UNIVERSITY OF MISKOLC
FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

INTELLIGENT MANUFACTURING SYSTEM AND GEOMETRICALLY EXACT MANUFACTURE OF THE HELICOID SURFACES

PhD DISSERTATION THESES

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1. INTRODUCTION

At the level of nowdays technical progress, the design of mechanical products and manufacturing equipment have been taken over not only by computer-assisted systems, but also by fully automated systems. In many areas of the mechanical engineering industry, various worm gear drive pairs have been used, either in the form of moving spindles or tools, resulting in their design, manufacture and, last but not least, their qualification.

Already in the 1970 years, it was expected that the noise level, weight and price of the engine of the dry wire drawing machines of the Diósgyőr Machine Factory (DIGÉP) had to be reduced, while its efficiency and specific performance had to be increased and the mechanically complex structure simplified.

During the development of worm gear drives in DIGÉP, several types were developed: convoluted, rolling element, and curve profiled worm gear drives with localized bearing pattern. Comparing these, further development of the curved profile and conical worm gear drive pairs seemed expedient. On this topic - I could use the results to my research in the field of production development, drive pair geometry, complete inspection and qualification of the gear unit, and tooling [25].

Unfortunately, there is a difference between the theoretical ideas in the publications and the practical problems, but in the same way, due to the differences in technical conditions, worm surfaces are not designed or manufactured everywhere geometrically exactly or often do not necessarily choose the best solution. With the most modern technology, heavy-duty and high-efficiency drive pairs with favorable hydrodynamic conditions, the energy loss in the gear units can be significantly reduced. It is not indifferent to the loss of power - and this applies to all drive types - that the possible tooth geometry characteristics that result in favorable connection conditions are used.

In order to design and manufacture these versatile, geometrically correct surfaces, it is advisable to formulate a production system that can serve as a basis for the development of CAD / CAM / CAQ / CIM systems related to the research topic to work together to increase production efficiency and product quality.

1.1. The subject of the research

1. The integration of a production system capable of machining the components of an existing worm gear drive pairs into an integrated production system.
2. Examination of the optimization of an existing intelligent manufacturing system suitable for machining the components of worm gear drive pairs.
3. **Constructive geometrical modelizing** of the geometrical relationships of the machining of the conical helicoid with shaft construction. Analysis of pitch fluctuation in the manufacture of a spiroid worm surface by adjusted shaft at threading with a cylindrical and counter-conical drive pin. Examination of the position geometry of the counter-conical drive pin with respect to the effect on fluctuation.
4. Analysis of the correlations between the conicity of the conical drive pin and the thread pitch fluctuation. Determination of a mathematically correct drive pin profile for machining the conical worm with adjusted shaft to eliminate thread pitch fluctuation.
5. Analysis of the spiroid worm machining with the grinding wheel, functional determination of the grinder profile corve for CNC-controlled machining.

1.2. The preludes of the researches

These kind of projects are the history of Worm Gear School in University of Miskolc: provided financial support for the researches:

1.”Optimisation of toothed driving pairs and gearing, development of their mating and their tribology” (OTKA-National Scientific Research Basic Programs – T000655 BME-ME). 1991-94.

2.”System of conditions for the forming of optimum mating” (OTKA-T019093). 1996-99.

3.”Complex analysis of machine industrial technologies, regarding mainly the research fields of the production geometry of sophisticated geometrical shapes and computer aided production engineering”, MTA-ME Research group at the Department of Production Engineering. 1996-98.

4.”Developing of 3D measuring method by the use of CCD cameras” Hungarian-Japanese common research project by the support of Monbusho foundation. 1995-7.

5.”Development of measuring method by CCD cameras on the field of machine industrial quality assurance” (OTKA 026566). 1998-2001.

6. ”Research of spiroid drives with new geometry, elaboration of production geometry. ”OTKA T038288 Duration of the research: 2001-2005.

7. "Complex investigation of production geometry and connection characteristics in the case of modern worm drives ”OTKA K 63377. Duration of the research: 2006-2008.

8. Dr. Károly Bányai -, Óváriné Dr. Zsuzsanna Balajti-, László Dudás-, Dr. János Csóka, Gábor Pay, Doctoral dissertations.

9. Dudás I., Bodzás S., Dudás I. Sz., Mándy Z .: Concave thread profile spiroid worm drive pair and process for its production by grinding, Patent registration number: P1200405, Patent application date: 04.07.2012. % Distribution of the authors' work: Dr. Illés Dudás: 50%, Sándor Bodzás: 20%, Szabolcs Illés Dudás: 20%, Zoltán Mándy: 10%

1.3. The area of the discussed research area and define of the main objective

The description of research topic:

The research of Integrated Manufacturing is a new trend. The discuss of spiroid drive pairs at geometry, which is analogized the former publication it is isolated the real and theoretical works. There are less and less researcher, who works with specialised manufacturing technology, and there are less and less technologist, who analysis concretised problems in theoretical level. For example, the theoretical projects creating from helicodial movements with general curves and general enveloping surfaces. They determine the manufacturing tools in a reverse continuation. Those publications and articles raise up the manufacturing process problems, and evaluates the solving methods in a practical level, but these are not touch the empirical solved problem theoretical explanations. It is almost at the same understanding the geometrical checking of helicoidal surfaces. The requirements is in the XXI. Century that the CNC controlled machines with 3D coordinate measuring machines changes the present tooth cutting, geometry and technology.

The background of my research in this direction was provided by DIFI-CAD Engineering Agency, Research, Development Trade and Service Ltd. in a cooperation agreement with the University of Miskolc.

The determined objectives:

1. *The further problem occurred in our research work:*

   There has been appeared a requirement to transform the manufacturing equipments and parts into a production system a suitable for machining the components of worm gear pairs, and then to integrate and adapt the existing production system into an intelligent production system.

Objective:

Transforming existing tools for machining the components of worm gear pairs into a production system and then creating a model to integrate and to adapt the integration of this production system into a higher degree of intelligent production system.

2. *The further problem occurred in our research work:*

   Due to the missing of specialise group, furthermore the energy and cost efficiency, there has been appeared a requirement to increase efficiency in the operation of an existing intelligent manufacturing system for machining the components of worm gear pairs.

Objective:

Development of an optimization model for the operation of an existing production system suitable for machining the components of worm gear drive pairs, and the creation of a new, possible concept for this purpose.

3. *The further problem occurred in our research work:*

   In the case of classic thread grinding machines, it is necessary to adjust the saddle to grind the conical worm surfaces. Due to the shaft adjusting, the normal drive results in an elliptically varying angular speed of the workpiece in addition to the constant angular velocity on the worm, which causes, among other things, a pitch error and profile distortion. At manufacture of conical helicoid surfaces at lathe –center displacement get used the cylindrical – and non- conical driving pins. The similarity analysing of raised pitch fluctuation used surfaces of the two driving pins. It has been mentioned that the diameter of main spindle and non –conical driving pin at manufacture of conical helicoidal surfaces for the analysis of the effect can capable to mean a cost effect solution for the reduction the pitch error.

Objective:

To avoid the described problem the mentioned conical helicoidal surfaces with thread grinding machines to manufacture with lathe –center displacement. To analyse the size of the pitch fluctuation at manufacture of conical helicoidal surfaces with cylindrical and conical driving pin. The analysis for the pitch fluctuation of main spindle and driving pin diameter for the manufacture of conical helicoid surfaces at lathe center displacement.

4. *The further problem occurred in our research work:* Examination of the conicity of the conical drive pin used for drive when machining the conical worm surface with shaft adjustment. Designing the drive pin profile for proper driving.research.

Objective:

Analysis of the effect of the half-opening angle of the conical drive pin on the pitch fluctuation when machining the conical worm surface with axial adjustment. Mathematically exact determination of the profile of a geometrically correct drive pin in the form of an explicit equation instead of a series of points to eliminate the thread flutation in the manufacture of a conical worm surface with aadjusted shaft.

5. *The further problem occured in our research work:*

The geometrically correct design of the conical worm grinding technology must ensure that the change in the grinding wheel and the worm shaft does not affect the shape of the worm, so always produce the mathematically correct conical worm surface. As a result, there has been a need for a functional description of the changing on the working surface of a grinding wheel for CNC-controlled machining.

Objective:

Elaboration of a mathematical kinematic model for the study of worm drives and their production, where the technological wheelbase can change during production, for which purpose I had aimed to elaborate the methods of mathematical studies necessary for the production. My further goal was to functionally write the contact curve of the conical helicoid surface and grinding wheel, and thus the profile curve of the wheel, to promote CNC-controlled machining.

2. SOME BACKGROUND IN THE PROFESSIONAL LITERATURE

2.1. Development of tooth theory of spatial drives

In this chapter I have highlighted the writings influencing our research on worm gear drives shoots.

In some areas, it took centuries to theoretically research the teeth of planar gears and systematize the results. The first writings on the two most important areas of the theory of toothed mechanisms, such as the connection of toothed elements and their manufacturing geometry, are given in the 19th century. published in the middle of the twentieth century [33, 45]. **Olivier**'s research in France has long been unique in this area. In his work published in 1842, he separated synthetic and analytical methods in the theory of tooth surface connection. In his view, "the question of tooth engagement belongs entirely to the descriptive geometry." However, according to Russia's **Gohman**, "tooth theory is a special area of the mathematical discipline," where, in contrast to other areas of mathematics, the researcher must almost "grope to find new ground for each step." In the field of tooth theory, the foundations have been laid in the works of the Russian scientist Theodore **Olivier** [45] and H. I. **Gohman** [33], a Russian scientist.

The analytical model for the analysis of the spatial surface connection was first developed by **Gohman** together with the elaboration of the mathematical method of enveloping surfaces.

In tooth theory, it has been combined differential geometry, manufacturing, design, measurement techniques, and not insignificantly with the disciplines of computer methods. Applying computer methods in the development of gear technology, its methodology was extended to the modified modern theory of gearing with its industrial application [36, 57].

Distelli [12], **Stübler** [52], **Altmann** [1] and **Crain**, among others, have contributed to the further development of tooth theory with the methods of descriptive geometry [11].

The concept of vector screw was first described by **R. Ball** in his T"heory of Screws" published in 1900. **Distelli** was one of the first to use the definition of tooth surfaces along straight lines in his work "Über instantane Schraubengeschwindigkeiten und die Verzahnung der Hyperboloidräder" published in 1904. **Willis** has become internationally recognized in this field, as described in "Principles of Mechanism" and summarized in the book "Gear handbook" by **Buckingham** [9], Wildhaber, and **Dudley** [32]. The law of contact of plane curves was defined by **Willis** in 1841 [56].

Investigations of the theoretical issues of connection can be simplified with the kinematic method, based on which e.g. Another prominent representative of **Litvin** and the Russian school of tooth theory was even **Kolchin** [37] and **Krivenko** [38], who developed expedient solutions for the criteria of connection and contact, as well as for the determination of curvature conditions and interference phenomena. Manufacturing geometry research — that is, the kinematic processing, systematization, and analysis of machining in manufacturing technology — has received significant new impetus in recent decades. The basic questions were clarified by **Weinhold** [55], **Kienzle** and **Perepelica**.

Among the Hungarian researchers achieving outstanding results in this field are **Szeniczei, L**. [53], **Drahos, I.** [13-17], **Lévai I.** [39-41], **Tajnafői J.** [54], **Magyar J.** [43], **Hollanda, D.** [44], **Bercsey, T** [5-7], **Horák, P.** [35], **Drobni J.** [20-22], **Dudás, Illés** [18-30], **Pay, G.** [48], **Dudás, László** [31], **Balajti ,Zs.** [3,4] and **Máté, M.** [61] . **Szeniczei** defined the concept of a "conjugated surface pair" by raising the idea of a related reciprocal coating [53]. **Magyar J.** [43] shed light on the connection problems of bolted elements before the foreign literature. **J. Tajnafői** incorporated the technological theory of gearing through the parameters of motion imaging [54]. **Drahos I.** dealt with the theory of tool geometry, including the manufacturing geometry analysis of helicoid surfaces and hypoid bevel gears. **I. Lévai** wrote on the analysis of the multiplicity of spatial shoots. He investigated the toothing theory of drive pairs with a bypass axis, a complex issue in the design of hypoid drives [39 - 41]. **Illés Dudás** developed a circular profiled worm in axial section and patented the manufacturing process and its theory, as well as the general mathematical model for the production geometrical developing of the conical and cylindrical worm gear drive pairs [18 - 30].furthermore the general mathematical model of production geometry of worm gear drives [18-30]. **T. Bercsey** analyzed the connection between the globoid snail and the hyperbolic wheel with a straight tooth surface and the toroidal shoots using a kinematic method to prove its applicability to other spatial shoots [5 - 7]. With the Surface Constructor software, **L. Dudás** supports the derivation of the tool surface, the associated tooth surface and the design of mechanisms for the element pairs of different drives from several aspects [31]. **Zs. Balajti** dealt with the localization of the bearing pattern of the worm gear drive pairs [3] and the relationship between the mathematical kinematic model of the conical and cylindrical worm gear drive pairs with the projective space model [4]. The tribology of the curved snail was studied by **P. Horák** [35]. **V. Simon** studied the geometrical conditions of cylindrical and globoidal worm drives and the friction loss, and optimized them in terms of load capacity in the flow and thermal lubrication model scheme [49 - 50]. **J. Pay** and **G. Pay** dealt with the research and development of internal worm shoots [46-48]. **M. Máté** has riched the professional literature with the principle of double enveloping by researching different types of drive pairs [44, 61].

2.2. History of Holonic Manufacturing systems

The conception of holonic manufacturing system is about the holon's Autonomous and co-operatable unit in the manufacturing system , that transforms, carries, storing physical objects. A holon can be a part of other holons.

The imagination is about that the circumstenses of the environment is so changable that's why we need quicker reaction ability to hold the competition level with other firms.The bases of holonic concept is from the Japenese researhers. They were the beginners of the co-operation in 1992 which is called Intelligent Manufacturing System (IMS). From **Fu-Shiung Hsieh** „Holarchy formation and optimization in holonic manufacturing systems with contract net" called publication desriebe about the connection between [60] a Petri-nets viszonyáról ír, he tried to alloy the elemental holons [60]. In University of Miskolc was developed the IAAR research group , especially with professor Tibor Tóth has a book the firm controlling with Computer This book alloyed the Manufacturing system, Informatics and Logistical science.In other hand in Hungary it is significant to mention the cast of MTA-SZTAKI company. There are so many excellent researher in here, especially Professor László Monostori and Botond Kádár [42]. Their publications for example holonic manufacturing, fractal firms is called about the cast and character of holonic manufacturing, holarchy which is about the cooperation self-adaptation and self –maintanenance , especially for the autonomy in the inside of manufacturing system.

3. METHOD OF SOLVING THE PROBLEMS

1. I developed the integrability into the intelligent manufacturing system based on my knowledge of both engineering and mathematics, I applied analytical calculation methods to the knowledge of neural networks.

2. Although the optimization model of the intelligent manufacturing system was developed for an engineering system, I clearly performed it using the tools of mathematics, including knowledge of set theory and analytical knowledge.

3. Knowing the general mathematical model developed for the study of the geometry of cylindrical and conical helicoid surfaces and their tools, a constructive geometric model has been developed, which includes the possibility of examining the transmission between the machine, the drive pin and the drive fork when machining conical worms. When machining the conical helicoid surface with axial adjustment, the cylindrical and counter-conical drive pin used for the drive and the counter-conical drive pin were tested for position geometry using the descriptive geometry, constructive geometry and a wide range of mathematical tools.is.

4. During the machining of the conical worm surface with axial adjustment, the effect of the half-hole angle change on the thread pitch fluctuation of the conical drive pin used for driving was investigated using graphical, constructive geometry and a wide range of mathematical tools. In the production of the conical worm surface with saddle adjustment, the geometric correct determination of the profile of the geometrically correct drive pin instead of the score line of the profile curve in the form of an explicit equation was performed using.

5. A mathematical model with the toolkit of onstructive geometry was developed to examine the geometry of the conical worm surface, the machining grinding wheel, and the disc adjuster. The results of the operations of the mathematical tools used to develop the kinematic model, such as the transformation matrices using homogeneous coordinates - matrix-matrix, matrix-vector multiplications - were checked with the DERIVE software.The developed procedure is the basis for determining the setting of the disc control to be performed in order to avoid the worm profile distortion. Thus, the following can be considered solved during production: If the disc is controlled by a mechanical worm peeler (DIFORM-M [29]), what density of peeling results in a disc shape in the production of conical worms that will make the ground worm within tolerance. During the manufacturing process, the tolerance range can be specified for the disc profile to match the tolerance range of the auger. During the design of the worms and their machining tools, using the results of tooth geometry and connection theory developed by Gohman, H. I. and Litvin, F. L.

4. NEW SCIENTIFIC RESULTS

The new scientific results of the dissertation are summarized in the following theses:

Thesis 1: I have created a neural network model of an existing intelligent manufacturing system tuned for the production of helicoid surfaces to the analogy of mathematical neural networks.

The structure of the intelligent manufacturing system built by us, is analogous to the neural networks used in mathematics, developed primarily for technical applications, which are similar to all human intelligent biological neural networks in the neuronal system. The basis of the cooperation is the conceptual system of the holonic production system, which is essential for the development and technological operation of multinational companies.

The model can be converted to the transformation of the manual labor force still found in the automotive industry (e.g. Takumi handicrafts) in the context of CAD-CAM-CAQ, High-Tech developments. The welding, painting, and assembly robots found in manufacturing and assembly plants are intelligent neurons that, according to my model, can form a neural network to achieve the goal of producing a product. **Taking these implementations into account, the purpose of my proposal is to integrate the elements of the existing intelligent manufacturing system (RAM-DISC, NCT, Measuring Equipment, Central Computer, Grinding Machine) into the possible system and the possible ways to do so.** [M-1, 4, 5, 6, 7, 9, 10, 11]

Thesis 2.: I have created the optimization model of the intelligent manufacturing system using the set theory method, taking into account the maximum profit, the minimum maintenance cost, the minimum human resource and the maximization of automation criteria.

The elements of the intelligent manufacturing system suitable for machining the elements of the existing worm gear pairs examined in the present model are the control unit set, the set of manufacturing (cutting) machines and the measuring set (the 3D measuring machine and the CCD camera unit). **The model created as a consequence of their aggregation is suitable for achieving the minimization or maximization required for each sub-task, which causes some improvement in the operating mechanism of the production system in terms of cost-effectiveness, even within a company.** During the TQM and related quality assurance processes, it is a sufficient condition that the system itself indicates the possibility of expected inoperability before failure, so that the programmability of maintenance does not affect the shutdown of the entire system. [M-1, 4, 5, 6, 7, 8, 10, 15, 16, 12]

Thesis 3: Based on the general mathematical model previously investigated for the production geometry developments of the cylindrical and conical worm gear drive pairs, a new constructive geometrical model was developed by me, to eliminate the driving problem during the machining of conical worms and hobs (f_1) with a grinding wheel (f_2). It is suitable for the simultaneous coordinated examination of the kinematics of the conical worm, the lathe dog (f_{mv}), the drive pin (f_{cs}) and the spindle (f_g), and for the mathematical determination oof the drive pin profile curve.

The new constructive geometric model is suitable for the analysis of the finishing of both cylindrical and conical worm surfaces with a rotating surface (such as a grinding wheel (f_2)) with the appropriate choice of parameters, for the correct drive of the conical worm surface), specifying the geometrical conditions of the driving pin (f_{cs}),

I have developed a method for comparing the pitch fluctuations that occur during machining with a cylindrical and a conical drive pin during machining of the conical worm with shaft adjustment.

I have found that the so-called counter-conical drive pin drive has a dampening effect on the fluctuation of the thread pitch when machining the conical worm with axial adjustment.

During the machining of the conical worm with shaft assembly, I have determined the relationship between the distance of the counter-conical drive pin from the spindle shaft and the degree of fluctuation.

This made it possible to determine the range within which the distance between the drive pin and the spindle meets the requirement that the ground worm be within a given manufacturing tolerance. [M-2, 3, 12, 13, 14]

Thesis 4: I have explored the relationship between the shape geometry of the drive pin, such as the half-opening angle of the taper drive pin, and the degree of fluctuation during machining of the conical worm.

This made it possible to determine the range within which the half-opening angle of the drive pin meets the requirement that the ground worm be within a specified manufacturing tolerance.

I have developed a new post-motion transfer method for machining the conical worm with shaft alignment to determine the profile of the drive pin to eliminate thread fluctuation. I defined the profile curve explicitly instead of in a row.

A constructive geometric model created for the study of driving, and the self-developed computer program based on it, is a manufacturing technology design procedure that is suitable for the study of specific cases. With this, the problem of driving can be considered solved.
[M-3, 12, 13, 14]

Thesis 5: The contact curves formed during the grinding of the conical worm with a disk-shaped tool were determined by continuous interpolation curves instead of a series of points; these are Bézier curves fitted to the points of contact of the smallest and largest diameters. The model greatly facilitates the handling of the grinding wheel profile change. The relationship between wheelbase change and disc tilt angle was determined as a function to increase manufacturing accuracy.

This determines the minimum value of the tool profile correction operation at which the ground worm can be produced within a given manufacturing tolerance. At the same time, by decompressing from the worm, the tolerance field of the controlled disk can be determined so that the surface of the worm ground with it is within the prescribed tolerance. [M-1, 8, 9]

5. DEVELOPMENT DIRECTIONS, OPPORTUNITIES

The manufacturing system will transform to fully –automatised system , from the semi-automatised system, which is already capable to opreate is Asia, USA. In Hungary Our developments is raising up the the other Western Europe countries in the technological level in these kind of circumstenses. The results of the reserches in the dissertation is capable to further industrial usages and product geometrical analysis. The spiroidal worm usage is sppread in wide range of the world, because of the good efficiency.The theory and the practice is much more different , that' s why we have to bring the solutions getting close to each other.The develeopment of conical helicoid surfaces the direction of CNC controlled manufacturing requires multi-disciplinar knowledge. The connection of driving pin-, and fork in the future I want to handle with surfaces connection for example the analysing of tooth of fork with cylindrical surfaces to descriebe the movement –giving. Further task can be the restore the the similarity of the inclination angle and to subscriebe this as a mathematical function for at manufacture of conical worms withe lathe center displacement.

6. PUBLICATIONS RELATED IN THE DISSERTATION TOPIC

Patent application:

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. A szerzők munkájának %-os megosztása: Dr. Dudás Illés: 50 %, Bodzás Sándor: 20 %, Dudás Illés Szabolcs: 20 %, **Mándy Zoltán: 10%**

Journal article published abroad written in a foreign language:

2. Illés, **Dudás ; Sándor, Bodzás ; Zoltán, Mándy**: Solving the pitch fluctuation problem during the manufacturing process of conical thread surfaces with lathe center displacement, International Journal of Advanced Manufacturing Technology 69 : 5-8 pp. 1025-1031. , 7 p. (2013)

3. Balajti Zs., **Mándy Z**.: Proposed solution to eliminate pitch fluctuation in case of conical screw surface machining by apex adjustment, PROCEDIA MANUFACTURING 2021, 2351-9789, 55. pp.: 266-273.

Article in a foreign language in a Hungarian journal:

4. **Mándy Zoltán**, Dr. Bányai Károly és Prof. Dr. Dudás Illés**:** Two special cases of The Holonic Manufacturing Systems Mobilitás és Környezet: Járműipari, energetikai és környezeti kutatások a Közép-és Nyugat- Dunántúli régióban” c. TÁMOP -4.2.1./B-09/1/KONV-2010-0003, Pannon Egyetemen 2010.08. 23-25. között, a Ph.D konferencia Konferenciakiadvány: Hungarian Journal of Industrial Chemistry, HU ISSN: 0133-0276. pp.:223-226.

Article published in a conference proceedings in a foreign language:

5. **Zoltan Mandy:** The Third Wave Of Advant Edge of Finite Element The application of software in the course of chipping and presentation of the experimental results GAMF Factory Automation (2010.04.16.) Kecskeméti Főiskola: Nemzetközi Konferencián való előadás angol nyelven, konferencia kiadvány, ISBN 978-963-7294-83-9, P.39-47.

6. **Mándy Zoltán,-**Prof. Dr.Dudás Illés**:** The aggregation approach of Holonic Manufacturing Systems, , „The International Conference of MicroCAD 2011”Nemzetközi konferencián angol nyelvű előadás, lektorált cikk, 2011.03.31., ISBN 978963-661-965-7, P133-138

7. **Zoltan Mandy**: Third Wave Advant Edge of Finite Element the application of software in the course of chipping and introducing some solutions International Conference of Microcad (2010.03.18.) University of Miskolc, ISBN 978-963-661-925-1, pp.: 39-47.

8. Dr. Illes Dudas - **Zoltan Mandy**: "Defining of the profile of the grinding wheel of conical worm surfaces" c. előadás angol nyelven 2012.03.29."The International Conference of MicroCAD 2012" , On CD, pp.: 45-49.

9. **Zoltan Mandy,** Dr.Illes Dudas, Sandor Bodzas.: Manufacture of Spiroid Worm Surfaces in Intelligent Integrated Systems Factory Automation 2011 Conference in University of István Széchenyi, 2011. 05. 25-05.26., Győr, Hungary, ISBN 978-963-7175-3, p. 140-148.

Professional scientific lecture in a foreign language:

10. **Zoltan Mandy**: Few strategies of Holonic Manufacturing Systems „Doktoranduszok Fóruma 2010." Miskolci Egyetem, 2010.november 10.,Előadás angol nyelven előadva, p.78-84

11. **Zoltan Mandy**: A possible neural network for the Holonic Manufacturing System, 2011.11.08., Issue of PhD Students Forum, University of Miskolc, pp.: 78-84.

Article published in a conference publications in Hungarian:

12. **Mándy Z**., Dudás I., Balajti Zs.: Kúpos csavarfelület csúcselállítással való megmunkálása során fellépő menetemelkedés ingadozási probléma megoldása affinitással, OGÉT 2019, ISSN 2668-9685, Nagyvárad, Románia, pp.: 336-339.

13. Balajti Zs., **Mándy Z**., Dudás I.: Kúpos csavarfelület csúcselállítással való megmunkálásának konstruktív geometriai elemzése menetemelkedési probléma kiküszöböléséhez, OGÉT 2020, https://ojs.emt.ro/oget/article/view/173/99

14. Balajti Zs., **Mándy Z**.: Menetemelkedési fluktuáció analízise kúpos menesztőcsappal hajtott spiroid csiga tengelyelállítással történő megmunkálása esetén, OGÉT 2022. ISSN 2668-9685, pp.: 351-354.

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16. **Mándy Zoltán:**. A Third Wave of Advant Edge véges elemes szoftver használata a forgácsolás során és néhány eredmény értékelésének az ismertetése, „Tudomány az Észak –Alföldi Régióban" Conference, Nyíregyháza, 2010.05.19.

17. **Mándy Zoltán:** A Holonikus gyártórendszer optimalizálási lehetősége,c. előadás 2011.05.18., A „ Műszaki Tudomány az Észak-Kelet Magyarországi Régióban" Conference, University of Miskolc, Technical Publications of the University of Debrecen, www.mfk.unideb.hu, pp.:95-100.

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