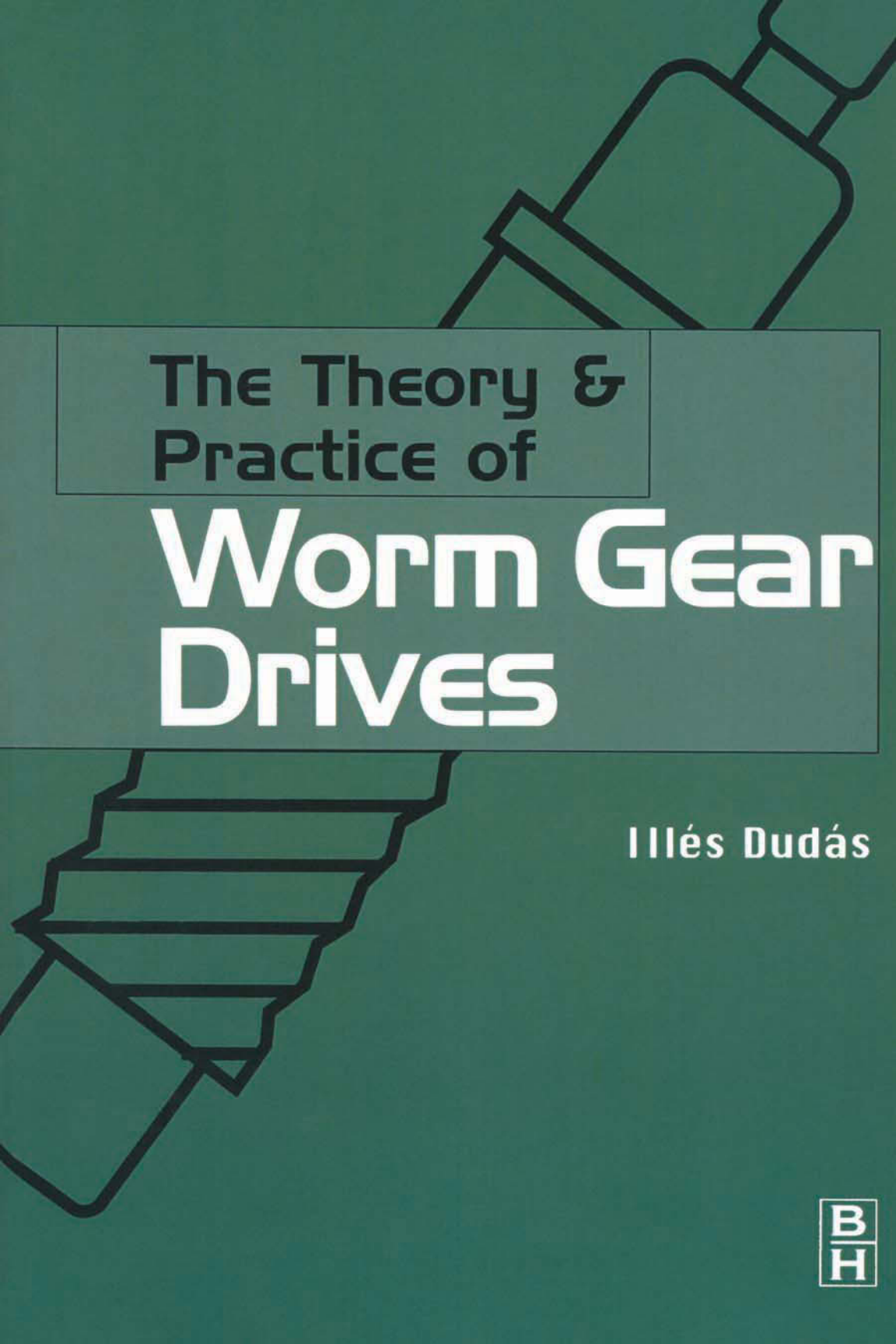




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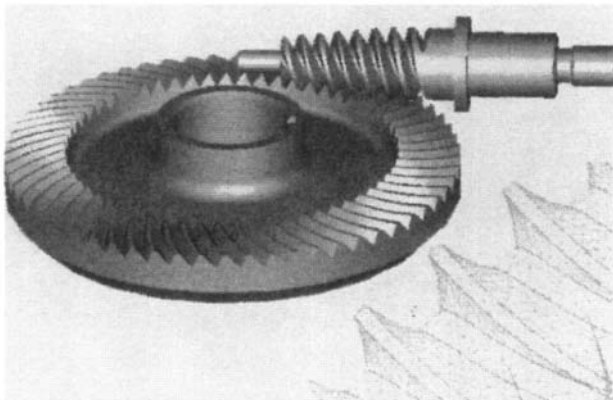
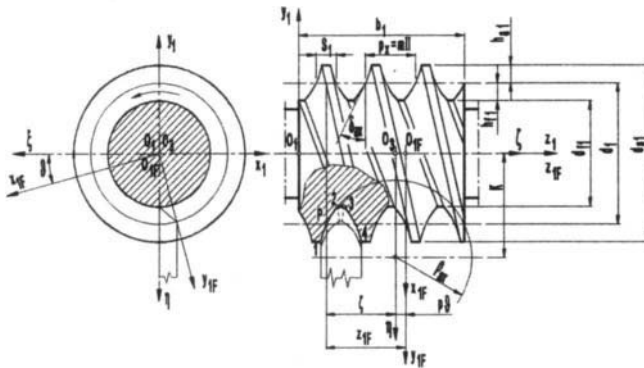
Worm Gear Drives

Illés Dudás



THE THEORY AND PRACTICE OF WORM GEAR DRIVES

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THE THEORY AND PRACTICE OF WORM GEAR DRIVES

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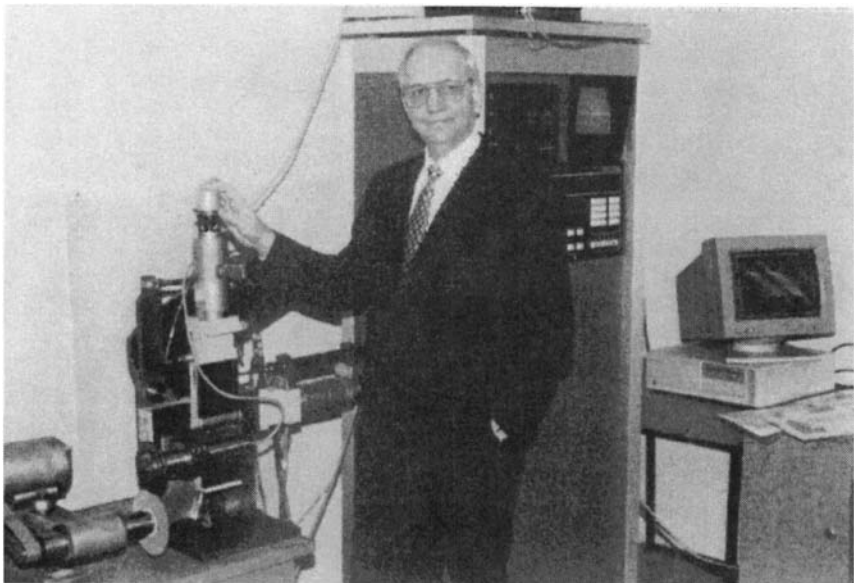
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To my wife, three children and parents



The author with his early CNC grinding wheel dressing experimental equipment

CONTENTS

Foreword <i>by Professor F.L. Litvin, University of Illinois</i>	xi
Preface	xiii
Acknowledgements	xvi
List of symbols	xix
1 Introduction	1
1.1 Classification of worm gear drives	4
2 A short history and review of the literature	7
2.1 A short history of the worm gear drive	7
2.2 Development of tooth cutting theory for spatial drives	13
2.3 Cylindrical worm surfaces	16
2.3.1 Helicoidal surfaces having arched profile	16
2.3.2 Cylindrical worm gear drives with ruled surfaces	26
2.4 Conical helicoid surfaces	26
2.5 Surface of tools	29
2.6 General conclusions based on the literature	30
3 Manufacturing geometry for constant pitch helicoidal surfaces	33
3.1 Development of manufacturing of cylindrical worm gear drives having arched profile	33
3.1.1 Analysis and equation of helicoidal surface having circular profile in axial section	35
3.1.2 Analysis of worm manufacturing finishing; an exact solution	42

3.1.3	Problems of manufacturing geometry during final machining of worm – determination of grinding wheel profile	44
3.2	Investigation of geometric problems in manufacturing cylindrical helicoidal surfaces having constant lead; general mathematical – kinematic model	61
3.2.1	Investigation of geometric problems when manufacturing cylindrical helicoid surfaces using general mathematical – kinematic model	64
3.2.2	Analysis of manufacturing geometry for conical helicoid surfaces	75
3.3	Geometric analysis of hobs for manufacturing worm gears and face-gears mated cylindrical or conical worms	102
3.3.1	Investigation of cutting tool for manufacturing worm gear mated with worm having arched profile	110
4.	General mathematical model for investigation of hobs suitable for generating cylindrical and conical worms, worm gears and face gear generators	124
4.1	Application of general mathematical – kinematic model to determine surface of helicoidal surface-generating tool for cylindrical thread surfaces	135
4.2	Machining geometry of cylindrical worm gear drive having circular profile in axial section	136
4.3	Machining geometry of spiroid drives	148
4.4	Intersection of cylindrical helicoidal surface having circular profile in axial section (ZTA) and the Archimedian thread face surface as generating curve of back surface	162
4.4.1	Generation of radial back surface with generator curve	164
4.4.2	Contact curve of the back surface and the grinding wheel	165
4.5	Manufactured tools for worm gear generation and other tools having helicoidal surfaces	169
4.5.1	Design and manufacture of worm gear milling cutters	169

5	Grinding wheel profiling devices	182
5.1	Devices operated according to mechanical principle	183
5.2	Advanced version of the wheel-regulating device operating on the mechanical principle	186
5.3	CNC-controlled grinding wheel profiling equipment for general use	191
6	Quality control of worms	200
6.1	Checking the geometry of worms	200
6.1.1	Determination of worm profile deviation	201
6.2	Checking of helicoidal surfaces on 3D measuring machines	204
6.2.1	Use of 3D measuring machines	206
6.3	Checking of helicoidal surfaces by application of 3D measuring device prepared for general use (without circular table, CNC-controlled)	209
6.4	Results of measurement of helicoidal surfaces	217
7	Manufacture of helicoidal surfaces in modern intelligent integrated systems	222
7.1	Application of expert systems to the manufacture of helicoidal surfaces	222
7.1.1	Problems of manufacturing worm gear drives	223
7.1.2	Structure of the system	224
7.1.3	The full process	224
7.2	Intelligent automation for design and manufacture of worm gear drives	227
7.2.1	Conceptual design of helicoidal driving mates	228
7.2.2	Manufacture of worms and worm gears	245
7.3	Measurement and checking of helicoidal surfaces in an intelligent system	251
7.3.1	Checking of geometry using coordinate measuring machine	253
7.4	Development of the universal thread-grinding machine	255
7.4.1	Review of thread surfaces from the point of view of thread-grinding machines	255
7.4.2	Manufacturing problems of thread surfaces	255

7.4.3	Requirements of the thread-grinding machine	257
7.4.4	Development of a possible version	258
7.5	Conclusions	259
8.	Main operating characteristics and quality assessment of worm gear drives	260
8.1	Testing the meshing of the mated elements	260
8.1.1	Building in the mating elements	261
8.1.2	Adjustment and position checking of contact area	262
8.2	Checking the important operational characteristics of worm gear drives	271
8.2.1	Running in of the drives	271
8.2.2	Determination of optimal oil level	274
8.2.3	Investigation of warming up of the drives	274
8.2.4	Investigation of efficiency of drives	277
8.2.5	Investigation of noise level of drives	280
9	Summary of results of research work	289
	References	294
	Further reading	303
	Index	331

FOREWORD

The writing of this Foreword to this book presents me with a wonderful opportunity to recall my visits to Miskolc and my meetings with the distinguished scientists and the friends that I was lucky enough to make there.

My friends from Miskolc, Professor Zeno Terplan and Dr Jozsef Drobni, gave me the best present that I could have asked for – they translated in 1972 the Russian edition of my book *Theory of Gearing* into Hungarian.

I was delighted to find in my conversations with Drs Imre Levai, Zeno Terplan and Illés Dudás a mutual interest in topics such as non-circular gears, planetary trains and worm gear drives.

The greatest reward for a scientist is to have a following, and this I found in Hungary.

My joy in this could perhaps best be expressed by citing the famous verse ‘The Arrow and the Song’ by Henry Wadsworth Longfellow:

*I shot an arrow into the air,
It fell to earth, I knew not where;
And the song, from beginning to end,
I found again in the heart of a friend*

I hope that this short introduction explains why I am grateful for the opportunity to write a Foreword to this excellent book written by Professor Dudás.

The generation and manufacture of worm gear drives and the design of tools (hobs, grinding disks) for worm and worm gear generation is an important area of research. The application of CNC machines to the manufacture of worms and worm gears, their

precision testing, and the computerized design of tools have broadened the horizons of research and have required from the researchers a good knowledge of the theory of gearing and specialized topics in differential geometry.

In this book Dr Illés Dudás makes a significant contribution to these topics of research; included are the author's summaries of the results of research obtained by himself and other researchers. In addition, Professor Dudás demonstrates the results of his great and wide experience in the design and manufacture of worm gear drives and in neighbouring subject areas.

The contents of the book cover the main topics of the design and manufacture of gear drives. I am familiar with the research performed by Professor Dudás whom I was able to meet at International Conferences (in San Diego and Dresden) and at our University, and by exchange of our publications.

There is little doubt that this book will be prove to be a most useful work for researchers and engineers in the area of gears.

Faydor L. Litvin

University of Illinois at Chicago
Chicago, USA
1999

PREFACE

Automation is playing an ever-increasing role in the development of both product and manufacturing technologies. Automation provides important means of improving quality and increasing productivity as well as making production more flexible, in line with changing needs. State of art computer control now has a role for machine tools and in manufacturing technology. Design of the product as well as of manufacturing equipment has been taken over by computer-aided, and sometimes by completely automated, systems. In the increase in efficiency of manufacturing processes and product quality, the most important element has been computer-aided engineering.

Helicoid surfaces are often used in mechanical structures like worm gear drives, power screws, screw pumps and screw compressors, machine tools, and generating gear teeth. Therefore many research and manufacturing organizations are becoming involved with their design, manufacture, quality control and application.

Theory and practice in this field are usually treated separately in textbooks. There are significant differences between different machining technologies, and checking methods for helicoidal surfaces are not always designed and manufactured precisely and optimally.

I have been particularly fortunate to have been able to work, during the course of my career, in many fields of engineering. During my years as a professional engineer I always felt attached to scientific investigation concerned with the correlation between construction and manufacturing technology. Following a short period in industrial practice I worked, for ten years, as a designer. My first assignments were the design of service equipment (for example the DKLM-450 type wire-rope bunch lifter), and later, wire pulling

stages, wire-end sharpeners, etc. The need for an improved worm gear drive arose in the course of this work.

The machine factory at Diósgyőr (DIGÉP, Hungary) was using wire pulling stages and decided to modernize them, to reduce their noise level, weight and cost along with developing an increase in the efficiency and load-carrying capacity. The modernization was carried out successfully so that the kinematically complicated drive systems were simplified too.

The experience gained during tests showed that drive systems fulfilling exacting requirements can only be solved by using special worm gear drives. The technical development of worm gear drives at DIGÉP resulted in worm gear drives with different geometries such as convolute helicoids with limited bearing capacity, worm drives with rolling contact elements and helicoidal surfaces curved at their axial section. Comparing them, it became clear that the development of curved axial section type helicoidal surfaces was called for.

Research in the fields of manufacturing technology development, as well as toothing geometry of mated pairs and the overall checking and quality control of these drives, are summarized in some of my published works (Dudás, 1973, 1980, 1988b).

Worm gear drives designed and manufactured by application of this newly developed method have operated efficiently both in Hungary and abroad in a range of different products.

In my present position as Head of Department of Production Engineering at the University of Miskolc, it has been possible to continue my previous research work in this field, to fill gaps in the work and to search for a possible description of their generalized geometry, starting from the common characteristics of the different types of helicoidal surfaces.

This book basically aims to clear up geometrical problems arising during manufacture and provide theoretical equations necessary to solve them, thus filling a gap existing in publications in the field.

In the nine chapters of the book, both theory and practice are covered. The contents may be summarized as follows:

1. This introductory chapter provides the reader with a view of the aim of the book and provides a short review of the history of worm gear drives.
2. An analysis of the literature of the subject and a summary of conclusions to be drawn from it concerning the field covered by the book.

3. The theory needed for the proper geometrical manufacture of helicoidal surfaces of constant pitch is introduced here. Further, a mathematical model is developed, suitable for the handling of the production geometry of both cylindrical and conical helicoidal surfaces.
4. Introduces a general mathematical kinematic model for both cylindrical and conical worm gear drives, as well as the design and manufacture of the necessary tools.
5. Newly patented truing equipment for grinding wheels is described.
6. Checking methods for helicoidal surfaces are described.
7. Design methods and the procedures for manufacturing helicoidal surfaces using intelligent CIM systems are introduced.
8. The basic theory, operational characteristics and the possible applications for drives are summarized in this chapter.
9. Comprises a summary of results of research work.
10. A full bibliography of publications relevant to the subject of this book is included in References and Further Reading.
11. Index.

In writing this book, it is the author's hope that it will prove useful for those involved in both graduate and postgraduate work in research and development and also practising engineers in industry.

Illés DUDÁS

ACKNOWLEDGEMENTS

In the course of the research on which much of the content of this book is based, there were many people who assisted me or contributed directly or indirectly to my work. To them, I would like to give my heartfelt thanks.

While I cannot manage to mention all of those involved, I should like to express my grateful thanks to the following, who helped and encouraged my development in this area of research.

First, from my undergraduate days, when I first became interested in the correlation between research and manufacture, Dr József Molnár, who played an important role in bringing to my attention the lack of precision in the WFMT; in the various phases of my research, Drs Károly Bakondi, István Drahos and Imre Lévai, and also Drs Tibor Bercsey and József Hegyháti of the Technical University of Budapest for their active and helpful collaboration.

My thanks are also due for the help of Professor Dr Zéno Terplán, who was the Head of Department of Machine Elements at the University of Miskolc for several decades, and I am grateful for having been able to consult Professors Friedhelm Lierath (Otto-von-Guericke University of Magdeburg), Boris Alekszeyevich Perepelica (Technical University of Kharkov) and Hans Winter (Technical University of Munich).

I should like to express special thanks to Professor Dr Faydor L. Litvin (University of Illinois, Chicago), whose work helped me in my basic research and who allowed me to consult him personally, and I should like to acknowledge my debt to Dr F. Handschuh (NASA Glenn Research Center), whose critiques in various publications of The American Society of Mechanical Engineers increased the scope of my awareness.