to discontinuity in manufacturing make it necessary to redesign these components using precise methodologies and techniques.

Profile correction in cylindrical gears is a fundamental technique in the redesign of the gear components. As stated by González Rey *et al.* (2007), this correction enhances tooth strength through the radial displacement of the cutting tools, optimizing the active tooth profile to prevent the meshing interference.

Maintaining and repairing equipment in industrial companies promotes increased productivity, improves cost-benefit ratios, increases service hours, and maintains equipment efficiency (Luddey Marulanda & Trujillo, 2007). Process optimization enables companies to reduce downtime and maximize the use of the available resources (Arroyo Vaca & Obando Quito, 2022; Guillén-Sánchez & Depaz-Paucar, 2023). According to Cruz Deviana *et al.* (2025), the redesign of the mechanical items is a continuous and essential process for achieving product quality, reducing production times in industrial processes, and also, it allows to increase machine durability. By modifying the manufacturer's original configuration, it can improve process management without compromising the mechanical components quality (Yime & Páez, 2016; Aldea Molina, 2021; Chalupa *et al.,* 2023); therefore, implementing the redesign methodologies, according to current operating conditions, is essential (Montijo-Valenzuela, 2019; Cortez Olivera *et al.,* 2022).

This paper aims to redesign the full planetary gear train of the МПОZМ-10 gearmotor, through the comprehensive dimensional analysis, the application of profile corrections, and the appropriate selection of materials and heat treatments. Also, it provides the technical documentation that is required for the mechanical component manufacturing and the repair of the out-of-service equipment within the nickel industry.

This research paper involves precise size measurements of existing components, the determination of key geometric parameters, the application of gear calculation methodologies, and establishing the technical manufacturing specifications, that just contribute to the solution of a specific industrial problem, based on the application of the mechanical engineering principles.

2. Materials and methods

The planetary gear train to be designed consists of several fundamental mechanical items as follows: a sun gear, three planetary gears, as well as two ring gears.

The sun gear is the central gear, that is made of 18X steel; it consists of two sections. One section has 18 teeth and an outer diameter of 30 mm. The second section is provided with 36 teeth, with an outer diameter of 75 mm, and a length of 72 mm. It consists of three planet gears, each consisting of two sections. The larger section is provided with 48 teeth, with an outer diameter of 75 mm, while the smaller section is provided with 47 teeth, with an outer diameter of 72.2 mm, and a length of 55 mm. There are two ring gears, both with an outer diameter of 213 mm and 140 teeth. The internal gear section that meshes with the larger planet gear section has 114 teeth and an inner diameter of 172.5 mm; the section that meshes with the smaller planet gear section has 112 teeth and an inner diameter of 166.5 mm. Both ring -gear sections are 18 mm long and they are made of 40X steel.

The diameters correspond to the current external and internal measurements taken from the physical sample, without including the calculations. The tooth counts are exact, based on the measurements performed.

2.1 Measurement instruments

A Vernier caliper with a resolution of 0.05 mm was used. Each measurement was performed three times at different positions, and the average value was taken to minimize possible failures. Measurement uncertainty was estimated at ±0.02 mm.

2.2. Chemical composition of the 40X and 18X steels

The chemical composition of 40X steel reveals a balance designed for applications subject to high mechanical requirements. To achieve greater strength—specifically, improved fatigue strength—a Quenching and Tempering treatment must be applied (Table 1)

Table 1. Chemical composition of 40X steel

Element	Composition (%)
C (carbon)	0,36-0,44
Cr (chrome)	0,80-1,10
Ni (Nickel)	1,30-1,70
Mo (Molybdenum)	0,15-0,25
Si (silicon)	0,17-0,37
Mn (manganese)	0,50-0,80

The formulation is focused on maximizing the surface properties. This composition is specifically designed for the parts, that require maximum surface wear resistance, without compromising the core toughness (Table 2). To achieve this, a carburizing heat treatment + a quenching process must be carried out to ensure high wear resistance.

Table 2. Chemical composition of the Steel 18x

Element	Composition (%)
C (carbon)	0,15-0,21
Cr (chrome)	0,90-1,20
Mn (manganese)	0,80-1,10
Ti (titanium)	0,03-0,09

2.3. Calculation methodology for the planetary gear train

The module (M) indicates the relative size of the teeth.

$$M = \frac{De}{N+2} \qquad [1]$$

Where:
D_e: outside diameter taken from the physical sample
N: Number of teeth

The total tooth height (h) is the portion that extends beyond the pitch diameter and the root height.

$$h = 2{,}167 * Módulo \qquad [2]$$

The tooth thickness (e) must be sufficient to withstand the forces without fracturing, but not excessive, to avoid interference.

$$e = 0{,}5 \ * paso \qquad [3]$$

The tooth space (c) is the gap between two consecutive teeth. It must match the tooth thickness of the mating gear for precise meshing.

$$c = 0{,}5 * paso \qquad [4]$$

Tooth root fillet radius (R)

$$R = 0{,}3 * Módulo \qquad [5]$$

Pitch (P) is the distance between two corresponding points on consecutive teeth.

$$P = 3{,}1416 * M \qquad [6]$$

The equations 7–14 present the formulas for calculating the pitch diameter, the corrected inner crown head diameter, the outside diameter for uncorrected gears, the profile-shifted gear, the root diameter for a corrected gear, the root diameter for a corrected internal gear, and the root diameter for uncorrected gears.

The pitch diameter (Dp) is the theoretical diameter where the contact between the gears occurs.

$$D_p = M * N \quad [7]$$

The corrected internal gear tip diameter (Da), for gears with corrections, this diameter varies with respect to the standard value, in order to avoid interference and improve contact.

$$D_a = D_p - 2M(1 - X) \quad [8]$$

Where:
Dp: pitch diameter
X: Correction factor

The outside diameter for uncorrected gears (De) is the total diameter of the gear, including the teeth.

$$D_e = M(N + 2) \quad [9]$$

Tooth tip diameter for profile-shifted gears (Da):

$$D_a = M(Z + 2 + 2x) \quad [10]$$

Where:
Z: Teeth number

The tooth root diameter for a corrected pinion (Df) defines the depth reached by the tooth root.

$$D_f = M(Z - 2{,}5 + 2X) \quad [11]$$

Root diameter for corrected internal gear (Df):

The center distance (a) is the separation between the axes of two gears.

$$D_f = D_p + 2M(1{,}25 + X) \quad [12]$$

The center distance (a) is the separation between the axes of two gears.

$$a = \frac{(z_2 - z_1)M}{2cos\beta} \quad [13]$$

Root diameter for uncorrected gears (Df):

$$D_f = Pitch\ diameter - (2 * 1) \quad [14]$$

Figure 2 shows the gears nomenclature and geometry.

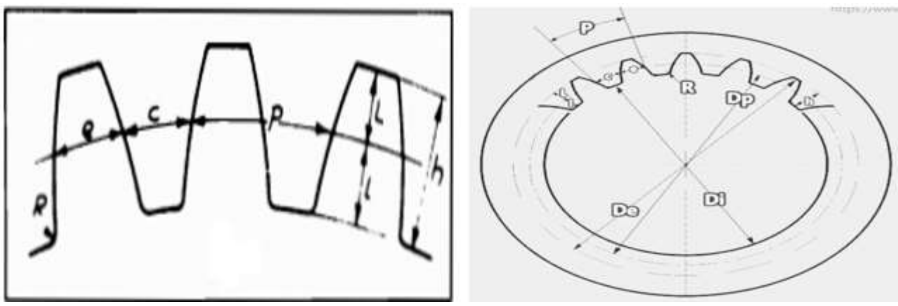

Figure 2. Gear design and calculation (Casillas, 2000).

2.4. Heat treatments for planetary gear train components

The treatment for 40X steel (satellite and ring gear), consisted of a preheating process to the target temperature, followed by an outdoor air-cooling process, under controlled ambient conditions. The purpose of this process was to refine the granular structure and relieve internal stresses resulting from forging or machining.

The second tempering stage process, consisted of heating the component in an Atmosphere furnace—to prevent decarburization—for approximately one hour per millimeter of thickness. It was then cooled down in mineral oil at a controlled rate to prevent cracking.

Finally, the tempering process was performed by heating the part and then cooling it outdoor. The objective of this treatment was to achieve high mechanical strength and a tough core, combined with sufficient surface hardness to resist wear (Ovalle, 2020; Parra, 2025).

2.5. The 18X steel heat treatment for the sun gear

The 18x Steel heat treat for the sun gear consisted of the three fundamental stages as follows:

- It began with carburization treatment, which must be performed in an atmosphere furnace where the part is exposed to carburizing gases at high temperatures for several hours to induce carbon diffusion into the material's surface layer.
- Following carburizing, quenching was applied; this involves rapidly cooling the part in a liquid medium. This process transforms the crystalline structure of the carbon-enriched surface zone, creating an extremely hard, wear-resistant layer.
- As a final stage (tempering), the part was subjected to a controlled heating process, at an intermediate temperature. So that It reduced the internal stresses that were generated during quenching process and it improved the material's hardness.

3. Findings and discussions

3.1 Analysis of the findings for the satellite gears, Section A

Concerning the development of the satellite gears, for the planetary gear set, significant findings have been observed, which allow the design of these essential items for the system operation.

3.1.1. Technical specifications and the findings during the process

The calculated module was 1.5 mm. The tooth height was 3.25 mm. Upon applying a correction factor, the tooth height changed to 4.71 mm. The tooth thickness is of 2.35 mm.

Based on the module and a correction coefficient of 0.100, the inner and outer diameters of the planet gears were calculated, yielding an outer diameter of 75.3 mm and an inner diameter of 68.55 mm. The calculated pitch diameter is 72 mm.

The distance between the planet gear centers is 49.5 mm. This value is essential for the proper alignment and meshing of the planet gear within the planetary system, ensuring balanced force distribution and minimizing mechanical stresses.

The selection of a positive correction factor (X=+0.100) for this section of the planet gear aimed primarily to increase the tooth root thickness, thereby improving its capacity to withstand bending loads and reducing stress concentration at the root.

3.2. Analysis of the findings for the Section B, planet gears

The 1.5 mm module of the Section B, planet gear, was verified using the Equation 1. The tooth geometry features a height of 3.25 mm, a pitch of 4.71 mm, and a thickness of 2.35 mm. By applying a correction factor (X=-0.400), an outer diameter of 72.3 mm (Equation 10) and an inner diameter of 67.05 mm (Equation 11) were obtained, along with a pitch diameter of 70.5 mm (Equation 7) and a center distance of 48.75 mm (Equation 13).

The correction factor (X=-0.400) applied to this section is supported by the need to avoid meshing interference with the mating internal gear, ensuring uniform contact and eliminating the possibility of flank interference.

3.3. Analysis of the findings for the ring gear A002

The ring gear A002 is characterized by a module of 1.5 mm, determined using Equation 1. Its geometric parameters include a tooth height of 3.25 mm (Equation 2), a pitch of 4.71 mm (Equation 6), and a thickness of 3.25 mm (Equation 3). The resulting diameters are as follows: pitch diameter 172 mm (Equation 7), outer diameter 174.48 mm (Equation 8), and inner diameter 167.7 mm (Equation 12).

3.4. Analysis of the findings for the ring gears B002 and B003

The ring gears B002/B003 use a module of 1.5 mm (Equation 1) with a tooth height of 3.25 mm (Equation 2) and a pitch of 4.71 mm (Equation 6). The tooth thickness is of 3.25 mm (Equation 3). The resulting diameters are as follows: pitch diameter, 210 mm (Equation 7), outer diameter, 213 mm (Equation 9), and the inner diameter, 208 mm (Equation 14).

3.5. Analysis of the findings for the ring gear section A003

Equation 1 confirmed a module of 1.5 mm for the design of the ring gear A003. The gear tooth configuration shows a height of 3.25 mm (Equation 2), as well as a pitch diameter of 4.71 mm (Equation 6), and a thickness of 3.25 mm (Equation 3). The characteristic diameters are as follows: pitch diameter, 168 mm (Equation 7), outer diameter, 171.45 mm (Equation 8), and inner diameter, 164.7 mm (Equation 12).

3.6. Analysis of the findings for the sun gear, section A

The sun gear was designed with a module of 1.5 mm, indicating an appropriate relationship with the tooth size. The tooth height of 3.25 mm and tooth pitch of 4.71 mm are parameters that ensure proper meshing and efficient transmission. The tooth thickness of 3.25 mm, determined using Equation 3, is consistent with the gear's overall dimensions.

The pitch, outer, and inner diameters are equally significant in the sun gear design; an outer diameter of 30 mm (Equation 9) and an inner diameter of 25 mm (Equation 14) were obtained, ensuring correct alignment and functionality. The pitch diameter of 27 mm was established using the Equation 7.

3.7. Analysis of results obtained for the sun gear, section B

The design of ring gear A003 confirms the module of 1.5 mm. The gear tooth configuration shows a height of 3.25 mm, a pitch of 4.71 mm, and a thickness of 3.25 mm. The characteristic diameters are: pitch diameter, 168 mm, outer diameter, 171.45 mm, and inner diameter, 164.7 mm.

4. Conclusions

The complete design of the planetary gears for the МПОZМ-10 gearmotor was successfully developed, by determining all the geometric parameters that are required for manufacturing.

The application of the profile corrections with factors ranging from -0.400 to +0.100, allowed to optimize the meshing conditions for each component, based on their specific requirements.

The planet gears in sections A and B, have pitch diameters of 72 mm and 70.5 mm, respectively, featuring positive and negative corrections, suited to their functions.

The ring gears A002, B002/B003 and A003, have pitch diameters of 172 mm, 210 mm, and 168 mm, respectively, ensuring the correct kinematic relationship.

The resulting technical documentation enables the parts to be manufactured using the conventional equipment, providing a practical solution for the industrial equipment maintenance.

Bibliographic references

Aldea Molina, A.L. (2021). Influencia del rediseño de los procesos productivos de una empresa de envolturas flexibles basado en la mejora continua. *Revista Industrial Data 24*(1), 7-22. https://dx.doi.org/10.15381/idata.v24i1.19616

Arana, A., Ulacia, I., Larrañaga, J., Iñurritegui, A., & San José, E. (2025). Modelo térmico-dinámico acoplado para engranajes rectos de alta velocidad. *Anales De Ingeniería Mecánica*, *1*(24). https://doi.org/10.63450/aim.1.193.2025

Bermúdez, H.H., Gallego, H.A., & Bermúdez, H.F. (2011). Prototipo mecatrónico para la enseñanza y el aprendizaje del movimiento armónico simple. *Scientia et technica*, *16*(49), 245-252. https://www.redalyc.org/pdf/849/84922625041.pdf

Casillas, A.L. (2000). *Diseño y Cálculo de Engranajes*. Editorial Paraninfo.

Cooley, C.G., & Parker, R.G. (2014). A Review of Planetary and Epicyclic Gear Dynamics and Vibrations Research. *Journal of Applied Mechanics, 66*(4). http://doi.org/10.1115/1.4027812

Cortez Olivera, R., Martínez Cosgalla, J.J., & Santana Villarreal, J. (2022). Propuesta metodológica para el rediseño de una pieza automotriz, utilizando simulación matemática. *Revista de Ingeniería Industrial y Mecánica*, *6*(11), 16-16. https://hologramatica.unlz.edu.ar/index.php/riiym/article/view/102

Cruz Deviana, M.R., Olmedo Obrero, G., Aguilar Pérez, A., Padilla García, E.A., & Rosas Amaro, M.C. (2025). Análisis y rediseño de una impresora 3d tipo cartesiana. *Humanidades, Tecnología y Ciencia, del Instituto Politécnico Nacional, 3*, 21-26. https://revistaelectronica-ipn.org/ResourcesFiles/Contenido/33/TECNOLOGIA_33_001345.pdf

Chalupa, V., Stanek, M., Vanek, J. Strnad, J., & Ovsik, M. (2023). Design of Dual-Head 3D. Printer, *Manufacturing Technology, 23*(2), 177–185. https://doi.org/10.21062/mft.2023.032

Ghorashi, M. (2025). Fixed-Axis and Planetary Gear Trains. In *Introduction to Machine Dynamics*. Cham: Springer Nature Switzerland. https://link.springer.com/chapter/10.1007/978-3-031-94736-0_7

González Rey, G., Frechilla Fernández, P., & García Martín, R.J. (2007). Coeficiente de corrección en engranajes cilíndricos como factor de conversión entre sistemas AGMA e ISO. *Ingeniería Mecánica*, *10*(3), 63-69. https://www.redalyc.org/pdf/2251/225115060009.pdf

Guerra, D., Pedrero, J.I., Pleguezuelos, M., & Sánchez, M.B. (2025). Determinación de la profundidad de rebaje óptima para reductoras planetarias*. Revista Iberoamericana de Ingeniería Mecánica, 29*(1), 17-30. https://doi.org/10.5944/ribim.29.1.44287

Guillén-Sánchez, J.S., & Depaz-Paucar, Á. (2023). Mantenimiento productivo total en la eficiencia productiva de las empresas industriales: una breve revisión de literatura. *Signos, Investigación en Sistemas de Gestión, 16*(1). https://doi.org/10.15332/24631140.8807

Hu, Y., Ryali, L., Talbot, D., & Kahraman, A. (2019). A theoretical study of the overall transmission error in planetary gear sets. Proceedings of the Institution of Mechanical Engineers, Part C. *Journal of Mechanical Engineering Science, 233*(21-22), 7200-7211. http://doi.org/10.1177/0954406219830436

Huo, G., Sánchez-Espiga, J., Iglesias Santamaria, M., Fernández-del-Rincón, A., Jiao, Y., & Viadero-Rueda, F. (2023). Influence of manufacturing errors on the behavior of a two-stage planetary dear train. *DYNA, 98*(4), 384.390. https://doi.org/10.6036/10879

Iglesias, M., Fernández Del Rincón, A., De-Juan, A., Diez-Ibarbia, A., García, F., & Viadero, P. (2015). Advanced model for the calculation of meshing forces in spur gear planetary transmissions. *Meccanica, 50*(7), 1869-1894. http://doi.org/10.1007/s11012-015-0130-3

Kailuke, J., & Yenarkar, Y. (2013). Investigation of stresses in the thin rimmed spur gear tooth using fem. *IJRET: International Journal of Research in Engineering and Technology,* *2*, 437-441. https://ijret.org/volumes/2013v02/i11/IJRET20130211064.pdf

Letsela, M., Filipeson, D., Tchomeni, B.X., & Alugongo, A.A. (2026). Transmission error in Planetary gear Systems as an excitation Source Influencing vibration response and wear Mechanisms. *Engineering Proceedings, 132*(1). https://doi.org/10.3390/engproc2026132003

Luddey Marulanda, J., & Trujillo, G. (2007). Recuperación de piezas desgastadas con recubrimientos protectores. *Scientia et Technica, XIII*(37), 199-204. https://www.redalyc.org/pdf/849/Resumenes/Resumen_84903734_1.pdf

Mena Chavarrea, J.M., Granizo, J.A., Hernández Dávila, E.S., & Audelo Guevara, M.E. (2023). Calculation of abrsive wear speed in straight and helical gears with evolving profile, using a Matlab Gui. *Ingenius. Revista de Ciencia y Tecnología, 29.* https://doi.org/10.17163/ings.n29.2023.03

Montijo-Valenzuela, E.E. (2019). Metodología de cálculo teórico y diseño computarizado de un engrane planetario para aplicación en generador eólico por medio de programa computarizado. *Revista de Investigación Académica Sin Frontera, 12*(29). https://doi.org/10.46589/rdiasf.v0i29.204

Mott, R., Vavrek, E.M., & Wang, J. (2018). *Machine elements in mechanical design*. Pearson Education. https://ftp.idu.ac.id/wp-content/uploads/ebook/tdg/DESIGN%20SISTEM%20DAYA%20GERAK/Machine%20Elements%20in%20Mechanical%20Design.pdf

Ovalle, S.J. (2020). *Práctica sobre temple y revenido: tratamiento térmico en aceros*. https://www.academia.edu/44458155/PRÁCTICA_SOBRE_TEMPLE_Y_REVENIDO_Tratamiénto_térmico_en_Acero

Parra, P. (2025). *Tratamientos térmicos en el acero: temple, revenido y recocido*. Transformados Metálicos Toral. https://transformadosmetalicostoral.com/tratamientos-termicos-en-el-acero-temple-revenido-recocido/

Verucchi, C.J., Bossio, G.R., Bossio, J.M., & Acosta, G.G. (6-9 de octubre de 2015). *Detección de fallas en reductores a engranajes impulsados por motores de inducción: un estudio experimental.* XVI Reunión de Trabajo en Procesamiento de la Información y Control, Argentina. https://bicyt.conicet.gov.ar/fichas/produccion/en/5573581

Xu, H., Ren, H., & Qin, D. (2023). Dynamic characteristics of the planetary gear system with rolling bearing. *Multibody System Dynamics*, *59*(2), 171-191. https://link.springer.com/article/10.1007/s11044-023-09905-9

Yime, E., & Páez, J. (2016). Rediseño y automatización de un molde para la fabricación de Vitrinas Refrigeradas usando inyecciones de espuma de Poliuretano. *Ingeniería,* 21(3), 290-304. https://doi.org/10.14483/udistrital.jour.reving.2016.3.a03

Zamora-Hernández, Y.K., Santana-Reyes, S.A., Morales-Tamayo, Y., Cárdenas-Yanez, R.A., & Jacome-Alarcon, L.F. (2023). Procedimiento para la determinación de la calidad geométrica del perfil del diente en engranajes cilíndricos de dientes rectos. *Revista EIA, 20*(40), 1-19. https://doi.org/10.24050/reia.v20i40.1686

Conflict of interest:

The authors declare that there are no conflicts of interest.

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Surlenis Torres Aguirre: Investigation/Visualization/Writing – original draft
Eider Sánchez Olivero: Data curation/Methodology/Visualization