On the Improvement of the Bio-Robots Transmissions: Basic Elements of the Drivings and Alternative Solutions

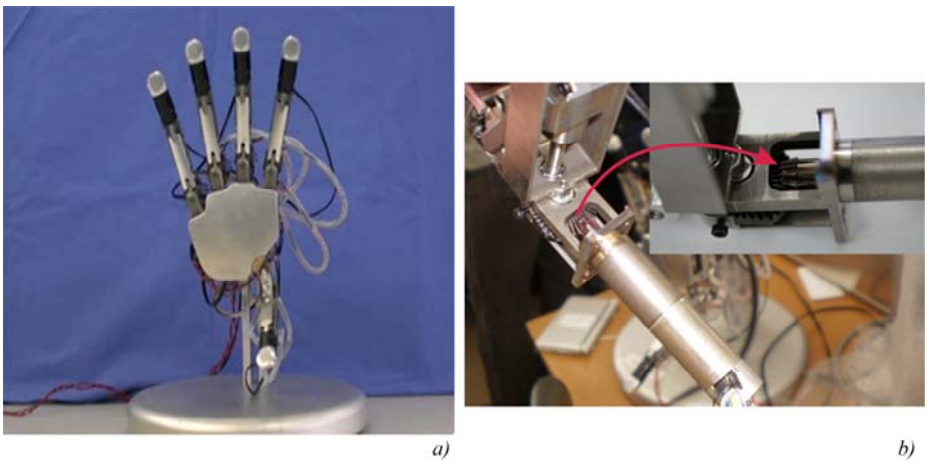
Emilia Abadjieva [1,2], Valentin Abadjiev[2]

[1]Institute of Information and Communication Technologies – Bulgarian Academy of Sciences,
abadjieva@gmail.com
[2]Institute of Mechanics – Bulgarian Academy of Sciences
abadjiev@imbm.bas.bg

Keywords: bio- robot hand; medical examination; rehabilitation; bio-robots; plane gear mechanism; spatial gear drives

The future bio-robots will execute various complicated tasks by communicating with human users. Such robots will be equipped with anthropomorphic multi-fingered hands, which are similar to human hands. The main future purpose of such bio-robot's hand is to replace the human presence, when doing dangerous tasks in the fields such as: industrial manufacturing, space, seabed and so on. One other future application of the bio - robot hand is its use as prosthesis for handicapped people. Hence, the requirement to such bio- robot hands is to obtain characteristics as accuracy and smoothness.

A five-fingered bio- robot hand (see Fig. 1) [1] is developed in an Engineering department of Gifu University. The aim of the robot hand is to be used as the standard platform for the study on dexterous grasping, manipulation of various types of objects and for diagnostics of tumors in female breast.



a) *b)*

Fig. 1. Model of robot hand: a) whole hand; b) bevel gear with straight teeth with $i_{12} = 4$; $z_1 = 10$; $z_2 = 40$; $m = 0{,}5$ mm

adfa, p. 1, 2011.

The current work aims to present the realized by authors activates related with improvement of exploitation properties of the bio-robot hand.
One of the tasks related to the mentioned above goal is to find out a solution to the problems connected to the increment of the number of simultaneously contacting active tooth surfaces and also to create preconditions for controlling the backlash between mating gears which are implemented into the fingers of this hand. This is achieved when a plane bevel gear (Fig. 1b) is replaced with kinematically equivalent spatial gear drive of type Spiroid or Helicon [2, 3, 6-10]. The gear drives shown in Fig. 2 and 3 are specially synthesized by choosing the optimal structure and geometrical characteristics and they are CAD modelled. The aim is smooth integration into already existing robot hand, which will result in its technical precision.

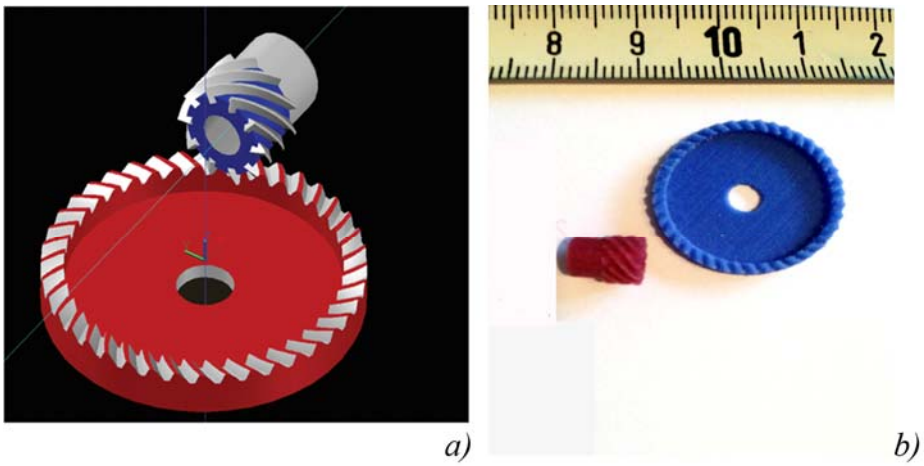


Fig. 2. Helicon gear drive with offset 4 mm, gear ratio 40/10 (axial module 0. 5 mm): a) 3D CAD model; b) 3D printed model (the shown scale is in mm)

The novelty of this design solution is that developed Helicon and Spiroid gears have a boundary small gear ratio. This is a challenge both for their optimization synthesis and design in terms of their technical realization. The reason for this is that these gear pairs usually ensure rotations transformation with gear ratio more than 10.
The extreme difficulty of elaboration with available technical and technological device and the high manufacturing cost, define the reason to use 3D software technology for the creation of the above mention gear transmissions (see Fig 2 and Fig 3).

This 3D software technology include the following stages:

- Mathematical modeling for optimization synthesis of skew-axes gears upon a „pitch contact point“ [3, 4];
- Development of a mathematical model for synthesis upon a „mesh region“ [3, 4] (development of a 3D CAD model);
- 3D printing of the synthesized gear drives.

Fig. 2b and Fig 3b illustrate the last two stages of the 3D software technology.

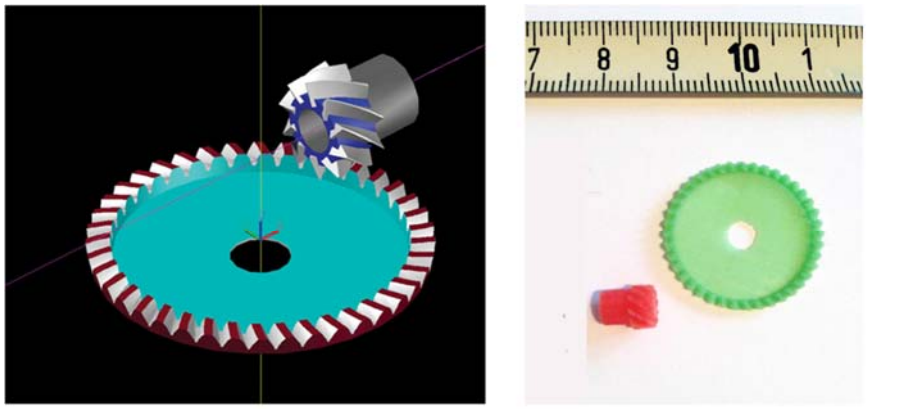


Fig. 3. Spiroid gear drive with offset 4 mm, gear ratio 40/10 (axial module 0. 5 mm): a) 3D CAD model; b) 3D printed model (the shown scale is in mm)

The use of this technology is a guarantee of [5]:

- Shortening of the cycle "innovative idea - innovative product" [8, 9];
- Impetus of the innovative strategies development and increasing the actual quality of the created prototypes by improving their accuracy and a fast realization of various modifications (variants) of a physical prototype;
- Impetus to the process of building a competitive environment;
- Stimulation of the inventive and innovative activity of engineers, designers and scientists.

An essential problem, related to the 3D technology of manufacturing is the optimal choice of 3D printers and materials for the gear sets elaboration. The quality solution of these tasks is a guarantee for the optimal teeth strength, optimal smoothens and hardness of the active tooth surfaces.

Acknowledgment

The authors gratefully acknowledge the funding by project AComIn: Advanced Computing for Innovation of the FP7 Capacity Programme, Research Potential of Convergence Regions, FP7-REGPOT-2012-2013-1; Institute of Information and Communication Technologies

References

1. Mouri, T., Kawasaki, H., Nakagawa, S. and Miura, T., High Power Humanoid Robot Hand, Proc. of RSJ2012, No RSJ2012AC202-3, Sapporo, Japan, (in Japanese), (2012)
2. Abadjieva E., V. Abadjiev, H. Kawasaki, T., Mouri. On the Synthesis of Hyperboloid Gears and Technical Applications, Proceedings of ASME 2011 International Power Transmissions and Gearing Conference, IDETC/CIE 2013, 4-7 August 2013 Portland, Oregon, USA (published on CD) , (2013)
3. Abadjiev, V., Gearing Theory and Technical Applications of Hyperboloid Mechanisms, Sc. D. thesis, Institute of Mechanics, Bulgarian Academy of Sciences, Sofia, (in Bulgarian), (2007)
4. Litvin, F., Gear Geometry and Applied Theory, PTR Prentice Hall, A Paramount, (1994)
5. http://www.cadcamcae.bg/index.php?m=1302&lang=1
6. Abadjieva, E., V. Abadjiev, H. Kawasaki, T. Mouri. Application of the Gearing Primitives to Skew-Axes Gear Set Synthesis. Part. 1. Principles of the Synthesis of Skew-Axes Gears Upon a Pitch Contact Point, Proceedings of 12th National Congress on Theoretical and Applied Mechanics 23-26 September 2013, Saints Constantine and Helena, Varna, Bulgaria, (published on CD) , (2013)
7. Abadjieva, E., V. Abadjiev, H. Kawasaki, T. Mouri. Application of the Gearing Primitives to Skew-Axes Gear Set Synthesis. Part. 2. Mathematical Model for Synthesis and Applications, Proceedings of 12th National Congress on Theoretical and Applied Mechanics 23-26 September 2013, Saints Constantine and Helena, Varna, Bulgaria, (published on CD) , (2013)
8. Abadjieva E., V. Abadjiev, H. Kawasaki. Pitch Configurations- An Innovative Solution to the Synthesis of Hyperboloid Gears. Part 1. Essence and Basic Characteristics of the Innovative Solutions, Advances in Education Research, 2013 The 2nd International Conference on Social Science and Education (ICSSE 2013), December 24-25,2013, Hong Kong, China, Vol. 47, pp. 511-517, ISSN: 2160-1070, (2013)
9. Abadjieva E., V. Abadjiev, H. Kawasaki. Pitch Configurations - An Innovative Solution to the Synthesis of Hyperboloid Gears. Part 2.Analytical and Software Content of Pitch Configurations, Advances in Education Research, 2013 The 2nd International Conference on Social Science and Education (ICSSE 2013), December 24-25, 2013, Hong Kong, China Vol. 47, pp. 518-525, ISSN: 2160-1070, (2013)
10. Abadjiev, V., E. Abadjieva, H. Kawasaki, T. Mouri, D. Petrova. Some Principles of Mathematical Modelling and Computer Synthesis of Hyperboloid Gears with a Conjugate Linear Contact. 2014 International Conference on Information Science, Electronics and Electrical Engineering, ISEEE 2014, April 26-28. 2014. Sapporo City, Hokaido, Japan (published on CD) (2014)