UNIVERSITY OF MISKOLC
FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

CONNECTION ANALYSIS OF SURFACES OF CONICAL WORM, FACE GEAR AND TOOL

THESIS OF PHD DISSERTATION

WRITTEN BY:

SÁNDOR BODZÁS
certified mechanical engineer
assistant professor
Collage of Nyíregyháza

ISTVÁN SÁLYI DOCTORAL SCHOOL,
TECHNICAL MATERIAL STUDIES, THEME GROUP OF PRODUCTION SYSTEMS AND PROCESSES

THE LEADER OF THE DOCTORAL SCHOOL:
Dr. MIKLÓS TISZA
doctor of technical sciences

THE LEADER OF THE THEME GROUP:
Dr. ILLÉS DUDÁS
doctor of technical sciences

SCIENTIFIC LEADER:
Dr. ILLÉS DUDÁS
doctor of technical sciences

MISKOLC
2014.

SÁNDOR BODZÁS

CONNECTION ANALYSIS OF SURFACES OF CONICAL WORM, FACE GEAR AND TOOL

THE THESIS OF PHD DISSERTATION

MISKOLC, 2014

The members of review committee:

President:

Dr. Miklós Tisza

D.Sc., ME, Institute of Material Structure and Material Technology, Institutional Department of Mechanical Technology,
institutional head of department, university teacher

Secretary:

Dr. László Kamondi

Ph.D., ME, Institute of Machine and Product Design,
c. university teacher

Members:

Dr. Péter Horák

Ph.D., BME, Department of Machine and Product Design,
head of department, university docent

Mrs. Óváriné Dr. Zsuzsanna Balajti

Ph.D., ME, Institution of Mathematics, Institutional Department of Descriptive Geometry,
educational vice rector, university docent

Dr. László Sikolya

Ph.D., Collage of Nyíregyháza, Faculty of Agriculture and Engineering, Transportation Science and Infotechnology Faculty,
institution director, head of department, collage teacher

Offical leaders:

Dr. Tibor Bercsey

C.Sc., BME, Department of Machine and Product Design,
university teacher

Dr. Vencel Csibi

D.Sc., Technical University of Cluj Napoca, Department of Mechanics,
university teacher, outer member of MTA

FOREWORD

I graduated in June, 2009 in the University of Miskolc at the Department of Production Technology specialized in quality assurance. I worked as a full time doctoral student from September 2009 till February 2011 at the Department of Production Technology at the University of Miskolc. After gaining my PhD absolutorium from February 2011 I started working at the College of Nyíregyháza, at the Department of Technical Preparatory, Physics and Production Technology as a college lecturer.

I reviewed the field based on previously started results on worm drives and based on the similar marks I am looking for the solution of the missing parts. The dissertation has been made by the published publications, discussions, and books connected to modelling and mathematical toolbars, it deals with the analysis of a new type worm drive from production geometrical point of view.

The structure and the style of this dissertation are theoretical and practical at the same time, which consist of 8 chapters. Bibliography lists more than 170 pieces of work and 44 own publication related to this field.

During the preparation of my dissertation and getting the results there were a lot of people to help me directly or indirectly and I am really grateful for that to all of them.

When I was a university student I showed great interest towards the field of machine production technology and quality assurance. That is why I chose my specialization at the University of Miskolc at the Department of Production Technology.

At the department under the lead of Dr Illés Dudás Professor I did research work as a student in the field of worm drive, I wrote scientific student pages and I wrote my degree from this field as well. My research was supported by "The Analysis of Production Geometry and Connection Characteristics in case of modern worm" **OTKA K 63377.** research project (theme leader: Dr. Illés Dudás).

In the different phases of my research project, many well-known professors and teachers helped my work and I would like to thank to all these people, i.e. **Dr. Lévai Imre** professor, **Dr. Csermely Tibor, Dr. László Dudás, Dr. Ferenc Szabó** docent, **Mrs. Óváriné Dr. Zsuzsanna Balajti** docent, in close cooperation with Budapest University of Technology and Economics, Department of Machine and Product Design **Dr. Tibor Bercsey, Dr. Károly Váradi** professor, and **Dr. Péter Horák** docent, who ensured consultation opportunities for me.

I am grateful for **Dr. Faydor L. Litvin** (University of Illinois, Chicago), **Dr. Alfonso Fuentes Anzar** (University of Cartagena, Cartagena) and **Dr. Illés Dudás** professor, as our published work basically helped my research project.

My doctoral mates, **Dr. Károly Bányai, Zoltán Mándy** and **Mrs. Monostoriné Renáta Hörcsik,** my patent mates, **Szabolcs Illés Dudás**, who all supported my work with useful professional remarks.

I specially thank to the colleagues of "Research Group of Screw and Thread Surfaces" operating on the College of Nyíregyháza (theme leader: Dr. Illés Dudás), their helpfulness, and their professional consultations. I must be thankful for **Dr. Ferenc Szigeti** head of department, **Dr. László Sikolya** head of institution, and **Dr. Róbert Horváth** college teacher for their support.

I also thank to **DifiCAD Engineering Ltd.** for the significant financial and professional support (Miskolc, Szentpéteri Gate 5-7, CEO: Dr. Illés Dudás), where production geometry has been developed, and experimental elements and tools have been produced, and I also thank to **Invest-Trade Ltd.** (Miskolc, Szentpéteri Gate 5-7, CEO: Mrs. Dr. Dudás Illésné) for ensuring the technological background. I thank to the help of **István Kollár** and **László Pallai** during the experimental productions.

I thank to István Sályi Doctoral School and its head professor **Dr. Miklós Tisza** for supporting my work.

Finally I would like to thank to **My Family** here, that they provided me with a relaxed background without which this dissertation has not been made.

TABLE OF CONTENT

FOREWORD 4
1. INTRODUCTION 6
  1.1. The objective of the research project 6
  1.2. The antecedent of research 7
  1.3. The aim of this dissertation 7
2. THE METHOD OF SOLVING THE TASKS 10
3. NEW SCIENTIFIC RESULTS OF THE DISSERTATION 11
4. DIRECTIONS FOR FURTHER DEVELOPMENT, OPPORTUNITIES 13
5. PUBLICATIONS IN THE TOPIC OF THE DISSERTATION 14
  5.1. Ongoing publications 18
6. PROFESSIONAL LECTURES IN THE TOPIC OF THE DISSERTATION 20
7. BIBLIOGRAPHY QUOTED IN THE THESIS 21
  7.1. The researches, projects that serve as antecedent for this dissertation 21

1. INTRODUCTION

I have written my Ph.D. dissertation from designing the tooth, production of tooth surfaces. Energy loss in power units can be reduced by modern drive pairs which have good efficiency and high portative characteristics, and have favourable hydrodynamic ratio. From the point of view of the loss in capacity it is not indifferent that from the possible tooth geometry characteristics we apply those ones which result in favourable connecting relations.

The topic of this Ph.D. dissertation is a modern, new type, conical worm gear drive pair having arched profile {1, m4, m7, m9} **which has low sound level and good efficiency; the analysis of the meshing production tool, its development steps, its modelling, its production and its evaluation.**

1.1. The objective of the research project

The conical worm - face gear spiroid drive pair - like robots, tool machines and jointless drives, can be applied as advantageous because jointless drives can be ensures by feeding (setting) the worm in a simple axial direction.

In case of the cylindrical helicoidal surfaces having arched profile, concave - convex tooth connection is favourable because of lubrication conditions and to reduce connection tension [2, 10]. A new geometric conical worm drive that is the worm drive having arched profile in axial section was developed by mixing the favourable characteristics of the worm drive having cylindrical arch profile and the worm gear having linear component. During the research the following problems were solved:

1.) On the basis of production and connection geometric point of view, mathematical functions were defined for choosing the proper arch radius values in axial section in the case of conical worm drive having arched profile in axial section based on arch radius distance and earlier literatures.

2.) Factors that affect the connection area were also defined in case of worm drive having arched profile in axial section. With exploring the connection between the connection area and the geometric parameters the most favourable connection and tooth have been determined.

3.) Based on previous production geometric models [3, 5, 7, 10] for producing geometrically proper conical helicoidal surface, a newly developed model has been made. During its production in the function of conical worm drive angular displacement, shaft distance and pitch angel correction are constantly changing. This model serves as the theoretical basis of making a new CNC machine.

4.) With the knowledge of the cutting edges of the face gear hob on the basis of double mashing, surface points of the face gear have been determined by numerical method, then drive pair (spiroid worm and face gear) and the CAD model of the hob has been made.

5.) The mathematical model has been defined with the knowledge of the distinctive surfaces of the hob, during the resharpening along the face surface of the hob, new cutting edges are produced of which the face gear comprises for defining tooth surfaces points of the face gear.

6.) Analyzing the manufactures spiroid worm shaft by three coordinate measuring technique.

1.2. The antecedent of the researches

Dissertations of Dr. Illés Dudás [5, 10, 11], research projects led by him, from which the outstanding results are the following:

- Designing, manufacturing and validation of cylindrical worm drive having arched profile in axial section [3, 4, 5, 7, 8, 10, 11, 14].
- Developing a new grinding method, where the profile of the wheel is the same as the back worked of the worm.
- With this knowledge, choosing the optimal wheel hobbing place will result in a worm having profile error within the tolerance level [3, 6].
- Developing a general mathematical model for analyzing cylindrical, conical helicoidal surfaces and worm gear hob and face gear hobs [1, 3, 7, 10].
- Designing CNC grinding wheel hobbing equipment, which makes it possible to produce any arbitrary helicoidal surface [3, 6, 9].
- Analyzing and further developing the singularity and undercut conditions of the conjugated surface pairs from geometric and production geometric point of view [K6].
- Geometric analysis and modelling of regression surfaces [K7].
- Applying numerical methods for localizing the contact area, for further developing tool profile analysis. For this different Coons spots, Gordon and Bezier spline surfaces were used [1, K7].

1.3. The aim of this dissertation

The aim of this dissertation is to solve the following tasks, based on the results so far, carried out by the members of the so called "worm gear school" (Dr. Zsuzsanna Óváriné Balajti, Dr. Károly Bányai, Dr. János Csóka, Dr. László Dudás, Sándor Bodzás, Zoltán Mándy, Renáta Monostoriné Hörcsik, etc.) which is led by Dr. Illés Dudás. The tasks are the following:

1.) With the knowledge of the advantageous characteristics of cylindrical and direct line generating conical worm drives having arched profile in axial section, the new type conical worm drive - conical worm drive having arched profile in axial section - and its production tool has to be developed and analyzed.

2.) The mathematical analysis of conical worm drive surface having arched profile in axial section (Figure 1.1). Between the conical foot- and addendum surfaces there is the pitch surface along which the profile curve is constantly changing due to arch radius distance because of the pitch circle diameter. That is why the main goal is the optimum election of the arch radius and the position of the arch radius distance by production and meshing aspects.

3.) In case of conical worm drive having arched profile in axial section, defining the meshing area and the geometrical parameters are the main goals, and the meshing and the formation of the tooth should be optimalised.

4.) On the basis of the mathematical model made by Dr. Illés Dudás [3], the machining of the conical worm with a wheel banking angle correction, an improved mathematical model can be defined (Figure 1.2).

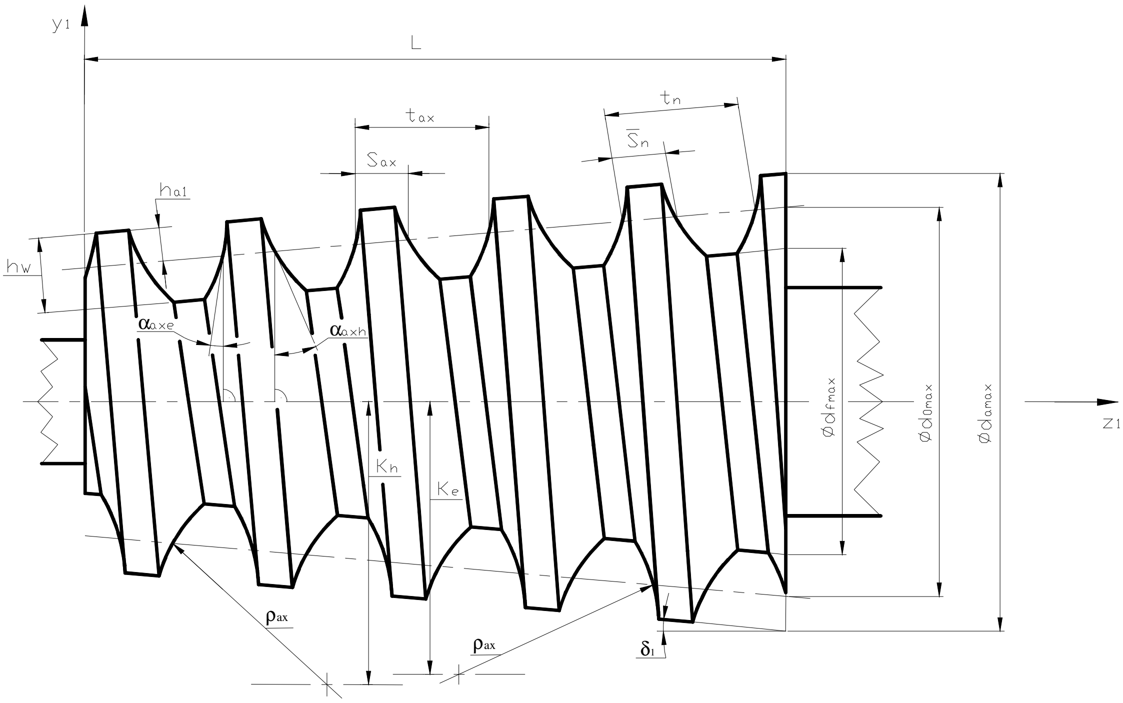

Figure 1.1
The profile and the geometric characteristics of conical worm having arched profile

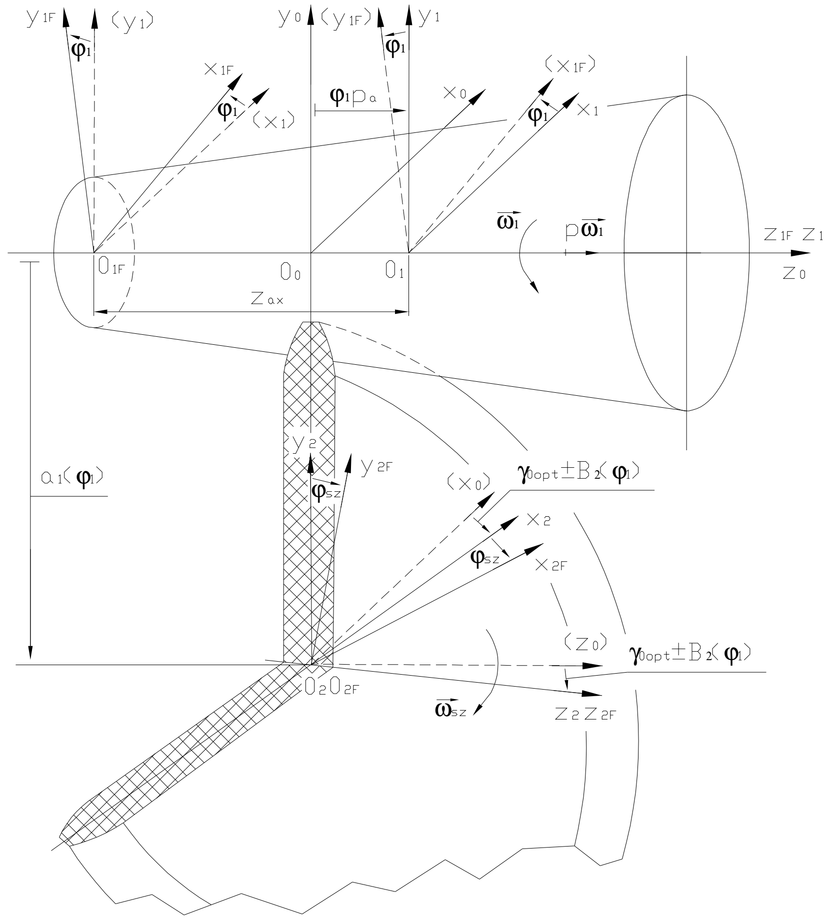

Figure 1.2
The mathematical modell of the conical worm production using grinding wheel banking angle correction

5.) The definition of a modelling method by which any arbitrary conical worm connecting with tooth profile of a face gear can be produced. With the knowledge of the tooth surface of the face gear one should model (CAD) the conical worm gear drive pair, the face gear hob. To verify the accuracy of CAD modelling, rapid prototyping model, real production of the drive pair and its production tool must be done.

6.) Determining the mathematical model just to define the face gear profile points and the face gear profile error which can be produced by the new cutting edges that can be made during the resharpening along the face surface of the face gear hob (Figure 1.3). This model can be applied to define the sharpenability range of the face gear hob having arched profile in axial section.

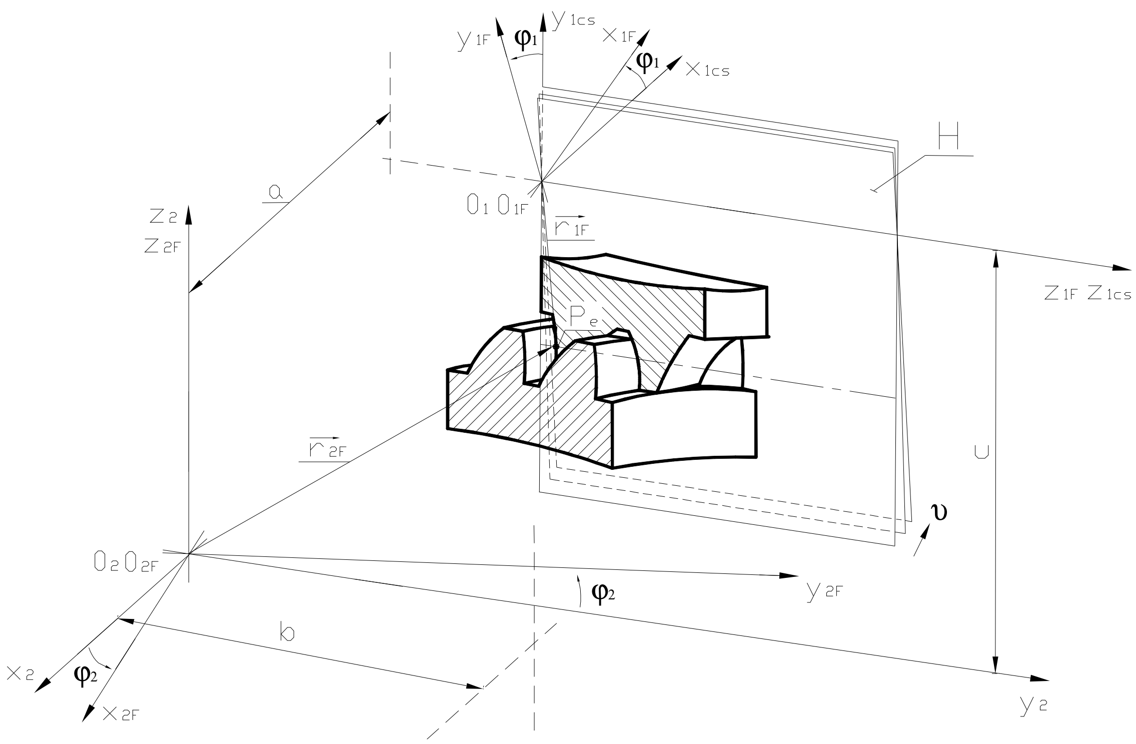

Figure 1.3
Mathematical model for defining the tooth surface of face gear derived from the resharpening of the hob

2. THE METHOD OF SOLVING THE TASKS

For the analysis of conical worm having arched profile in axial section, the two parametric vector - scalar function of the worm profile has been defined.

For choosing the proper arch profile value of the worm in axial section, Krivenko's offers [12] for cylindrical worm having arched profile in axial section were applied.

The most favourable connection and tooth formation positions were chosen, i.e. to determine the optimal arch profile distance and arch radius values in axial section, you should analyze the profile establishments and the position of the contact lines.

Those geometric parameters of the worm were determined which have an effect on the positioning of the contact lines.

In the further developed mathematical model, which is the shaft distance between the conical worm and its production tool, and change of the banking of the production tool with wheel banking angle correction at the same time, make it possible to produce the proper worm shape. Tool profile connected to optimal wheel hobbing place should be defined with which conical worm can be ground, and the result will be a geometrical proper helicoidal surface with the constant change of the shaft distance and the wheel banking angle. The solution of the task with kinematic method is based on the theory of double mashing.

Making of the mathematical model is to produce the tooth profile of the spiroid face gear. Producing the tooth profile points of the face gear is with numerical calculations, according to direct method of kinematic method (designing of the needed tool for a given helicoidal surface).

Face gear produced by double mashing is to fit an interpolate B spline spatial surface onto tooth surface points.

With the use of Solid Works 2012 designing software CAD model of the worm drive pair and production tool have been produced.

For verifying the accuracy of modelling and connection on the basis of polyjet method, with the help of OBJET Eden 350 V print machine, the physical model of the worm drive pair and face gear hob have been made.

The defining process of the tooth surface points of the face gear formed by the resharpening of the hob along the face surface is with numerical calculations according to direct method of kinematic method.

The face surface of the conical face gear hob having arched profile in axial section, its backworked side surfaces and cutting edges have been determined by analytical method, then resharpenable analysis were made along the face surface of the hob, considering the profile accuracy of the hob and face gear hob.

Checking the results and the operations - matrix - matrix and matrix - vector multiplications - of the transformation matrices applying homogeneous coordinates by DERIVE software has been done.

In this dissertation calculations happened with the help of software written in MATLAB language developed on my own.

For the verification of the given results, the conical worm drive having arched profile in axial section, the production tool and the spiroid worm shaft have been produced and checked by Aberlink Axiom TOO 3D type, CNC controlled, three coordinate measuring machine.

3. NEW SCIENTIFIC RESULTS OF THE DISSERTATION

Thesis 1: The production and meshing analysis of conical worm gear drive pair having arched profile in axial section - a new geometrical worm gear drive pair, which unifies the characteristics of cylindrical worm having arched profile in axial section and worm gear drive pairs having direct line profile - have been carried out {1, m4}.

In case of conical worm drives having arched profile in axial section, there is a certain connection to define the value of arch radius in axial section ρ_{ax} and K arch radius distance as a function of the parameters of the worm (modul in axial section, pitch circle diameter, profile angle). I stated that arch radius distance should be calculated on the pitch circle diameter that is situated in the half of the conical worm pitch length. This is because in that case the geometrical and meshing parameters of the profile shape will be suitable, the width of foot and addendum surface will be also appropriate and the tooth of the worm gear will not be sharpened {1, 17, m4, m7, m10}.

Thesis 2.: Parameters which have a great effect on meshing area have been analyzed in case of conical worm gear drive pairs having arched profile in axial section. The value of the arch radius in axial section and the changing of the profile angles have an effect on the meshing area. By determining the relationship between the meshing area and the geometrical parameters and with the analysis of the meshing areas acquired by the profile angle in axial section ($\alpha_{axe} = 6 \div 16°$) and the changing value of arch radius ($\rho_{ax} = 27 \div 37 mm$), the best meshing and tooth formation position have been stated. Based on this I have made suggestions for the choice of the value of the arch radius in axial section ($\rho_{ax} = (6 \div 8) \cdot m_{ax}$) and the profile angel on the low and high side of the worm ($\alpha_{axe} = 8 \div 14°$, $\alpha_{axh} = 34 \div 40°$) {1, 17, m4}.

Thesis 3.: A new kinematical model has been carried out in which the shaft distance between the conical worm and its production tool and banking the production tool by its wheel banking angel correction made it possible to machine a conical worm which has a different geometrical accuracy and preciseness as before.

Based on double meshing theory taking into consideration the transmission change between the wheel and the worm due to the geometry of the conical worm, the formation of the grinding wheel profile in case of changing shaft distance and changing wheel banking angle correction was also carried out. Application of the changing shaft distance during production and the changing wheel banking angle correction, changing wheel profile values calculated at the smallest and the largest pitch circle diameters of the worm, are within a thinner range as opposed to those without wheel banking angle correction. Thus the optimal tool profile determination method, suggested by Dr. Illés Dudás, and with the application of wheel banking angle correction, a more precise thread profile can be produced. This results in a more accurate worm than in case of a worm produced without wheel banking angular correction {12, m3, m8, m11}.

This method provided a basis for a modern CNC path control.

Thesis 4.: Based on the path of the cutting edge the tooth surface points of the spiroid face gear were calculated in a numerical way. I draw B spline spatial surface on the tooth surface points by interpolation so that I could make the face gear by computer geometrical model. The accuracy of the calculations and modelling were verified by Rapid Prototyping production and real production also, as an appropriately meshing drive pair was produced.

I determined the applied method is adapted for the modelling of face gear of spiroid gear drive having arched profile in axial section, the description of tooth surfaces and other analysis {5, 10, 15, 16, 21, 24, 25, 37, 39, 40, 42, m1}.

Thesis 5.: The face surface of the conical face gear hob having arched profile in axial section, along the logarithm spiral radially backworked side surface and the equations of the cutting edges have been defined. The face gear tooth surface which can be produced by the new cutting edges that can be made during the resharpening along the face surface of the face gear hob has been also defined. Resharpening analyses were carried out along the face surface of the hob in a numerical way, in case of conical face gear hob having arched profile in axial section. During the sharpening analysis I could state the following {17, 27, 42, m5, m6}:

a) The resharpening border angle position ($\vartheta = 5°$) in case of conical face gear hob having arched profile in axial section is due to the fact that in case of an angle position which is larger than this angle, in axial plain of the hob, the tooth profile of the high side of the face gear will be not within tolerance limit and the reduction of the height of the tooth is also over the appropriate limit.
b) Thus it is always the tooth of the high side of the face gear that should be analyzed because this determines the limit of resharpenability of the hob.

4. FURTHER DIRECTIONS FOR DEVELOPMENT, OPPORTUNITIES

1.) During the resharpening process along the face surface of the conical face gear hob having arched profile in axial section, analysis of the change of the edge angle of the tool was taken place, in the function of the profile accuracy of the face gear.

2.) The analysis of the conical worm having arched profile in axial section, more than one number of threads of the conical worm, based on production and connection geometric point of view was defined.

3.) Rigidity analysis and analysis with finite element method, the deformation of the tool shaft during manufacturing the face gear having arched profile manufactured by a hob have taken place.

4.) Determining the tooth range of the conical worm drive having arched profile in axial section, from the point of view of maximal number of threads, the least number of teeth, the linear dimension of the worm, interference, undercutting etc.

5.) Analysis and simulation of the dynamic behaviour of the conical worm drive having arched profile in axial section.

5. PUBLICATIONS IN THE TOPIC OF THIS DISSERTATION

Patent notice

{1} **Dudás, I., Bodzás, S., Dudás, I. Sz., Mándy, Z.:** *Konkáv menetprofilú spiroid csigahajtópár és eljárás annak köszörüléssel történő előállítására*, Szabadalmi iktatószám: P1200405, Szabadalmi bejelentés napja: 2012.07.04.

The percentage of the amount of work of the authors:

Dr. Illés Dudás: 50 %, **Sándor Bodzás:** 20 %, **Illés Szabolcs Dudás:** 20 %, **Zoltán Mándy:** 10%

Lectured foreign journal articles written in foreign language

{2} **Dudás, I., Bodzás, S.:** *Geometric analysis and mathematical modelling of spiroid worm*, Journail Technological Engineering, number 2/2011, volume VIII, Zilina, Csehország, pp.: 6 – 9., ISSN 1336 – 5967

{3} **Dudás, I., Bodzás, S.:** *Production geometry analysis, modeling and rapid prototyping production of manufacturing tool of spiroid face gear*, Advenced Manufacturing Technology, Springer, (Online), 2012.07.19. (Online), ISSN 0268-3768 (Print), Volume 66, Issue 1 - 4., pp. 271 – 281., 2013. 04. (Printed), **(IF 1.203)**
http://www.springerlink.com/content/t12l4xh51g664266/?MUD=MP
http://www.springer.com/home?SGWID=0-0-1003-0-0&aqId=2362785&download=1&checkval=5131188b9d22673b4f7f1f6eb76f3a2e

{4} **Dudás, I., Bodzás, S.:** *Measuring technique and mathematical analysis of conical worms,* Advenced Manufacturing Technology, Springer, ISSN 0268-3768, DOI 10.1007/s00170-012-4483-7, 2012.09.14., **(IF 1.203)**
http://www.springerlink.com/content/97744668843ukp07/
http://www.springer.com/home?SGWID=0-0-1003-0-0&aqId=2388273&download=1&checkval=51c4b487d0f43b24be21924d58a0daf9

{5} **Bodzás, S., Dudás, I.:** *CAD modelling and additive production of conical worm and conical face gear,* Journal Technological Engineering, number 1/2012, volume IX, Zilina, Csehország, pp.: 13 – 16., ISSN 1336 – 5967

{6} **Dudás, I., Bodzás, S., Mándy, Z.:** *Solving the pitch fluctuation problem during the manufacturing process of conical thread surfaces with lathe center displacement,* International Journal of Advenced Manufacturing Technology, Springer, ISSN 0268-3768 (Online), 2013.06.14. (Online), Volume 66, Numbers 9 – 12, (**IF 1.203**)
DOI 10.1007/s00170-013-5010-1,
http://link.springer.com/article/10.1007%2Fs00170-013-5010-1
http://www.springer.com/home?SGWID=0-0-1003-0-0&aqId=2485615&download=1&checkval=b52fa61a5054910ead25d69d932b7803

{7} **Bodzás, S., Dudás, I., Horváth, R., Dudás, I. Sz., Mándy, Z.:** *Measuring and analysis of noise level of a new geometric, arched profile conical worm gear drive in axial section*, Machine Design, Volume 5, Numbers 2, 2013, Novi Sad, Szerbia, pp. 75 – 78., ISSN 1821-1259

Lectured domestic journal articles written in foreign language

{8} **Bodzás, S., Dudás, I.:** *Designing of Smoother Hob,* Hungarian Journal of Industrial Chemistry, 2010, Volume 38, Number 2, Pannon Egyetem, Veszprém, pp.: 89 – 94., ISSN 0133-0276

{9} **Bodzás, S., Dudás, I.:** *Production geometrical analysis of logarithm spiral backward turned curve,* Debrecen, Debreceni Műszaki Közlemények 2010/2, 2010.10.25., pp.: 49 - 55., http://www.mfk.unideb.hu/userdir/dmk/docs/20102/, ISSN 2060-6869

{10} **Bodzás, S., Dudás, I.:** *Connection theory of conical worm gear drives*, Hungarian Journal of Industrial Chemistry, 2011, Volume 39, Number 2, Pannon Egyetem, Veszprém, pp.: 173 – 176., ISSN HU ISSN 0133-0276

Lectured journal articles written in Hungarian

{11} **Bodzás S., Dudás I.:** *Csavarfelületek méréstechnikai elemzése,* GÉP folyóirat LXI. évfolyam 2010/3, Gépipari Tudományos Egyesület, Miskolc, 2010.07.06., pp.: 3 - 9., ISSN 0016-8572

{12} **Bodzás S., Dudás I.:** *Kúpos csavarfelület előállítása változó köszörűkorong bedöntési szög korrekcióval,* GÉP folyóirat LXIV. évfolyam 2013/3, Gépipari Tudományos Egyesület, Miskolc, 2013.03., pp.: 3 – 6., ISSN 0016-8572

Lectured foreign conference issues written in foreign language

{13} **Bodzás, S., Bányai, K., Dudás, I.:** *Worm gear drives measuring*, Annals of MTeM for 2009 and Proceedings of the 9th International Conference Modern Technologies in Manufacturing, Cluj Napoca, Romania, 2009.10.08. -2009.10.10. pp.: 17 - 21., ISBN 973-7937-07-04

{14} **Bodzás, S., Dudás, I.:** *Backward turning of hob along logarithm spiral*, IN-TECH 2010, Tisk AS, s.r.o., Jaromer, Prague, Czech Republic, 2010.09.14. - 2010.09.16., pp.: 255 - 257., ISBN 978-80-904502-2-6

{15} **Dudás, I., Bodzás, S.:** *Geometric analysis and mathematical modelling of spiroid worm,* 10th International Symposium on Measurement Technology and Intelligent Instruments, ISMTII 2011, Daejeon, South Korea, http://www.ismtii2011.org/article/xml/sub/current.kin

{16} **Bodzás, S., Dudás, I.:** *Modeling and mathematical analysis of conical helical surface*, Annals of MTeM for 2011 and Proceedings of the 10th International Conference Modern Technologies in Manufacturing, Cluj Napoca, Romania, 2011.10.05. - 2011.10.07., pp.: 37- 40., ISBN 978-606-8372-02-0

{17} **Dudás, I., Bodzás, S.:** *The analysis of cutting edges of face gear hob with analytical calculation and three coordinate measuring machine,* 11th International Symposium on Measurement Technology and Intelligent Instruments, ISMTII 2013, 2013. 07.01. – 2013. 07. 05., Aachen, Németország, pp. 30. (abstract), Terjedelem: 6 oldal, Guide to Selected Topics pp. 22., ISBN 978-3-86359-138-0

„The publication and the travelling to the ISMTII 2013 Conference was carried out as part of the **TÁMOP-4.2.2/B-10/1-2010-0008** project in the framework of the New Hungarian Development Plan. The realization of this project is supported by the European Union, co-financed by the European Social Fund."

{18} **Bodzás, S., Dudás, I.:** *The geometric controlling of a new type spiroid worm shaft by three coordinate measuring machine*, Annals of MTeM for 2013 and Proceedings of the 11th International Conference Modern Technologies in Manufacturing, Cluj Napoca, Romania, 2013.10.17. - 2013.10.19., pp.: 5 - 11., ISBN 973-9087-53-1

Lectured domestic conference issues written in foreign language

{19} **Bodzás, S., Dudás, I.:** *Modern quality assurance of spiroid worm, Factory Automation 2010,* Kecskeméti Főiskola GAMF Kar, Kecskemét, 2010.04.15. - 2010.04.16., pp.: 139 - 144., ISBN 978-963-7294-83-9

{20} **Dezső, G., Dudás, I., Péter, L., Bodzás, S.:** *Multicontast problem of spiroid worm gear drives,* XXV. microCAD International Scientific Conference, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2011.03.31 – 2011.04.01., pp.: 47 – 52., ISBN 978-963-661-965-7

{21} **Bodzás, S., Dudás, I.:** *Production geometry and finite element method analisys of archimedean worm gear drive*, XXV. microCAD International Scientific Conference, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2011.03.31 – 2011.04.01., pp.: 29 – 34., ISBN 978-963-661-965-7

{22} **Bodzás, S., Dudás, I., Péter, L., Dezső, G., Kósa, P., Százvai, A.:** *Rapid prototyping production of conical worm with arched profile,* XXV. microCAD International Scientific Conference, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2011.03.31 – 2011.04.01., pp.: 35 – 40., ISBN 978-963-661-965-7

{23} **Bodzás S., Dudás I.:** *Analysis of the grinding territory of worm gear hob*, International Multidisciplinary Conference 2011 9th Edition Proceedings, Bessenyei Publishing House, Nyíregyháza, 2011.05.19 – 2011.05.21., pp.: 61 – 66., ISBN 978-615-50-97-18-8

{24} **Mándy, Z., Dudás, I., Bodzás, S.:** *Manufacture of spiroid worm surfaces in modern intelligent integrated systems*, Factory Automation Conference 2011, Széchenyi István Egyetem, Győr, 2011.05.24 – 2011.05.26., pp.: 140 – 147., ISBN 978-963-7175-3

{25} **Bodzás, S., Dudás, I.:** *Modeling and prototyping production of conical face gear hob*, Proceedings of the 13th International Conference of Tools ICT 2012, Miskolc, 2012.03.27 – 2012.03.28., pp.: 339 – 345., ISBN 978-963-9988-35-4

{26} **Bodzás, S., Dudás, I.:** *Mathematical generation and modeling of face gear surface*, The Publications of the XXVI. microCAD International Scientific Conference CD, Miskolci Egyetem, Miskolc, 2012.03.29 – 2012.03.30., ISBN 978-963-661-773-8

{27} **Bodzás, S., Dudás, I.:** *Defining of the resharpening territory of the new type spiroid face gear having arched profile by analytic calculations,* International Multidisciplinary Conference 2013 10th Edition Proceedings, Bessenyei Publishing House, Nyíregyháza, 2013.05.22. – 2013.05.24., pp.: 29 – 34., ISBN 978-615-5097-66-9

Not lectured domestic conference issues written in foreign language

{28} **Bodzás, S., Pudmer, S. G.:** *Theoretical basis of Measurements of Conical Thread Surfaces on 3D Measuring Machine,* XXIII. microCAD International Scientific Conference, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2009..03.19. - 2009.03.20., pp.: 41 - 46., ISBN 978-963-661-878-0

{29} **Bodzás, S., Dudás, I.:** *Analysis of production geometry of the hob for producing helical surfaces,* Doktoranduszok Fóruma, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2009.11.05., pp.: 33 -39.

{30} **Bodzás, S., Dudás, I.:** *Modern Check up of Spiroid Worm*, XXIV. microCAD International Scientific Conference, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2010.03.18. - 2010.03.20., pp.: 45 - 51., ISBN 978-963-661-918-3

{31} **Bodzás, S.:** *The Geometrical Examination of Worm Gear Hobs*, XXIV. microCAD International Scientific Conference, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2010.03.18. - 2010.03.20., pp.: 39 - 45., ISBN 978-963-661-918-3

{32} **Bodzás, S., Dudás, I.:** *Defining of the maximum grinding angle of hobs by advancing method,* Doktoranduszok Fóruma, Miskolci Egyetem Innovációs és Technológia Transzfer Centrum, Miskolc, 2010.11.10. pp.: 25 – 30.

{33} **Bodzás, S., Dudás, I.:** *Designing and modelling of worm gear hob*, Doktoranduszok Fóruma, Miskolci Egyetem Tudományszervezési és Nemzetközi Osztály, Miskolc, 2011.11.08., pp.: 12 – 17.

{34} **Bodzás, S., Dudás, I., Horváth, R.:** *Measuring and analysis of noise level of spiroid worm gear drive*, Doktoranduszok Fóruma, Miskolci Egyetem Tudományszervezési és Nemzetközi Osztály, Miskolc, 2012.11.08., pp.: 18 - 23.

’This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of TÁMOP-4.2.2.B-10/1-2010-0008.’

{35} **Bodzás, S., Dudás, I.:** *Finite element method analysis of special conical transmission,* The Publications of the XXVII. microCAD International Scientific Conference CD, Miskolci Egyetem, Miskolc, 2013.03.21 – 2013.03.22., ISBN 978-963-358-019-9

Lectured conference issues in Hungarian

{36} **Bodzás S., Dudás I.:** *Csigakerekek megmunkálása és a megmunkáló szerszám köszörüléséhez szükséges maximális korongátmérő meghatározása*, Gyártás 2010 „Manufacture” CD, MANUFACTURE-HU Nemzeti Technológiai Platform „GTENTP08” Szakmai Tanácsadó Testülete 2010, Budapest, 2010.10.20. - 2010.10.21., ISBN 978-963-9058-31-6

{37} **Dudás I., Bodzás S.:** *Csigakerék lefejtőmaró élezhetőségi tartományának meghatározása közelítő módszerrel*, XVI. Fiatal Műszakiak Tudományos Ülésszaka 2011, Erdélyi Múzeum Egyesület kiadványa, Kolozsvár, Románia, 2011.03.24 - 2011.03.25. pp.: 83-87., ISSN 2067-6 808

{38} **Dudás I., Bodzás S.:** *Spiroid csiga matematikai, geometriai modellezése és gyors prototípus gyártása*, Multidiszciplináris Tudományok, 1. kötet, 1. szám, Miskolc, 2011. pp.: 159 – 167., HU ISSN 2062 – 9737

Not lectured conference issues written in Hungarian

{39} **Bodzás S., Dudás I.:** *Lefejtőmaró gyártásgeometriai vizsgálata*, Műszaki Tudomány az Észak Alföldi Régióban Konferencia 2010, Debreceni Akadémiai Bizottság Műszaki Szakbizottsága, Nyíregyháza, 2010.05.19., www.mfk.unideb.hu/mszb/muszfuz, pp.: 187 - 193., ISBN 978-963-7064-23-4

{40} **Dudás I., Bodzás S.:** *Spiroid csiga matematikai, geometriai modellezése és gyors prototípus gyártása*, Miskolc, Műszaki Tudomány az Észak - Kelet Magyarországi Régióban 2011, Debreceni Akadémiai Bizottság Műszaki Szakkbizottsága, Debrecen, 2011.05.18., http://store1.digitalcity.eu.com/store/clients/release/mtekmr_2011.pdf, pp.: 215 – 220., ISBN 978-963-7064-25-8

{41} **Bodzás S., Dudás I.:** *Kúpos csigahajtás virtuális és gyors prototípus modellek előállítása*, XVII. Fiatal Műszakiak Tudományos Ülésszaka 2012, Erdélyi Múzeum Egyesület kiadványa, Kolozsvár, Románia, 2012.03.22. – 2012.03.23. pp.: 63 – 67., ISSN 2067 – 6 808

{42} **Bodzás S., Dudás I.:** *Spiroid tányérkerék megmunkálószerszám hátraesztergálási görbéjének megválasztása*, Miskolc, Műszaki Tudomány az Észak - Kelet Magyarországi Régióban 2012 Konferencia, Debreceni Akadémiai Bizottság Műszaki Szakkbizottsága, Szolnoki Főiskola, Szolnok, 2012.05.10., http://store1.digitalcity.eu.com/store/clients/release/mtekmr_2012.pdf, pp.: 181-191., ISBN 978-963-7064-28-9

{43} **Bodzás S., Dudás I.:** *Kúpfelületű csigakerék lefejtőszerszám gyors prototípusgyártása,* V. Nyíregyházi Doktorandusz (PhD/DLA) Konferencia Kiadványa, CD, Nyíregyházi Főiskola, Nyíregyháza, 2012. 12.04., pp.: 38-41., ISBN 978-963-9909-9

{44} **Bodzás S., Dudás I., Horváth R.:** *Kúpos csigahajtómű zajszintjének vizsgálata,* A VI. Nyíregyházi Doktorandusz (PhD/DLA) Konferencia Kiadványa, Szent Atanáz Görögkatolikus Hittudományi Főiskola, Nyíregyházi Főiskola, Debreceni Egyetem Egészségügyi Kara, Nyíregyháza, 2013., pp.: 9-14., ISBN 978-615-5073-18-2

5.1. Ongoing publications

Lectured foreign journal articles written in foreign language

{m1} **Bodzás, S., Dudás, I.:** *Additive production technique and analysis of spiroid worm gear drive*, Journal of Engineering and Automation Problems, Moszkva, Oroszország

{m2} **Bodzás, S., Dudás, I.:** *Comparative finite element method analysis of spiroid worm gear drives having arched profile and having linear profile in axial section,* Journal Technological Engineering, Csehország

{m3} **Dudás, I., Bodzás, S.:** *The kinematical model for the geometrically appropriate production of cylindrical and conical helidoidal surfaces having unvaried lead*, International Journal of Advenced Manufacturing Technology, Springer **(impakt faktor)**

{m4} **Dudás, I., Bodzás, S., Dudás, I. Sz., Mándy, Z.:** *Development of spiroid worm gear drive having arched profile in axial section and a new technology of spiroid worm manufacturing with lathe center displacement,* International Journal of Advenced Manufacturing Technology, Springer **(impact faktor)**

{m5} **Bodzás, S., Dudás, I.:** *Mathematical model for investigation of face gear tooth surface manufactured by new cutting edges of spiroid hob having arched profile in axial section,* Machine Design, Novi Sad, Szerbia

’This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of **TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’.**

Lectured journal articles written in Hungarian

{m6} **Bodzás, S., Dudás, I.:** *Tengelymetszetben körív profilú tányérkerék lefejtőmaró gyártásgeometriai elemzése,* GÉP folyóirat, Gépipari Tudományos Egyesület, Miskolc

’This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of **TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’.**

Lectured domestic conference issues written in foreign language

{m7} **Bodzás, S., Dudás, I.:** *Analysis of contact curves of spiroid worm gear drive having arched profile*, Doktoranduszok Fóruma 2013, Miskolci Egyetem Tudományszervezési és Nemzetközi Osztály, Miskolc

’This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of **TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’.**

{m8} **Bodzás, S., Dudás, I.:** Production technology of spiroid worm surface using grinding wheel banking angle correction, The Publications of the XXVIII. microCAD International Scientific Conference CD, Miskolci Egyetem, Miskolc, 2014

’This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of **TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’.**

Not lectured conference issues written in Hungarian

{m9} **Bodzás S., Dudás I., Horváth R.:** *Spiroid csigahajtómű zaj- és rezgésdiagnosztikai vizsgálata*, Tudomány Hete a Dunaújvárosi Konferencián, interdiszciplináris tudományos konferencia, 2012. november 12-17.

{m10} **Bodzás, S., Dudás, I.:** *Tengelymetszetben körív profilú kúpos csigatengely profilkialakításának elemzése,* VII. Nyíregyházi Doktorandusz Konferencia, 2013. december 06.

’This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of **TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’.**

Lectured conference issues written in Hungarian

{m11} **Bodzás, S., Dudás, I.:** *Kúpos csavarfelületek geometriailag helyes megmunkálásához szükséges kinematikai modell,* XIX. Fiatal Műszakiak Tudományos Ülésszaka 2014, Kolozsvár, Románia, 2014.03.20. – 2014.03.21.

’This research was supported by the **European Union** and the **State of Hungary, co-financed by the European Social Fund** in the framework of **TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’.**

6. PROFESSIONAL LECTURES IN THE TOPIC OF THE DISSERTATION

1. **Bodzás, S., Dudás, I.:** *Kúpos csigahajtások kapcsolódásának elmélete*, Veszprém, Mobilitás és Környezet 2011 Konferencia, 2011.08.29. - 2011.09.01.

2. **Bodzás, S.:** *Csigakerék lefejtőmaró gyártásgeometriai elemzése*, Gépipari Tudományos Egyesületi Ülés, Nyíregyháza, 2011.12.14.

3. **Bodzás, S.:** *Gyors prototípusgyártás*, Mérnök Szakest, Nyíregyházi Főiskola, Nyíregyháza, 2011.12.19.

4. **Bodzás, S.:** *Spiroid tányérkerék modellezése,* Kari Ph.D. beszámoló, Nyíregyházi Főiskola, Nyíregyháza, 2012.03.06.

5. **Bodzás, S.:** *Kúpos csigahajtópár CAD modellezése és additív gyártástechnológiája*, Prof. Dr. Dr. h. c. Prof. h. c. mult. Dudás Illés, D.Sc. egyetemi tanár, 70. születésnapja tiszteletére rendezett Jubileumi Tudományos Ülés, Nyíregyházi Főiskola, Nyíregyháza, 2012.09.25.

6. **Bodzás, S.:** *Spiroid csiga és tányérkerék virtuális és valós modelljeinek előállítása,* A Magyar Tudomány Napja Erdélyben, XIII. Műszaki Tudományos Ülésszak, Az Erdélyi Múzeum Egyesület, Műszaki Tudományok Szakosztálya, Kolozsvár, Románia, 2012.11.24.

7. **Bodzás, S.:** *Kúpos tányérkerék lefejtőmaró modellezése és élgeometriai vizsgálata,* Műszaki és Természettudományi Egyesületek Szövetsége Szabolcs-Szatmár-Bereg Megyei Szervezet 50. Jubileumi évfordulója, Nyíregyháza, 2012.11.29.

8. **Bodzás, S.:** *Kúpos tányérkerék lefejtőmaró élgeometriai vizsgálata,* GTE taggyűlés és Doktoranduszok szakmai napja, Nyíregyházi Főiskola, Nyíregyháza, 2013.03.05.

9. **Bodzás, S.:** *Production of conical helicoid surfaces having grinding wheel banking angle correction,* Universidad Politécnica de Cartagena, Cartagena, Spanyolország, 2014.02.11.

7. BIBLIOGRAPHY QUOTED IN THE THESIS

[1] **Balajti Zs.:** *Kinematikai hajtópárok gyártásgeometriájának fejlesztése*. Miskolc, 2007, Ph.D értekezés, Miskolci Egyetem.

[2] **Drahos I.:** *A Litvin-féle csigahajtás érintkezési vonalseregének és kapcsolási felületének szerkesztése*, Különlenyomat a NME Magyar Nyelvű Közleményei, XII. kötet

[3] **Dudás I.:** *Csigahajtások elmélete és gyártása*, Műszaki Kiadó, Budapest, 2007., ISBN 978-963-16-6047-0

[4] **Dudás I.:** *Gépgyártástechnológia III., A. Megmunkáló eljárások ész szerszámaik, B. Fogazott alkatrészek gyártása és szerszámaik*, Műszaki Kiadó, Budapest, 2011.

[5] **Dudás, I.:** *Ívelt profilú csigahajtások szerszámozásának és gyártásának fejlesztése,* Kandidátusi értekezés, Miskolc, 1980. p.153+30 mell

[6] **Dudás I.:** *Számjegyvezérlésű köszörűkorong profilozó berendezés, és eljárás annak szakaszos, illetve köszörülés közbeni folyamatos vezérlésére.* NME Szolgálati találmány. 1988. III. 30. OTH 4941/88. (88.IX.21)

[7] **Dudás, I.:** *The Theory and Practice of Worm Gear Drives,* Penton Press, London, 2000., ISBN 1877180295

[8] **Dudás I., Ankli J.:** *Ívelt profilú csigahajtás köszörűkorong profilozásának fejlesztése*, Elfogadott és bevezetett újítás, Miskolc, 1978. DIGÉP A-2843.

[9] **Dudás I., Drobni J., Ankli J., Garamvölgyi T.:** *Berendezés és eljárás főmetszetben ívelt profilú csigahajtópár geometriailag helyes gyártására alkalmas köszörűkorong profilozására*, Szolgálati találmány, szabadalmi lajstromszám: 170118, Szabadalmi bejelentés napja: 1983. 12. 27.

[10] **Dudás, I.:** *„Csavarfelületek gyártásának elmélete”*. Akadémiai doktori disszertáció, Miskolc, 1991.

[11] **Dudás I.:** *Ívelt profilú csigahajtás egyszerűsített gyártása és minősítése*, Egyetemi doktori értekezés, Miskolc, 1973.

[12] **Krivenko, I. Sz.:** *Novüe tipü cservjacsnüh peredacs na szudah,* Izd. Szudoszrovenie, Leningrád, 1967.

[13] **Niemann, G., Winter, H.:** *„Maschinenelemente” Band III.,* Berlin, Springer-Verlag, 1986.

[14] **Drobni J.:** *Az ívelt profilú hengeres csigahajtások számítása.* NME Gépelemek Tanszékének Közleményei, 194. szám 1968.

[15] **Hegyháti, J.:** *Untersuchungen zur Anwendung von Spiroidgetrieben*. Dissertation, TU Dresden, 1988.

7.1. The researches, projects that serve as antecedent for this dissertation

[K1] *"Fogazott hajtópárok és hajtások optimálása, kapcsolódás elméletének és tribológiájának továbbfejlesztése",* OTKA - Országos Tudományos Kutatási Alapprogramok - T 000655 BME-ME, (Research leader: **Bercsey, T.**, **Dudás, I.)**. The research period: 1991-94.

[K2] *"Optimális kapcsolódás kialakulásának feltételrendszere"* OTKA - Országos Tudományos Kutatási Alapprogramok - T 019093. The research period: 1996-99. (Research leader: **Dudás, I.**)

[K3] *"Gépipari technológiák komplex analízise, különös tekintettel a bonyolult geometriai alakzatok gyártásgeometriájára és a számítógéppel segített gyártástechnológia kutatási területeire"*, MTA ME Gépgyártástechnológiai Kutatócsoport. The research period: 1996 - 2002. (Research leader: **Dudás, I.**)

[K4] *"3D-s mérési rendszer kifejlesztése CCD kamerák használatával"*, Japán-Magyar közös kutatási projekt, Monbusho támogatás. The research period: 1995-97. (Research leader: **Dudás, I.**)

[K5] *"CCD kamerás mérési rendszerek kifejlesztése a gépipari minőségbiztosítás területén"* OTKA - Országos Tudományos Kutatási Alapprogramok - 026566. The research period: 1998-2001. (Research leader: **Dudás, I.**)

[K6] *"Új geometriájú spiroid hajtások kutatása, gyártásgeometria kidolgozása"* OTKA - Országos Tudományos Kutatási Alapprogramok - T038288. The research period: 2001-2005. (Research leader: **Dudás, I.**)

[K7] *„A gyártásgeometria és a kapcsolódás jellemzőinek komplex vizsgálata korszerű csigahajtások esetében"* OTKA K 63377. The research period: 2006-2010. (Research leader: **Dudás, I.**)