*International Journal Of Engineering Research And Development*
*e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com*
*Volume 21, Issue 4 (April 2025), PP 190-195*

# Some Aspects of the Usage of Friction Gear in the Construction of Nanorobots

Mariusz Giergiel[1], AndriiPolishchuk[2], OlehPolishchuk[2]
[1]*AGH University of Krakow, Poland*
[2]*Khmelnytskyi National University, Ukraine*
*Corresponding Author:Mariusz Giergiel*

***ABSTRACT:*** *An important challenge conditioning the development of nanoscale robots, for which there is still no clear solution, is the selection of nanomechanisms for their practical implementation. A fundamental source of problems is the fact that there are fundamental differences regarding the basic nature of physical phenomena relevant in the macro, micro and nano worlds. This is the case because some of the phenomena that occur or are relevant at the nano scale do not occur at the micro and macro scales, and vice versa. The basic element found in the drive and actuation systems of various devices, including robots, are mechanical gears, and they will undoubtedly also be needed for the construction of nanorobots. At the same time, it is an element that poses practical difficulties for its implementation at the nanoscale. The simulation studies carried out on friction gears at the nanoscale are a certain attempt to answer the question of whether and what solutions can find application in nanorobotics.*
***Keywords:*** *nanomechanisms, nanorobots, nanotechnology*

---

Date of Submission: 08-04-2025 Date of acceptance: 19-04-2025

---

## I. INTRODUCTION

Dynamically developing fields related to nanoscale engineering and robotics include nanorobotics and nanomechanics(Khulbe, 2014). Advances in these fields are creating new opportunities on the one hand, but on the other hand are posing increasing scientific, as well as technical and technological challenges. In 1959, physicist Richard Feynman gave a popular science lecture in which he pondered the limits of miniaturization (Roukes, 2001). In his reflections, he started from his contemporary technology, then analyzed the limitations of physical laws and concluded by saying that it would be possible, even inevitable, to construct objects at the atomic level, atom by atom, which at the time seemed like a rather impossible task (Kelsall et. al., 2005). Today, however, this can no longer be disputed. Through the following progress, the size of the devices that can be built has approached the molecular scale, and the progress of research and scientific work, including that on living organisms, has shown that Feyman's genius was right after all.

Nanotechnology (Kelsall et. al., 2005)can be described as operating at the level of atoms and molecules, with a nanometer being 1/1000000000th part of a meter, which is about 1/80000th the diameter of a human hair or 10 times the diameter of a hydrogen atom. It is undoubtedly a great challenge to measure, manipulate and do all sorts of things at the nanometer scale, that is, indicative down to a size of about 100 nm. To ensure the further development of nanotechnology, it seems essential to develop and apply new designs of nanorobots (Yang at. Al., 2019). A nanorobot (Khulbe, 2014) is understood here as a programmable machine at either the nano or molecular scale, for which it is necessary to use mechanisms realized and operating at the nanoscale, such as, among other things, gears, which are indispensable in drive and executive systems.

## II. TOOLS AND METHODS

If you are planning to design and especially implement a mobile robot in practice, the drive system will probably need some kind of gearbox.NanoEngineer-1 software, which was developed by Nanorex, was used to create a model and simulate the operation of the gearbox. The main technical advisor for putting up this computational system was K. Eric Drexler, considered the "father of nanotechnology." (Kelsall et. al., 2005)

Nanoengineer-1 (https://sourceforge.net, 2024) is both an advanced module for designing and modeling atomically precise parts and assemblies and features a molecular dynamics module for creating and simulating mechanical nano devices, whose user interface somewhat resembles the popular SolidWorks engineering support program in its appearance. Nanoengineer is available for computers running Windows, Mac OS, or Linux operating systems. NanoEngineer offers extensive capabilities for the design and modeling of structures, from less to more complex. It uses molecular dynamics and quantum mechanics systems for simulation and analysis, allowing for strong simulation capabilities in nanotechnology and nanomechanics.

## III. NANOSCALE FRICTION GEAR SIMUALTION AND REASULTS

Planetary gears are often used in mobile robots at the macro scale, however, as shown in the paper (Giergiel et. al., 2024) at the nanoscale there are big problems with their practical implementation. Due to the simplicity of construction, the use of friction gears (Skoc et.al. 2016) is worth considering in nanoscale robots.The friction gear subjected to simulation studies was imaged using carbon nanotubes (Singh et. al. 2014), (Okapa 2024). First, a nanotube with the parameters presented in Figure 1 was modeled, while a general view of this nanotube is shown in Figure 2.

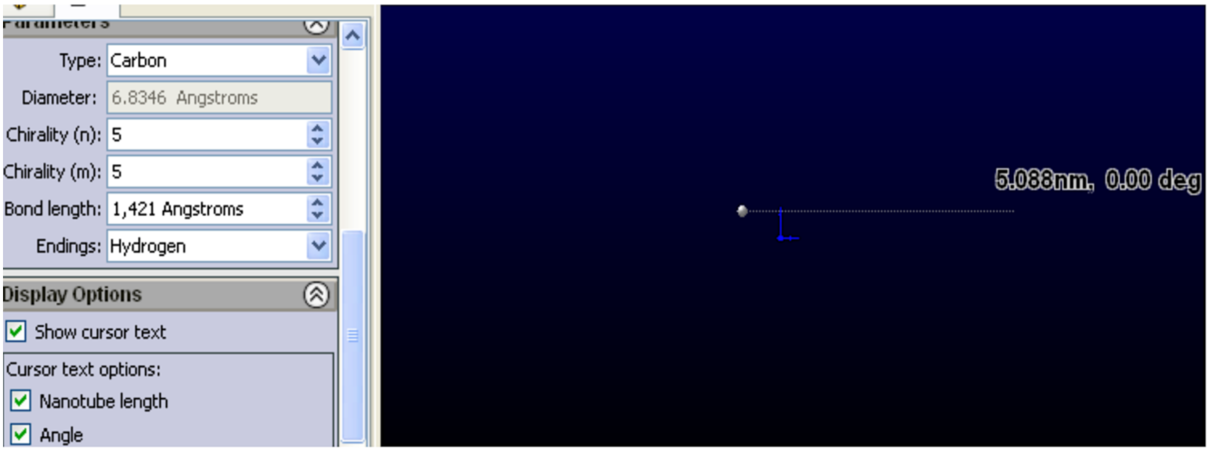


**Figure 1: Formation of the first carbon nanotube with parameters (length of 5.088nm and angle of $0^o$).**

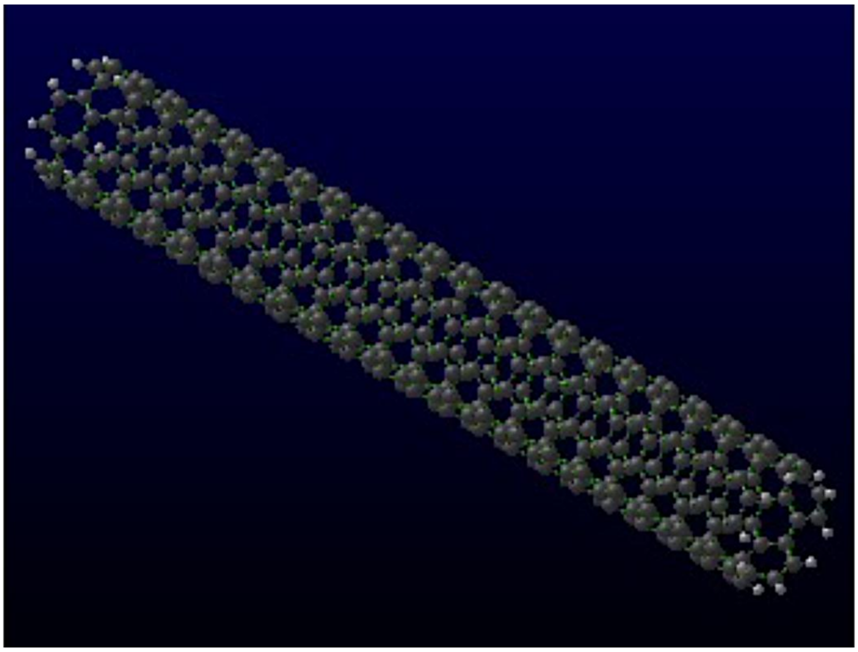

**Figure 2: Isometric view of the complete first carbon nanotube.**

Then another nanotube was created with three times the diameter. A view of the two tubes is shown in Figure 3. Making a translation in space then created a gear as shown in Figure 4.

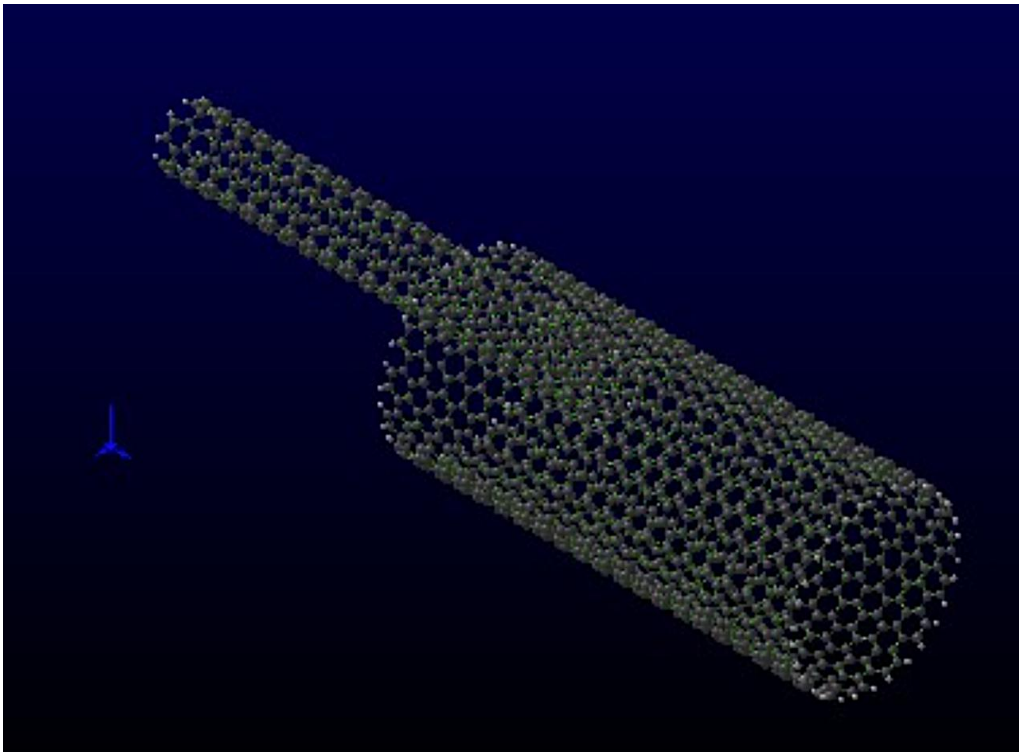

**Figure 3: Isometric view of the two carbon nanotubes that make up the friction gear.**

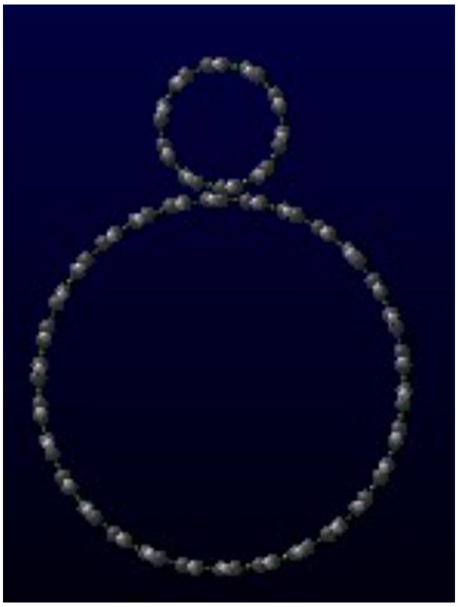

**Figure 4: A side view of the two nanotubes that make up the transmission.**

Torque was applied to the gearbox, specifically to the smaller tube, for which the 'simulation' command was used by selecting the 'rotary motor' command from among the many options, as shown in Figure 5, while an isometric view of the gearbox is shown in Figure 6.

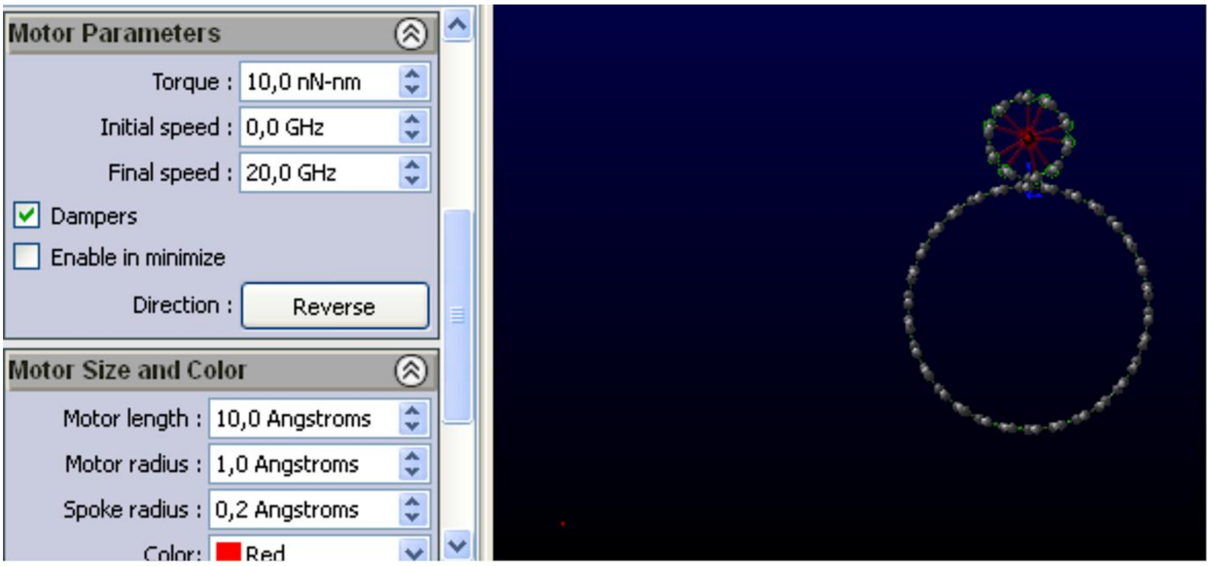


**Figure 5: Using the 'rotary motor' command, a smaller CNT is given a torque with the given parameters.**

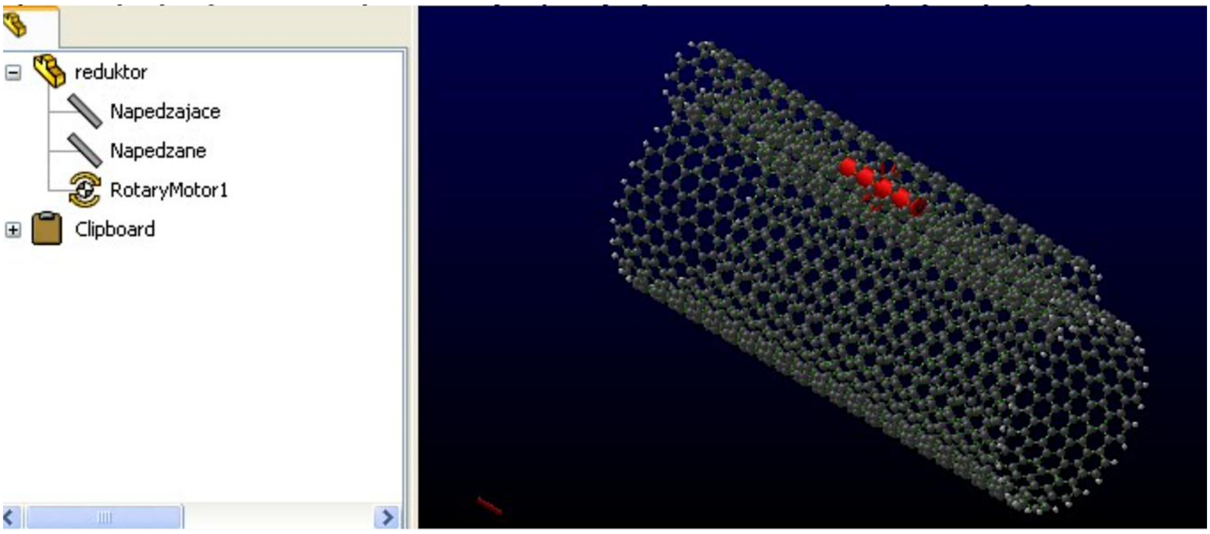


**Figure 6: Isometric view of the friction gear.**

Example simulation results are shown below, Fig. 7 shows a velocity plot for a drivennanotube, and Fig. 8 for a driven (passive) nanotube.

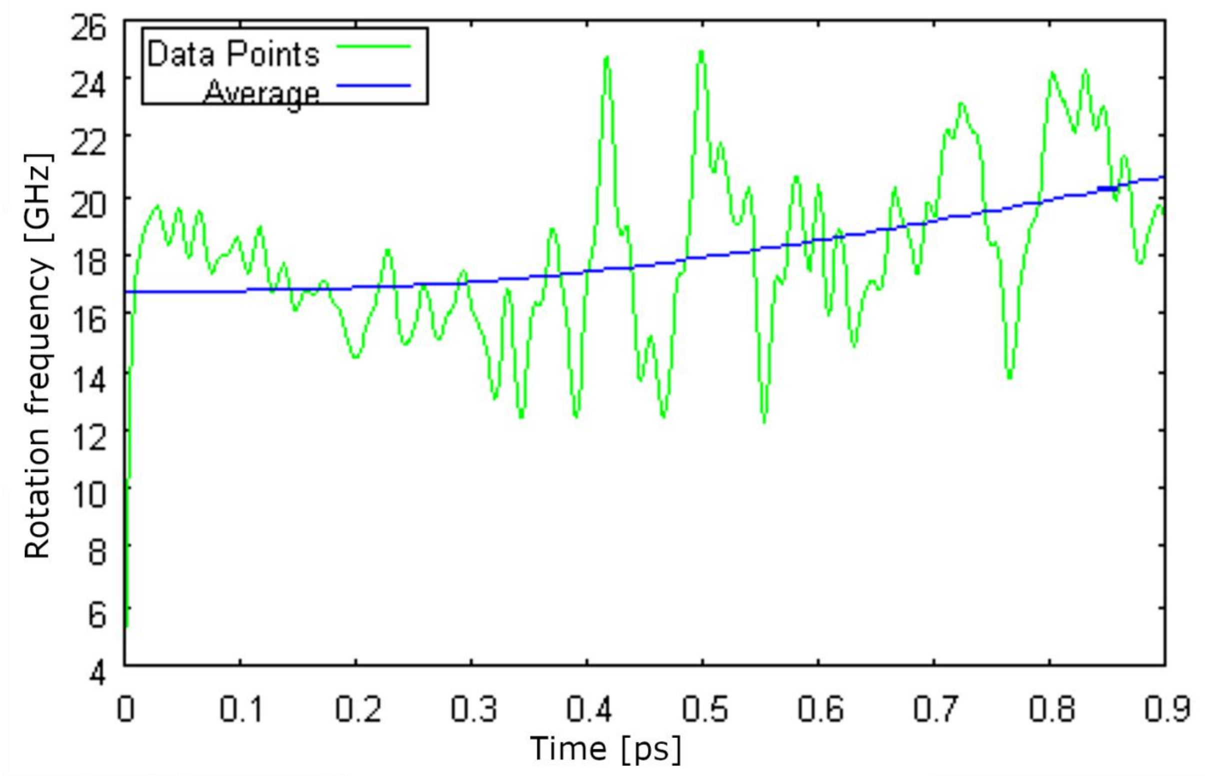


**Figure 7: Velocity plot for the driving (active) nanotube.**

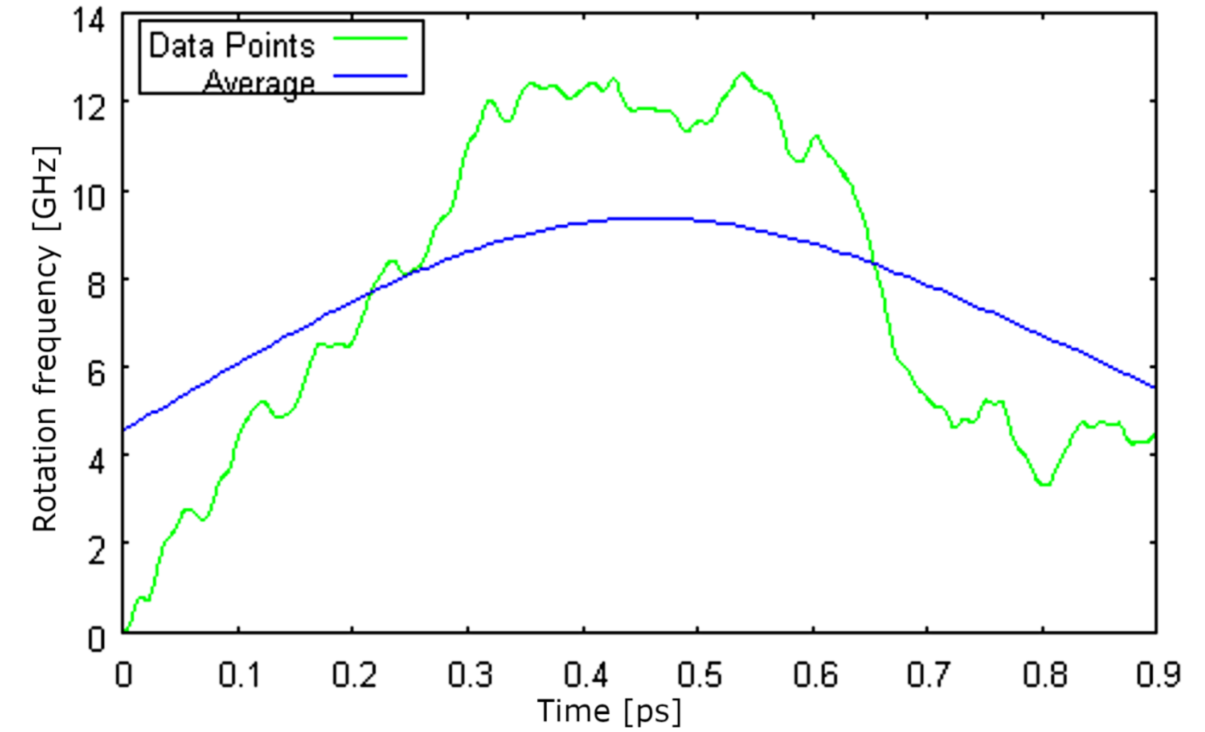


**Figure 8: Velocity diagram for a passive (driven) nanotube.**

As can be seen from the above designed and simulated gearbox with a ratio of 1 to 3 works as expected, although clear pulsations of angular velocity at the output of the gearbox are visible. While an angular velocity corresponding to a frequency of 20 GHz was forced on the driving wheel. The gear ratio resulting from the difference in shaft diameters contributes 1 to 3, so the angular velocity of the passive (receiving) nanotube should correspond to a frequency of 6.6 GHz. Meanwhile, the speed oscillates between 4 and 8 GHz, and the average is 6.6 GHz.

The reasons for this situation can be traced to the fundamental difference between the nano and macro worlds in that some of the phenomena taking place at the nano scale do not exist at the macro scale. The issue here is the granularity of matter, that is, the existence at the molecular level of the building material in the form of individual atoms. In addition, atoms are subject to forces not present at the macro scale. Atoms and molecules attract or repel each other depending on how far apart they are. At small distances, repulsion prevails due to the overlap of wave functions. On the other hand, at large distances there is attraction, which is caused by the presence of van der Waals forces (Kelsall et. al. 2005). Considering the use of nanomechanisms such as, for example, a gear of the type in question for the construction of nanorobots, this poses a potential problem and must be taken into account in their design.

## IV. DISCUSSION AND CONCLUSION

The drive for miniaturization and greater precision is posing increasing challenges to science. One major challenge, for which there is no clear solution affecting the development of nanorobots, is the selection of possible nanomechanisms for their design and practical implementation. The primary source of problems is that there are cardinal differences lying in the basic nature of physical phenomena relevant in the macro, micro and nano worlds. In other words, some of the phenomena that either take place or are relevant at the nano scale do not occur at the micro and macro scales, and vice versa. The simulation studies carried out give some answer to the question of what criteria are relevant and should be taken into account when constructing nanomechanisms, and whether it is at all reasonable to create certain mechanisms at the nanoscale. At the same time, it should be remembered that in nature there are and operate organisms whose nanoscale solutions (Gaissenau 2021)fit and work effectively. This means that perhaps bio nanotechnologies are a way to solve problems, and this is where the opportunity for real development of nanorobotics lies.

## REFERENCES

[1]. Buratowski T., Giergiel M., Polishchuk A., Polishchuk O. (2024) Perspectives and problems of nanoscale robot development. Actual problems of modern science: X Ukrainian-Polish scientific dialogues, 10th international conference. pp. 65–68

[2]. Gaissenau F. (2021) New Perspectives in Biomedical Engineering and Biotechnology: Information in Human and Biological Structures. Archives in BiomedicalEngineering & Biotechnology 6(2), pp.1-3

[3]. Giergiel M. (2024) Certain problems in the development of nanorobots. Online Journal of Robotics & Automation Technology, 2(5), pp. 1–2

[4]. Kelsall R, Hamley I, Geoghegan M. (2005) Nanoscale Science and Technology, John Wiley & Sons, Ltd.

[5]. Khulbe P. (2014) Nanorobots: A Review, Int J Pharm Sci Res 5(6), pp. 2164-2173.

[6]. Okapa C.C. (2024) Advances in Polymer Nanocomposites: Unveiling Benefits International Journal of Engineering Research and Development, 20(4), pp. 69-75

[7]. Singh A., Grover N.K., Singh P. (2014). Surface modification of EDM process using Carbon Nano tubes, A Review. International Journal of Engineering Research and Development, 10(7), pp. 63-68

[8]. Roukes M. (2001) Nanoelectromechanical systems face the future, Physics World 14 (2): 25-31

[9]. Skoć A., Świtoński E. (2016). Gears. Principles of operation. Geometric and strength calculations (in Polish), PWN, Warsaw

[10]. Yang J., Zhang C., Wang X., Wenxue W., Ning Xi, et al. (2019) Development of micro- and nanorobotics: A review. Sci. China Technol. Sci 62: 1-20.

[11]. https://sourceforge.net/projects/nanoengineer-1/ [Accessed: 11.02.2024]