

UNIVERSITY OF DEBRECEN
Faculty of Engineering
Department of Mechanical Engineering



PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING
(ISCAME 2017)

12-13 October, 2017

Debrecen, Hungary

organized by

Department of Mechanical Engineering
Faculty of Engineering, University of Debrecen

and

Working Commission in Mechanical Engineering
Specialized Committee in Engineering
Regional Committee in Debrecen, Hungarian Academy of Sciences



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



Edited by **Sándor BODZÁS PhD**
 Tamás MANKOVITS PhD

Technical editors **Levente CZÉGÉ PhD**
 Sándor HAJDU PhD
 Sándor PÁLINKÁS PhD
 Péter BALSA
 Zsolt BÉKÉSI
 Krisztián DEÁK
 Dávid HURI
 József MENYHÁRT
 Tamás Antal VARGA

Publisher: **Department of Mechanical Engineering**
 Faculty of Engineering
 University of Debrecen
 2-4 Ótemető str. Debrecen, Hungary
 Phone: +36 52 415 155
 Web page: old.eng.unideb.hu/gepesz

ISBN 978-963-473-304-1



PROCEEDINGS

5th INTERNATIONAL SCIENTIFIC CONFERENCE ON ADVANCES IN MECHANICAL ENGINEERING (ISCAME 2017)

**12-13 October, 2017
Debrecen, Hungary**



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



Chair of ISCAME 2017

Tamás MANKOVITS, University of Debrecen, Hungary

Scientific Program Committee of ISCAME 2017

Ágnes BATTÁNE GINDERT-KELE, University of Debrecen, Hungary

Sándor BODZÁS, University of Debrecen, Hungary

Gábor BOHÁCS, Budapest University of Technology and Economics, Hungary

István BUDAI, University of Debrecen, Hungary

Levente CZÉGÉ, University of Debrecen, Hungary

Igor DRSTVENSEK, University of Maribor, Slovenia

János Péter ERDÉLYI, University of Miskolc, Hungary

Lajos FAZEKAS, University of Debrecen, Hungary

Csaba GYENGE, Technical University of Cluj-Napoca, Romania

Sándor HAJDU, University of Debrecen, Hungary

György JUHÁSZ, University of Debrecen, Hungary

Gábor KALÁCSKA, Szent István University, Hungary

Ferenc KALMÁR, University of Debrecen, Hungary

Imre KOCSIS, University of Debrecen, Hungary

Ákos LAKATOS, University of Debrecen, Hungary

Stanislav LEGUTKO, Poznan University of Technology, Poland

Zoltán MAJOR, Johannes Kepler University Linz, Austria

Ljubica MILOVIC, University of Belgrade, Serbia

Imre Norbert ORBULOV, Budapest University of Technology and Economics, Hungary

Sándor PÁLINKÁS, University of Debrecen, Hungary

Tibor POÓS, Budapest University of Technology and Economics, Hungary

Milan RACKOV, University of Novi Sad, Serbia

Istvánné RÁTHY, Óbuda University, Hungary

Tamás SZABÓ, University of Miskolc, Hungary

Edit SZÚCS, University of Debrecen, Hungary

György THALMAIER, Technical University of Cluj-Napoca, Romania

Zsolt TIBA, University of Debrecen, Hungary

László TÓTH, University of Debrecen, Hungary

Matej VESENJAK, University of Maribor, Slovenia

László ZSIDAI, Szent István University, Hungary

Technical Assistance

Beáta KÖVÉR, University of Debrecen, Hungary

Tamás Antal VARGA, University of Debrecen, Hungary



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



CONTENTS

AL-MALIKI Hayder, KÁROLY Zoltán, KLÉBERT Szilvia, KALÁCSKA Gábor, SUKUMARAN Jacob, KALÁCSKA Ádám <i>Surface characterization of polytetrafluoroethylene treated by atmospheric plasma</i>	1 – 8
ANTAL Tamás, KERÉKES Benedek <i>Novel drying techniques for the preservation of by-products of food industry</i>	9 – 16
AZANE Thomas, BARKÓCZY Péter <i>Comparison of the production and properties of ACCC conductors to other HTLS conductors</i>	17 – 21
BADITA Liliana-Laura, ZAPCIU Aurel, GORNOAVA Valentin, VOCUREK Marian, MUNTEANU Iulian-Sorin <i>Nanostructured thin films used to improve the tribological properties in mechatronic actuating systems</i>	22 – 28
DE BATTISTA Péter Italo, SZABÓ József Zoltán, BAKUCZ Péter <i>Detecting knocking combustion of large gas engine by deep recurrent neural network</i>	29 – 35
BALOGH Gábor <i>Recycling possibilities of end period nuclear fuel cells</i>	36 – 40
BANJANIN Bojan, VLADIĆ Gojko, DELIĆ Gordana, ADAMOVIĆ Savka, KAŠIKOVIĆ Nemanja <i>Influence of post-treatment methods on mechanical properties of PLA parts fabricated by fused deposition modeling</i>	41 – 47
BELÉNYI Alpár, ACHIMAŞ Gheorghe <i>Vibration measurement on reconditioned semi-hermetic compressor</i>	48 - 53
BENCHABANE Ahmed Elmehdi, BARKÓCZY Péter <i>Effects of surface treatment to the properties of railway contact wires</i>	54 – 58
BODZÁS Sándor <i>Comparative tooth contact analysis of X-zero gear drives in the function of the module changing</i>	59 – 67
BOLDIZSÁR Csongor <i>Optimization of wood biomass gasification process</i>	68 – 72
BÖRÖCZ Péter <i>Averaged vibration levels of vans in package delivery</i>	73 – 78



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



BUBONYI Tamás, LÉRÁNTH Gábor, BARKÓCZY Péter

Automated image analysis of the inhomogenities in the microstructure of aluminum castings

79 – 83

BUSZNYÁK Tibor, LAKATOS István

Automotive engineering possibilities in combining global positioning and vehicle diagnostic

84 – 89

CHMIELARZ Krzysztof, MARCINIAK Szymon

Changes of microstructure and mechanical properties of nano crystalline steel X37CrMoV5-1 subjected to heat treatment as is used during nitriding

90 – 95

CSAVAJDA Péter

Shock testing in the evaluation of packaging performance

96 – 101

DEÁK Krisztián, KOCSIS Imre

Condition monitoring by applying advanced diagnostic method

102 – 108

DÓCS Roland, JOBBIK Anita

Porous system modeling using multi-capillary method

109 – 114

DOVRAMADJIEV Tihomir

3D computer processing and improvement of the geometry of received photogrammetric models through photo shooting with one camera

115 – 122

DUDÁS László, KAPITÁNY Pálma

Combustion chamber and fuel mixture motion analysis of a new rotary engine

123 – 128

DUDÁS László

The effect of profile variation on contact properties in case of quasi globoid worm gearing

129 – 134

ÉCSI Ladislav, ÉLESZTÖS Pavel, JANČO Roland

An alternative to hyperelastic-based multiplicative plasticity models

135 – 141

ERDÉLYI Viktor, JÁNOSI László

Digital twin and shadow in smart pork fatteners

142 – 146

FINŽGAR Miha, PODRŽAJ Primož

Feasibility of remote photoplethysmography for implementation in mobile robots

147 – 152

FODOR Antal

3D printed polymer specimens of fatigue test examination based on DMA tests

153 – 157

GEAMBAZU Elena Laura, MANEA Ciprian Alexandru, CSAKI Ioana, KARLSDÓTTIR Sigrún Nanna

High entropy alloys in geothermal environment

158 – 162



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



GORDIĆ Dušan, VUKAŠINOVIĆ Vladimir, ALEKSIĆ Aleksandar, NEŠOVIĆ Aleksandar <i>Introduction of water management in food production plant: a case study margarine production facility</i>	163 – 171
GRUJIĆ Ivan, STOJANOVIĆ Nadica, GLIŠOVIĆ Jasna, DAVINIĆ Aleksandar, MILOJEVIĆ Saša <i>Modeling and aerodynamic simulation of the passenger vehicle</i>	172 – 177
GULAN Ladislav, SCHMIDTOVÁ Carmen, IZRAEL Gregor <i>Effective designing of modular structures variants of mobile working machines</i>	178 – 183
HAGYMÁSSY Zoltán, PÁLINKÁS Sándor, BATTÁNE GINDERT-KELE Ágnes <i>Examination the physical characterising of fertilizers</i>	184 – 187
HAJDU Flóra, HORVÁTH Péter <i>Comparison of bathlift constructions</i>	188 – 191
HÉGELY László, SLEISZ Kristóf <i>Optimization of batch extractive distillation with different methods</i>	192 – 197
HNILICOVÁ Michaela, MATEJ Jaroslav, DADO Miroslav, HNILICA Richard <i>Design of the supporting frame for the fire-fighting adapter using the shape generator</i>	198 – 202
IHEMAGUBA Chukwuemeka, MAROSSY Kálmán <i>Application of thermally stimulated discharge current method for investigation of fine structure of polymeric materials</i>	203 – 209
JANČO Roland, ÉCSI Ladislav, ÉLESZTŐS Pavel <i>Numerical solution of friction stir welding compared by experimental measurement</i>	210 – 215
JOLDEŞ Nicolae Traian, GYENGE Csaba, ACHIMAŞ Gheorghe, POP-SZOVÁTI Anton-Gheorghe <i>The waste and the environment</i>	216 – 221
JÓNÁS Szabolcs, TISZA Miklós <i>Clinching of DP600 steel sheets</i>	222 – 227
JUHÁSZ János, BÁNYAI Tamás <i>Logistic aspects of real time decisions in intelligent transportation systems</i>	228 – 234
KÁDÁR Fanni, ERDŐDI István, HŐS Csaba <i>Phase space analysis of a pressure relief valve</i>	235 – 240
KALMÁR Csanád, HEGEDŰS Ferenc, FELHŐS Dávid <i>Transient simulations of gas dynamics with different numerical schemes</i>	241 – 247



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



KAŠČÁK Ľuboš, SPIŠÁK Emil <i>Mechanical joining methods of hot-dip galvanized steel sheets</i>	248 – 253
KINCSES Dávid, MEZEI Lajos, HAJDU Sándor <i>Review of wheel dynamic models at vehicle development</i>	254 – 260
KLAPCSIK Kálmán, HEGEDŰS Ferenc <i>Modelling of non-spherical bubble shape oscillations in viscous liquid</i>	261 – 267
KOLOZSVÁRY Zoltán <i>A few considerations on the state of the art and development trends in heat treatment and surface engineering</i>	268 – 273
KOVÁCS Róbertné, KESZTHELYI-SZABÓ Gábor, SZENDRŐ Péter <i>Optimization of operational parameters for microwave pre-treating system</i>	274 – 279
LAKATOS István, NAGY Andor <i>The development of the punctuality of railroad event recording in accident investigation</i>	280 – 288
LÁNG Péter, ÖRSI Márton, HÉGELY László <i>Comparison of batch and semi-continuous distillation</i>	289 – 295
LATEȘ Daniel, CĂȘVEAN Marius, CIOLOCA Flaviu <i>Application of the functions of a chatbot in the manufacturing process of a gear in IRUM company</i>	296 – 299
LOVREC Darko <i>Ionic liquid as a novel, high performance hydraulic fluid - selection process</i>	300 – 305
LOVREC Darko <i>Corrosion protection properties of ionic liquids</i>	306 – 311
MAJDIČ Franc <i>Research of carbon fibre hydraulic cylinder</i>	312 – 318
MAJDIČ Franc <i>Duration test of carbon fibre hydraulic cylinder: Water&oil</i>	319 – 322
MARCINIAK Szymon, SKOLEK Emilia, GOŁASZEWSKI Adam, ŚWIĄTNICKI Wiesław <i>Thermal stability of carbide-free bainite in two nanocrystalline steels</i>	323 – 328
MARKOVA Kremena <i>How the user became authority</i>	329 – 333
MENYHÁRT József, SZABOLCSI Róbert <i>Batteries operation parameter analysis with fuzzy logic</i>	334 – 338



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



MODLA Gábor, LÁNG Péter <i>Decrease of the energy demand of distillation with vapour recompression</i>	339 – 344
MOHAMAD Barhm, SZEPESI Gábor, BOLLÓ Betti <i>Review article: modelling and analysis of a gasoline engine exhaust gas systems</i>	345 – 357
MOLNÁR András, BUZA Gábor, FAZEKAS Lajos, PÁLINKÁS Sándor, BATTÁNE GINDERT-KELE Ágnes <i>Thermal sprayed and laser remelted wear resistant NiCrBSi coatings</i>	358 – 365
MOLNÁR Bence <i>Simulation framework for packaging dynamics of stacked units</i>	366 – 371
MUHANDES Hasan, SALLOUM Weal <i>Simulating the bruising damage of olive fruit during drop</i>	372 – 379
NAGY Péter Tamás, PAÁL György <i>Plane jets excited by vortices</i>	380 – 385
NAGY Péter Tamás, PAÁL György <i>The effect of spanwise flexible coating on the boundary layer transition</i>	386 – 390
NEMES Csaba, BODZÁS Sándor <i>Designing, modelling and analysis of straight turning tool geometry</i>	391 – 396
PÁLINKÁS Sándor, FAZEKAS Lajos, BATTÁNE GINDERT-KELE Ágnes, MOLNÁR András, HAGYMÁSSY Zoltán <i>Investigation of hot metal powder spray fusing of cultivator tines after tith</i>	397 – 405
PETHŐ Dániel, BENKE Márton, MERTINGER Valéria, BARKÓCZY Péter <i>The effect of thickness reduction on the recrystallization processes of cold rolled 3104 deep draw Al sheets</i>	406 – 417
POÓS Tibor, SZABÓ Viktor, VARJU Evelin, HORVÁTH Dániel <i>Introduction of freeze granulation technology</i>	418 – 421
POÓS Tibor, HORVÁTH Dániel, TAMÁS Kornél <i>Modeling the movement of the granular material in a static equipment with discrete element method</i>	422 – 427
POÓS Tibor, VARJU Evelin, SZABÓ Viktor <i>Determination of medicinal plants' porosity</i>	428 – 432
POP-SZOVÁTI Anton - Gheorghe, BORZAN Marian, GYENGE Csaba, JOLDEȘ Nicolae <i>Systems for counterbalancing the ram of the mechanical presses</i>	433 – 438



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



RACKOV Milan, KUZMANOVIĆ Siniša, PENČIĆ Marko, ČAVIĆ Maja, KNEŽEVIĆ Ivan <i>Analysis of different concept ways of two-stage gear reducers design</i>	439 – 444
RAZA Md Tanweer, SZEKERES András <i>Thermo-hygro- mechanics in indian science philosophy</i>	445 – 454
ROMÁN Krisztina, ZSOLDOS Gabriella <i>Examinations of mechanical properties of different PVC/CPE blends</i>	455 – 459
RÓNAI László, FÜVESI Viktor, VÖRÖS Csaba <i>Designing of a water sampling unit</i>	460 – 465
SEPSI Máté, ANGEL Dávid, CSEH Dávid, BENKE Márton, MERTINGER Valéria <i>Residual stress monitoring for machine industry</i>	466 – 471
SIDDIQUI Shiraz Ahmed, MAROS B. Mária, SZILAGYINÉ BÍRÓ Andrea <i>Investigation of the tribological performance of wear resistant surface layers produced on automotive tool steel by duplex heat treatments</i>	472 – 478
SKORIC Branko, MILETIC Aleksandar, TEREK Pal, KOVACEVIC Lazar, KUKURUZOVIC Dragan <i>Influence of ion implantation on duplex hard coatings</i>	479 – 484
SKRIBANEK Ádám, BODNÁR István, ISKI Patrik <i>Optimizing an uninterruptible solar power system for inductive natured loads</i>	485 – 490
STOJANOVIĆ Nadica, GRUJIĆ Ivan, GLIŠOVIĆ Jasna, MILOJEVIĆ Saša, DAVINIĆ Aleksandar <i>Vanes shape optimization of ventilated disc brakes for heavy duty vehicles</i>	491 – 496
STOJIC Boris, POZNANOVIĆ Nenad <i>Experimental research of tractor tyre response to quasistatic passage over the singular road obstacle</i>	497 – 502
STRAKA Luboslav, DITTRICH Gabriel <i>Dielectric fluids applied during electrical discharge machining</i>	503 – 507
STRAKA Luboslav, DITTRICH Gabriel <i>Improving reliability indicators of technical systems</i>	508 – 512
SZABÓ Sándor, FORGÁCS Attila, NAGY Gábor, SZIKRA Dezső <i>Research, development and optimization of nuclear tomography</i>	513 – 518
SZAKÁL Zoltán, PATAKI Tamás, KÁRI-HORVÁTH Attila <i>Strength examination of adhesive bonded joints of steel against DBD treated PTFE and PA66 surfaces</i>	519 – 527



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



SZALAI Judit

The development of evaluation system qualifying the iter diagnostic cable conduit the and satisfying the system requirements

528 – 532

SZENTESI Miklós Gergely, LAKATOS István

Road traffic accidents caused by mechanical failures in Hungary between 2012 and 2017

533 – 539

SZIKI Gusztáv Áron, SARVAJ CZ Kornél, SZÁNTÓ Attila

Dynamic simulation of a series wound DC motor applying the control design and simulation module of LABVIEW

540 - 543

SZÜLE Veronika, PERE Balázs

Solution of thermomechanical coupled problem using fem

544 – 547

TANASKOVIĆ Drakče, ĐORĐEVIĆ Branislav, SEDMAK Simon, VUČETIĆ Filip, GAJIN Marko

Repair welding of lower rails of a 30CrMoV9 steel transport beam and the conditions under which the welding procedure must be carried out

548 – 555

THALMAIER György, SECHEL Niculina, VIDA-SIMITI Ioan

Water leaching behaviour of carbamide space holder particles in TiAl foams

556 – 559

TIBA Zsolt, FEKETE-SZŰCS Dániel, MENYHÁRT József

Eliminating the positioning error of gamma knife; recommendations for the mechanical overhaul

560 – 568

TISZA Miklós

Lightweight manufacturing of automotive parts

569 – 574

TOMOR András, ANTAL-JAKAB Erik, KRISTÓF Gergely

Experimental investigation of a finite length lateral system in a dividing-flow manifold

575 – 580

TOMOR András, MERVAY Bence, KRISTÓF Gergely

Continuous parametrization of hydraulic losses caused by diameter transition in cylindrical pipes

581 – 587

TÓTH Kinga, VENCZEL Gábor, SZAMOSI Zoltán

Examination of biomethane production

588 – 594

UNGÁR Péter, SZABÓ Tamás

Designing a balancing machine for a plastic rotor

595 – 600

VÖRÖSKŐI Kata

Selection of packaging systems in automotive engine supply: The case of overseas transport

601 – 606



**PROCEEDINGS OF THE
5th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



ZÁKOPČAN Ján, JAVOREK Lubomír, BACHRATÝ Michal

The influence of tool diameter and feed speed on feed force and torque moment during steel S233J0 drilling

607 – 611

ZÁKOPČAN Ján, JAVOREK Lubomír, BACHRATÝ Michal

Dependence of the thrust force from the clearance angle and feed speed during drilling

612 – 616

SUPPORTING COMPANIES OF THE ISCAME 2017

Introduction of the companies

617 – 634

THE DEPARTMENT OF MECHANICAL ENGINEERING

Department staff and the mechanical engineering trainings

635 - 639



COMBUSTION CHAMBER AND FUEL MIXTURE MOTION ANALYSIS OF A NEW ROTARY ENGINE

DUDÁS László PhD, KAPITÁNY Pálma

University of Miskolc, Hungary

E-mail: iitdl@uni-miskolc.hu, kapitanypalma@gmail.com

Abstract

The paper introduces a new patented internal combustion engine construction that has rotary working parts only. The internal combustion takes place in the cavities formed between the rotor and the rotary chamber. The rotation of these two parts of the engine are synchronised by the third rotary part of the engine, by the block gear. The accomplished work analyses the form of the combustion chamber along the working cycles of the motor and the motion path of the fuel mixture. It has been proved that in this type of rotary engine the motion path of the fuel mixture is unique among all the well known internal combustion engines having closed combustion chamber: it is linear.

Keywords: Rotary engine, internal combustion, rotor, rotary chamber, fuel mixture.

1. INTRODUCTION

There is no doubt that the internal combustion engines will exist in special areas along with the rapidly evolving electric engines and machines powered by them. So the improvement of possible new types of internal combustion engines is also important. The paper presents a new patented motor construction [1] that has rotary working parts only and characterised by closed internal combustion chambers. The construction, the advantages and disadvantages, the possibilities of manufacturing and assembling were analysed in previously published articles [2,3,4]. In the research work demonstrated in this paper the formation of the internal combustion cavities and the motion path of the fuel mixture along the working cycles will be analysed and demonstrated. First the geometry of the engine is discussed and the special distinctive characteristic signs will be reviewed. Then the explanation will deal with the dynamic formation and special features of the internal cavities where the working cycle sections – sucking, compression, ignition, combustion, expansion and exhaust happen. The third main part of the review will analyse the motion path formation of the fuel mixture and the gas in the working engine. In the end a summary will conclude the achieved results and new recognitions.

2. THE PATENTED ENGINE CONSTRUCTION

The evolution history of screw compressor line and the progressive cavity pump line lead to the invention and patenting of the new rotary internal combustion engine that was published in [5] by one of the authors. The direct prequel of the invention was the FORCYL-type fluid pump [6]. Applying changing pitch along the rotor and the rotary chamber axes the modified helicoids produce increasing and decreasing volumes of the dynamically formed cavities between these two main parts of the motor. The patented engine construction (see Fig. 1) is similar to the original construction of Wankel rotary engine [7] with the fixed axes of the two main rotary parts, but the working cycles happens not in the plane of the rotation, but along the length of the axes of the



engine. Owing to this 3D feature the pitch modifications give maximal freedom for setting the compression and expansion cycle properties. In this construction the moving parts simple rotate, there is no alternating or planetary motion at all. As there is not direct contact between the rotor and rotary chamber surfaces, the rotation speed of the engine is limited by the rotation limits of the rolling bearings and the synchronising gears only. As a consequence, this engine can reach the extreme high 40 000 RPM, that is more than double of actual formula one car engines rev. The final realisation is planned using industrial ceramic materials for the parts of the motor.

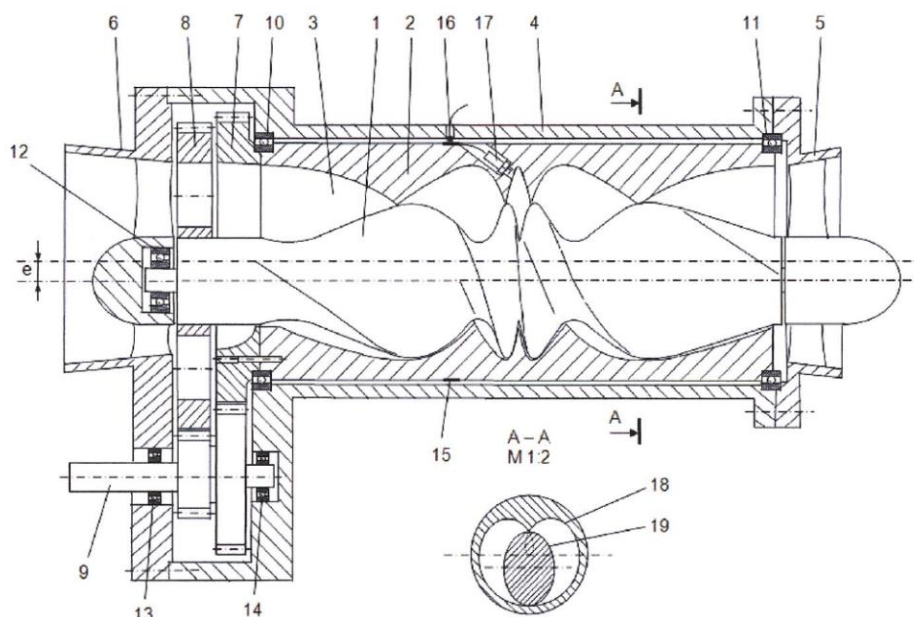


Figure 1 The patented rotary internal combustion engine

The next list summarizes the special distinctive characteristic signs of this motor:

- Prolonged or repeated sparking is also possible
- Two-stroke engine without any valves – no vibration and noise
- Compression and exhaust ratios can be controlled by any function
- There is no need for a tailpipe and muffler because the exhaust gas pressure may be as low as the environmental air pressure
- Mixture and exhaust gas are perfectly isolated
- There is no alternating motion – no vibration
- Very high rotational speed is possible: 40 000 RPM
- Very high temperature is applicable due to ceramic materials
- No need for water cooling
- Thermal fluctuation is minimal
- The friction between the rotor and the rotary house is drastically reduced because there is a very small gap.

Unfortunately there are some disadvantages also exist:

- Complex 3D surfaces, higher manufacturing cost
- Manufacturing and assembling precision is crucial
- Long internal cavities, more difficult combustion.



3. DYNAMIC FORMATION AND SPECIAL FEATURES OF THE CAVITIES

The cavities are formed dynamically between the rotary parts, namely between the rotor and the rotary chamber. These parts have own axes and there is a given eccentricity between them. The rotor and the chamber work as envelope surfaces in the relative motion. There is a very small gap between them and the dynamic effect happening on the fluid content of the fuel mixture and of the exploded gas act as sealing. In Fig. 2 the rotor is slightly enlarged to demonstrate the locations of the gaps on the rotary chamber surface in a given moment of rotation.

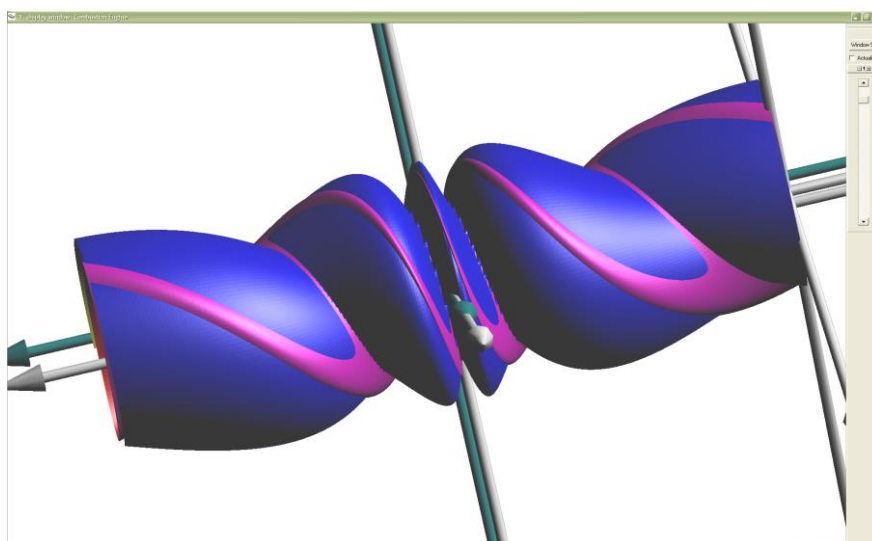


Figure 2 The enlarged rotor surface intersects the chamber surface and indicates the gaps locations

In accordance with the orthogonal intersection subfigure shown in Fig. 1, the ellipse curve of the rotor and the quasi-cardioid curve of the chamber are touches each other in two or three points depending on the angle of rotation. The chamber rotates with doubled rotation velocity of the rotor. The surface parts of the rotor and the chamber surfaces that are closed around by the touching spatial curves form closed cavities. These similar shape cavities are longer or shorter depending on the local pitch values of the rotary parts. As these cavities shorten a compression effect happens, and on the other hand the cavities becoming longer make possible the dilatation of the expanding gas. Owing to the used Surface Constructor [8] kinematic surfaces designer and motion animator computer program – developed by one of the authors – it is easy to study the motion of the engine parts. Any part can be chosen as fixed reference object and the relative motion of the other can be analysed. Using this possibility the next features were detected:

- The chamber is a one start helicoids, the rotor is a two starts helicoids
- The pitch of the rotor is two times longer than the pitch of the chamber
- A cavity length is one and a half thread (540 grad) on the rotor and three full thread (1080 grad) on the chamber
- The next cavity opens at every 180 grad rotation of the two starts rotor (360 grad of the one start chamber)
- A three thread (1080 grad) length rotor is suitable for an engine, after a 540 grad sucking in period the closing cavity moves along the axis 270 grad while performs a compression. In the next 270 grad expands fully and at the end of this period the cavity starts to open



- At every 180 grad rotor turning (360 grad chamber turning) there is an ignition
- There are three closed moving fills at the same time in different cavities, plus one half opening and one half closing (not closed) cavities at the two ends, and while a full 1080 grad four stroke cycle (see Fig. 3) takes place six explosions happen.

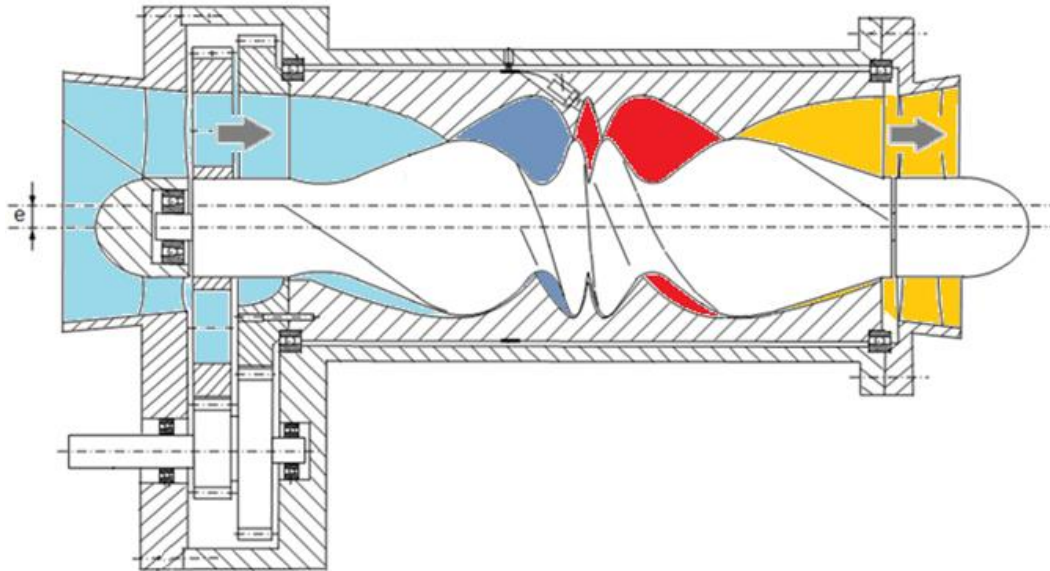


Figure 3 The four strokes of the engine are indicated by different colours

4. MIXTURE MOTION PATH FORMATION OF THE WORKING ENGINE

The goal of this section is to prove the presumption that the motion path of the mixture is linear, parallel to the rotary axes of the rotor and the rotary chamber. This property of the investigated engine is unique among all the well known internal combustion engines having closed combustion chamber and is similar to turbines.

The linear motion of the mixture comes from that fact that the formed planar regions between the intersection curves of the rotor and the chamber are moves along the axes as the rotary parts rotate. One moment of the working is fixed and is shown in Fig. 4. The figure shows the orthogonal intersections in different locations of the engine and these intersections are assigned to the proper location of the rotor with numbers. The formation of one cavity has been emphasised with grey filling of its area. The formed cavities have a 'slug' form that is curved in a helical manner. The thickest intersection of this 3D formation is in the upper region of the chamber because the rotor axis is under the chamber axis with the e eccentricity as marked in Fig. 3. As this eccentricity is constant along the length of the engine, the thickest part of the cavity is always in the upper region of the chamber when moves along the engine. As a consequence, the shown intersections, one after another, go through the engine parallel to the axes direction. It can be interpreted another way also, considering the 'slug', it moves linearly along the axis direction and it changes its form only in axial direction, as a spring, because of the compression and expansion. This motion was checked by the SC computer program that could animate the motions.

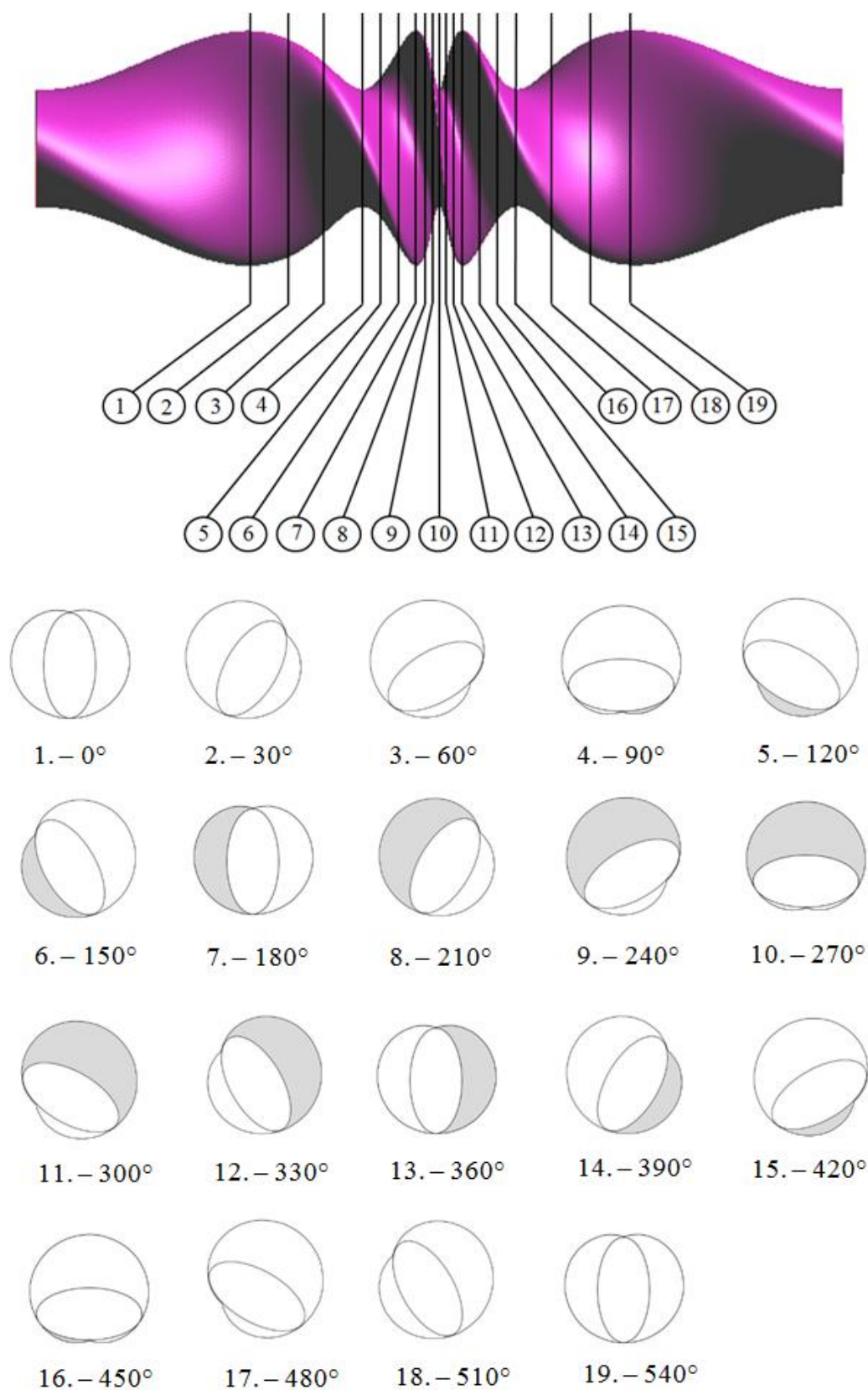


Figure 4 The orthogonal intersections of the rotor and the rotary chamber surface form closed regions



SUMMARY

The paper introduced a new patented internal combustion engine construction that has rotary working parts only. First the construction was presented with its unique features, then the advantages of such a type engine were listed together with the disadvantageous properties. Then the dynamically formed closed cavities were analysed in conjunction with the rotational angle of the rotor and the strokes of the engine were demonstrated. The investigations are shown that an engine having three full threads of the double start rotor having elliptical orthogonal intersection curve is enough for a well-working engine, and in the case of such a construction six explosion will happen in every cycle. In the last part of the accomplished analysis it has been proved that in this type of rotary engine the motion path of the fuel mixture is linear along the axes of the rotary parts and this feature is unique among all the well known internal combustion engines having closed combustion chamber.

ACKNOWLEDGMENTS

This research was partially carried out in the framework of the Center of Excellence of Mechatronics and Logistics at the University of Miskolc. The financial support is acknowledged. The authors also acknowledge the help of Máté Biró, who determined the intersection points used in Fig. 4.

REFERENCES

- [1] Dudás, L.: *Rotary Piston Internal Combustion Engine*. Hungarian patent HU230082, 2015.
- [2] Dudás, L.: *Computer Aided Design of a New Combustion Engine Having Only Rotary Parts*, SAMI2015 IEEE 13th International Symposium on Applied Machine Intelligence and Informatics, PROCEEDINGS, January 22-24, 2015 Herl'any, Slovakia, pp.295-300. IEEE Xplore: DOI: 10.1109/SAMI.2015.7061892
- [3] Dudás, L. Biró, M., Novák, L. L.: *Construction Modeling and Manufacturing Analysis of a New Rotary Combustion Engine*, INES 2016 • 20th Jubilee IEEE International Conference on Intelligent Engineering Systems • June 30-July 2, 2016 • Budapest, Hungary pp.89-94. IEEE Xplore: DOI: 10.1109/INES.2016.7555099
- [4] Dudás, L.: *Developing a Rotary Internal Combustion Engine Characterised by High Speed Operation*. In: Jármái K., Bolló B. (eds) *Vehicle and Automotive Engineering. Lecture Notes in Mechanical Engineering*. Springer. 2017
- [5] Dudás, L.: *Térbeli forgódugattyús motorok evolúciója (Evolution of spatial rotary piston engines)* (In Hungarian), Műszaki Füzetek 14. (HU ISSN 2060-7954) Ed.: prof. dr. László Pokorádi, pp.284-292.
- [6] Micro Europe Kft.: *A Sokszögmegmunkálás Élvonalaiban* (In the Frontline of Polygon Surface Machining), Available at: <http://www.microeurope.hu/indexsziv.html>, Accessed Febr. 19, 2012.
- [7] *NSU Wankel rotary engines and cars*, http://cp_www.tripod.com/rotary/pg05.htm, Accessed: Oct. 2, 2017.
- [8] Dudás L.: *Modelling and Simulation of a New Worm Gear Drive having Point-like Contact*, *Engineering with Computers*, Volume 29, Issue 3, pp. 251-272. 2013.



THE EFFECT OF PROFILE VARIATION ON CONTACT PROPERTIES IN CASE OF QUASI GLOBOID WORM GEARING

DUDÁS László PhD

University of Miskolc, Hungary

E-mail: iitdl@uni-miskolc.hu

Abstract

The paper presents the effect of the profile variation on the contact properties of a new, hourglass-like quasi globoid worm gearing. This gearing type is a novel construction and needs deeper analysis. The generation of the worm is made moving the generating profile along a line that is not parallel to the axis of the worm. The head surface of this worm is a hyperbolic surface of revolution. The advantage of the generation and the machining that it doesn't need special teething machine, like the normal Cone-type worms, but a modified turning machine is adequate. The worm wheel is enveloped by the worm. As this worm gearing is new, the evaluation of the properties, advantages and disadvantages are missing. This paper would like to analyse three types of profile curves: linear, circular and elliptical and presents the form of the mating curves.

Keywords: Hourglass-like worm, worm generation, worm wheel tooth generation, mating properties.

1. INTRODUCTION

The hourglass-like worms and the gearings using such worms are known as very precise, loadable drives. The original Cone-type gearing is characterised by advantageous contact lines and an undercut region on the gear tooth surface. Because of the advantageous properties many research was accomplished to avoid drawbacks and improve the driving [1, 2, 3]. One of the disadvantages is the expensive cutting method of the worm and the required special teething machine. The circular generating motion characterises the cutting process, as can be followed in Fig. 1.

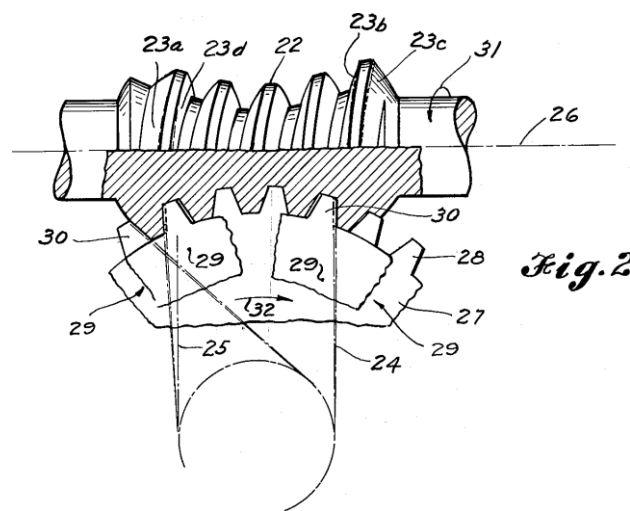


Fig. 2

Figure 1 The circular motion of the generating edge in case of Cone-type globoid worm [1]



The innovations concerning the profile curve modification and using rotary tool for generating the worm resulted in better, more economical technologies [3, 4]. The author introduced in [5] a globoid-like novel gearing type that uses linear motion of the cutting tool, but this path is not parallel to the worm axis. To refresh the method Fig. 2 is borrowed from that paper.

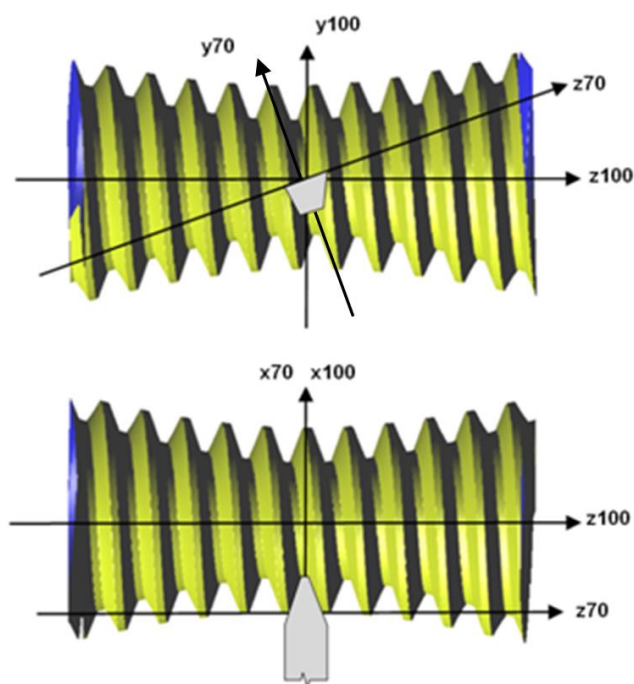


Figure 2 The generation of the tooth surface of the worm

Figure 2. shows the case when the edge of the tool is linear. This case was analysed in [5]. The enveloping of the worm wheel tooth surface and the generated segment of the worm wheel are shown in Fig. 3.

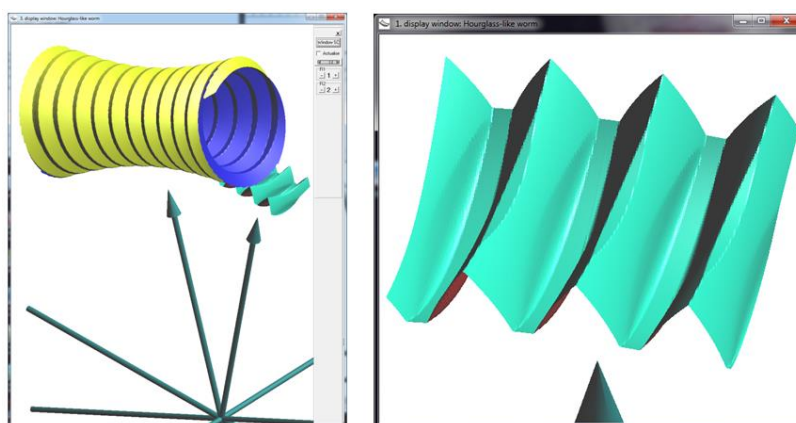


Figure 3 Generation of the worm wheel segment (left) and the segment having undercut region (right)

The results revealed that the worm wheel teeth may have large undercut region at the foot of the tooth.



Moreover the mating lines were also disadvantageous, almost parallel to the sliding velocity direction, as can be checked in Fig. 4.

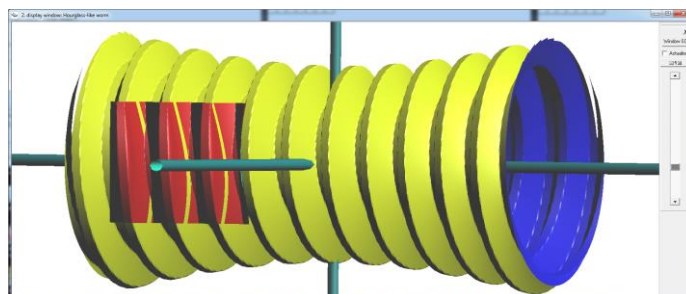


Figure 4 The characteristic curves on the inner side of the worm wheel segment

In the following two other profile curves, circle and ellipse will be used for sweeping the worm tooth surface and the mating worm wheel surface will be generated in the enveloping process. Then the form of the characteristic lines will be evaluated and compared. The modelling and the generation of surfaces were performed by the Surface Constructor (SC) 3D kinematic modeller computer program of the author.

2. CIRCLE GENERATOR PROFILE ON THE WORM

The theoretical cutting tool is positioned in the $x70$ - $z70$ coordinate plane, similarly to the case shown in Fig. 2 for the situation of linear edge. To improve the efficiency of the research the working tooth surfaces were modelled both for the worm and for the worm wheel only. A screenshot in Fig. 5 shows the model in SC with the axes of coordinate systems. Unfortunately the large undercut region could be detected in this case also, as shown in right side of Fig. 5. Applying larger distance of rotary axes this problem could be eliminated.

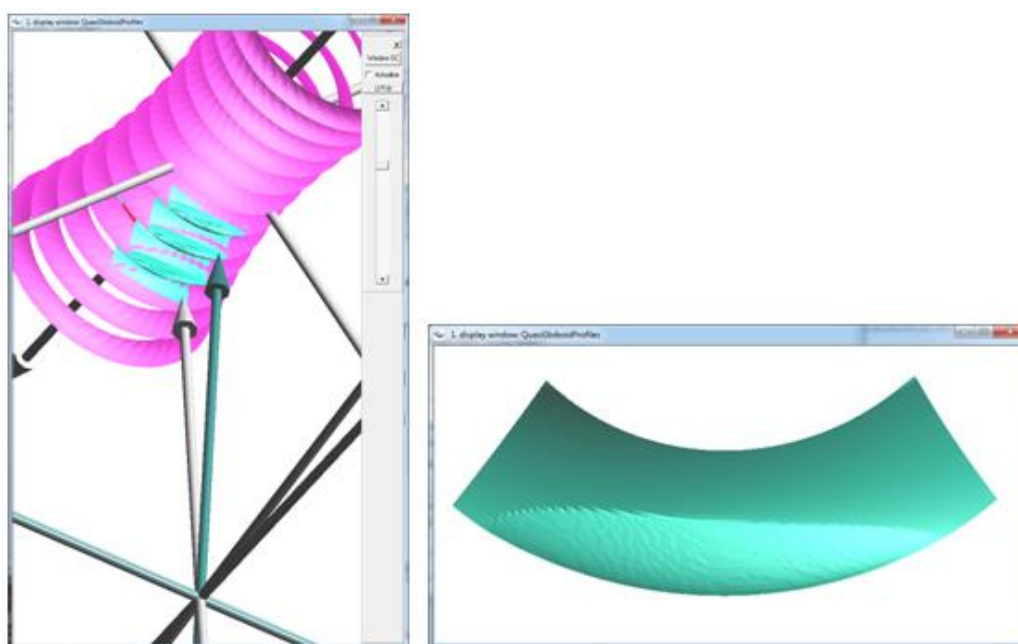


Figure 5 The model (left) and the undercut worm wheel tooth surface (right)

For the first it was surprising that the worm wheel tooth side is generated by the positive $z100$ half of



the worm only. This happens because of the asymmetric location of the generating motion path to the centrally symmetric helicoids of the threads of the worm which originates from the ALPHA angle between z_{100} worm axis and z_{70} generating curve translation direction. The axial relocation of the generating profile doesn't modify this feature. In case of circle profile the enveloped worm wheel, the enveloping worm and the characteristic curve between them show similarity to the helical worm having linear profile form. Some moments of the relative motion of the worm and worm wheel are shown in Fig. 6. Only the effective positive half of the worm is used.

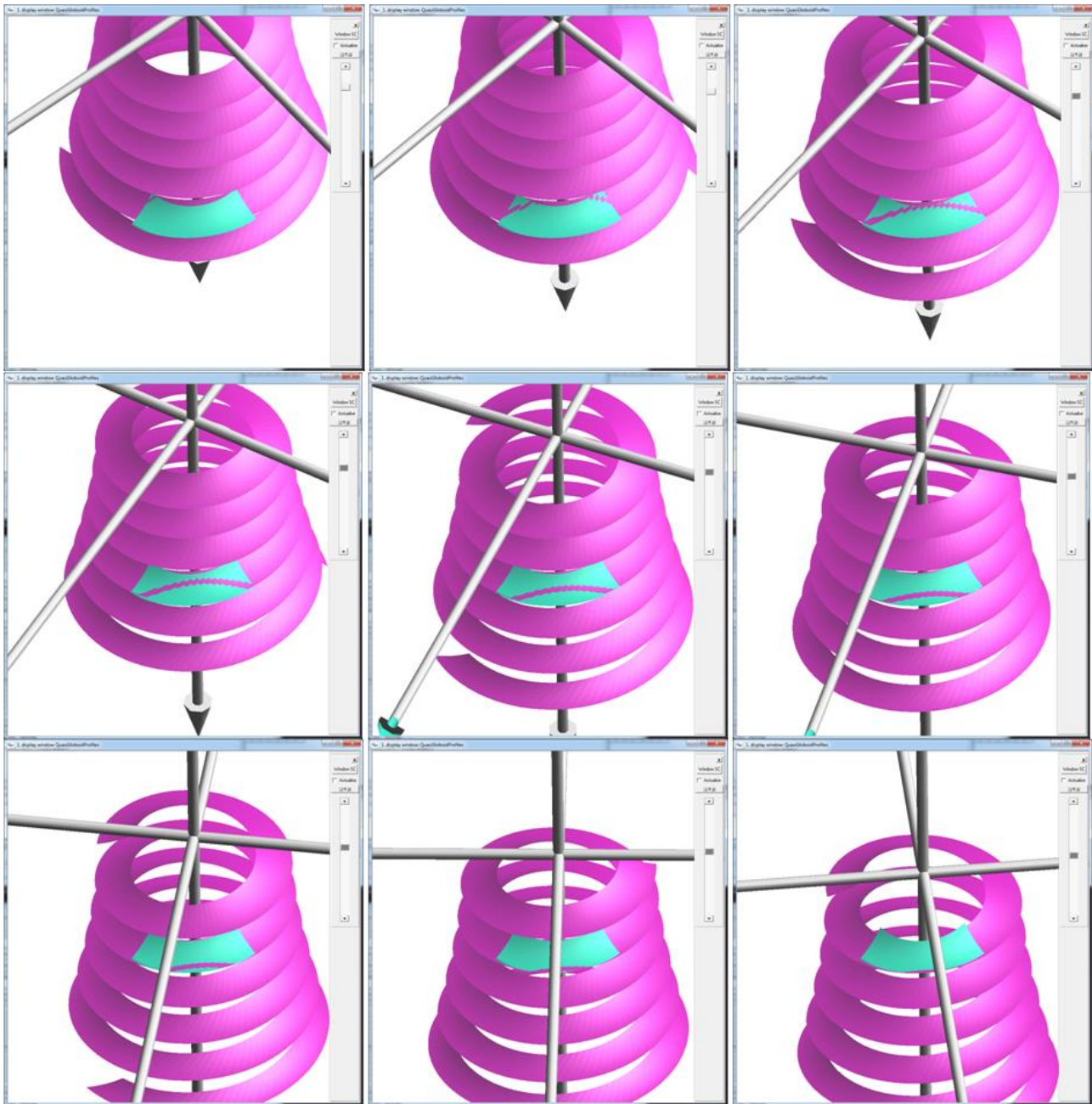


Figure 6 Characteristic curves of the mating worm and worm wheel tooth surfaces



2. ELLIPSE GENERATOR PROFILE ON THE WORM

The pictures of the mating surfaces of the gearing generated using ellipse profile curve are presented in Fig. 7. They are very similar to the curves of circular gearing.

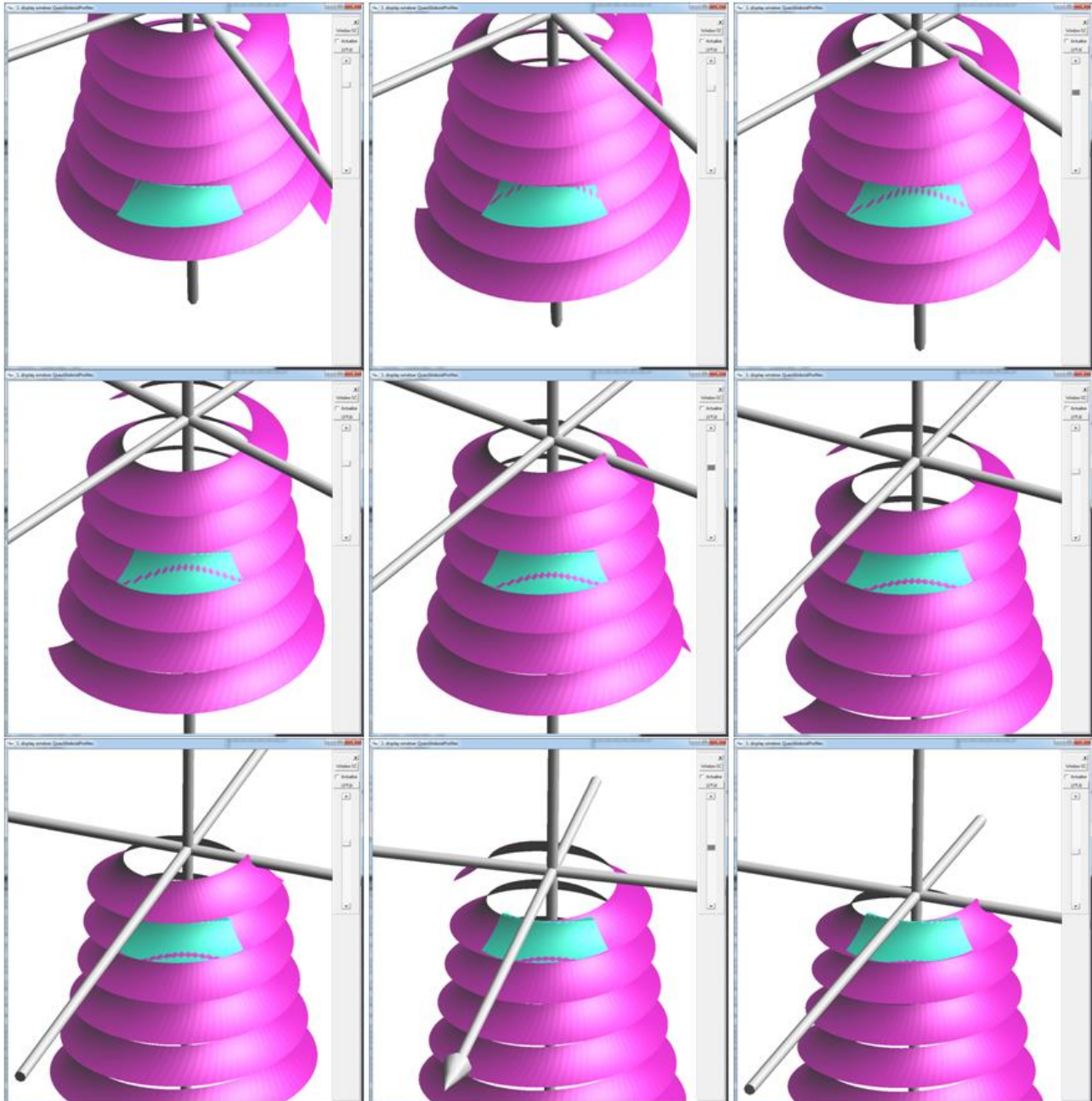


Figure 7 Characteristic curves of the mating worm and worm wheel tooth surfaces in case of elliptical generating curve

4. SUMMARY

The paper introduced a new worm gearing having hourglass-like worm. Despite of high similarity to globoid form, this type of worm can be generated without circular tool motion with a simple linear



feed and as a consequence it can be produced even on a normal lathe equipped with a tilted worm holder. The advantages and disadvantages are need additional investigations and modelling. Beside trivial advantages, like easy and cheap machining and the possibility of using the well-tried modification methods of cylindrical worm drives, the accomplished with SC (see Fig. 8) modelling revealed a special feature: the worm is not the usual, one half of the threads connect to the right hand side of the worm wheel teeth, and the threads of the other half connect to the left hand side of the worm wheel teeth. Foreseen analysis has to explore the balancing possibilities of the mating properties to improve the number of simultaneously connecting teeth.

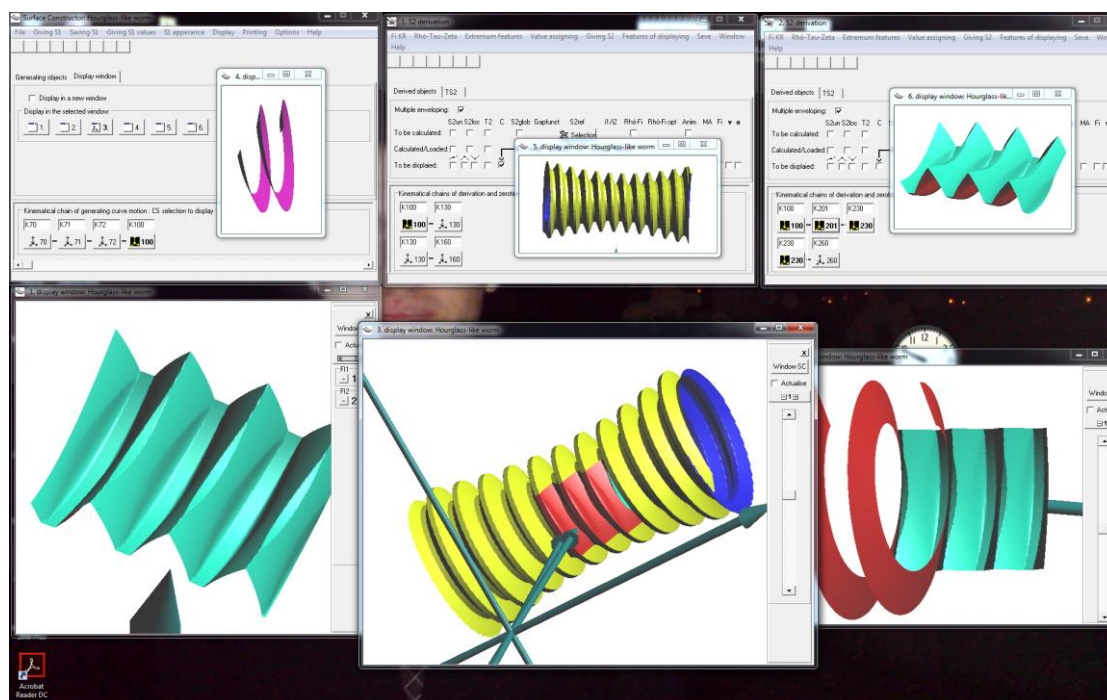


Figure 8 Snapshot of the computer screen in the midst of the analysis accomplished with Surface Constructor

ACKNOWLEDGMENTS

This research was partially carried out in the framework of the Center of Excellence of Mechatronics and Logistics at the University of Miskolc. The financial support is acknowledged.

REFERENCES

- [1] Skog, G.: *Gear worm thread generating machine*. US 2756641 A patent, 1956.
- [2] Wildhaber, E.: *Enveloping worm gearing*. US 2935886 A patent, 1960.
- [3] Kobayashi, T.: *Hourglass worm gear*. US 5325634 A patent, 1994.
- [4] Lunin, S. V.: *Globoid gear technology from ZAKGEAR* <http://www.zakgear.com/Wormoid.html>, Accessed: 10.10.2016.
- [5] Dudás, L.: *Generation and analysis of a new hourglass-like worm gearing*. PROCEEDINGS OF THE 4th INTERNATIONAL SCIENTIFIC CONFERENCE ON ADVANCES IN MECHANICAL ENGINEERING (ISCAME 2016) 13-15 October, 2016 Debrecen, Hungary, Eds. S. Bodzás, T. Mankovits