HABILITATION THESIS

Advanced Methods in Gear Design and New Data Models in Mechanisms

Abstract

The habilitation thesis starts with the SUMMARY on ACTIVITY and ends with the SCIENTIFIC AND ACADEMIC DEVELOPMENT PLANS. Chapters one to three are concentrating on new methods for designing helical (chapter 1), spur (chapter 2) and worm gears (chapter 3), while the chapter 4 is about using advanced data modeling in the fields of CAD and mechanisms.

Today, in the field of mechanical transmissions, an important **objective** is to manufacture **gears** with **high efficiency** in order to reduce power losses, operating temperatures, noise, vibration and wear. To achieve these demands balancing, at the start and end points of gearing, of the relative velocities, sliding coefficients, power lost by friction and efficiency are made for different types of gears. Based on the obtained results recommendations are made on choosing the addendum modification or the geometrical dimension of the gears designed with this benefits.

The domain of programming in mechanical sciences was restricted to procedural and modular paradigms. The objective of the researches from chapter 4 is to use **advanced data modeling** based on the object oriented and relational paradigms to obtain **easy programming** of AutoCAD and simple **simulations** in Java together with **data persistence** based on relational databases in the mechanisms structural description.

Chapter 1, entitled "**New design methods for helical gears**", is based on the theory of balancing or equalization of the relative velocities (§1.1) and the relative sliding (§1.2) at the points where the meshing begins and ends. Helical gears have silent operation, can transfer power between non parallel axes and can handle more loads compared to spur gears. Their use is in the field of spatial mechanisms, robot constructions and conveyor driving systems. However, the efficiency of helical gear is less because helical gears have sliding contacts between the teeth which s produce axial force in the gear shafts and generate more heat. Also, as a result of sliding contact, wearing in these gears is higher than those from spur gears. The research is giving two approaches to balance the relative velocities and the sliding coefficients, at the points where the meshing begins and ends, in order to maintain better work conditions of the gears in time. The effect of sliding equalizations is also studied with respect of the efficiency of the helical gear with the help of genetic algorithms in order to find out the best pair of addendum modifications for

highest efficiency and lowest balanced sliding. For this purpose from the Optimization Tool in Matlab the "Multiobjective Optimization using Genetic Algorithm" solver is used.

Chapter 2 is dealing with "**New methods for designing cylindrical spur gears with addendum modification**" as these are the most common type of gear. They have straight teeth, are parallel to their axis and are used frequently to create large gear reductions. Used in many devices, during the meshing, the teeth collide and this increases the stress on the gear teeth and makes noise. The use of addendum modification can increase the load capacity and reduce noise in spur gears. Several methods for determining the specific addendum modifications at cylindrical spur gears can be found in the technical literature, however, these don't consider the friction coefficient. The following research gives two new methods where the balancing or equalization of powers lost by friction (§2.1) and of the efficiencies (§2.2), at the points where the meshing starts and ends are used to determine the specific addendum modification taking into account the friction coefficient between teeth flanks.

Chapter 3, entitled "**New methods for designing worm gears**" are concentrating on choosing the main geometrical parameters of worm gears to have higher efficiency (§3.1), better uptime (§3.2) and hydrodynamic lubrication conditions (§3.3). Worm gears are used in high gear reductions and they can be used to either greatly increase torque or greatly reduce speed. This is one of the reasons why one would choose a worm gear over a spur gear. Another reason would be the inability to reverse the direction of power due to the friction between the worm and the wheel.

Chapter 4 entitled "**Modern programming technologies and data models in mechanisms and gear design**" begins by a method to interact, only on 32 bit Windows platform, between Java and AutoCAD based on the Jawin open source project. This can be used to program AutoCAD in Java as It would be in VBA and in Visual Basic to perform high quality and precise 2D and 3D simulations (§4.1). The second paragraph (§4.2) approaches the science of mechanisms using an object oriented data model considering the morphology based on functional (elements and links) and topological (geometry and restrictions) descriptions and the kinematics (based on the relative positions) of the mechanisms. Paragraph §4.3 is based on the relational data model used to describe a database structure that can store mechanisms by describing three relationships: element, type and link. A database implementation is given then, using SQL and Oracle database, to demonstrate the use of the three types of relationships in the storage of planar mechanisms. The paragraph §4.4 is based on based on the theory of balancing or equalization of the relative velocities (§1.1) and the relative sliding (§1.2) at the points where the meshing begins and ends for helical gears and the object oriented data model. This paradigm is used to give a unified view of the two balancing methods in a single object model. For this purpose Java class diagrams having the proper implementations of numerical methods are provided with the necessary object instantiations in order to use the object model in the study of profile shift coefficients (addendum modification) of balanced helical gears form §1.1 and §1.2.