Use of The Design Accelerator From Autodesk To Enhance The Teaching of Machine Design

Andy S.J. Zhang
azhang@citytech.cuny.edu
NYC College of Technology of CUNY
Department of Mechanical Engineering Technology
300 Jay Street, Brooklyn, NY 11201

Abstract: This paper presents an innovative approach to complement the teaching of machine design and machine design process through the use of the Design Accelerator developed by Autodesk. With the help of the Design Accelerator, students can enter geometric information directly onto templates to create various 3D machine parts effectively, reducing the part creation time.

This paper will demonstrate that by using the Design Accelerator not only are the students able to accelerate the design process by entering the geometric information directly onto the templates but they also can incorporate the engineering principles directly into the creation of the part geometry.

The Design Accelerator makes it possible for the instructor to effectively introduce the concurrent design and engineering practice into the classroom. Students are able to implement the concurrent engineering concept into their class work and treat machine design as a system design and not as the design of unrelated individual parts.

Key words: Machine design, Design Accelerator, Concurrent engineering.

Introduction

Machine design is a major course in the mechanical engineering department that is designed to teach the students the basics of designing products that contain moving parts. Traditional approaches to teaching machine design used to emphasize the engineering analysis of individual parts, such as gears, shafts, and bearings.[1-2] The advancement in computer technology over the past twenty years has created a new way to design a machine or a product called concurrent design and engineering. This new approach to machine design requires that the engineering analysis tools such as Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD) packages be tightly integrated with design tools such as the solid modeling and virtual animation packages. With the advanced solid modeling and virtual animation tools, three-dimensional (3D) digital models of each machine part can be created and virtually assembled inside the computer. Engineers and designers can then use the virtual assembly model to do many things, such as to perform interference studies, animate motions, perform assembly sequence studies, and to exchange ideas among the designers, the engineers, and the customers, etc. This practice has become the industrial standard practice in product design and development. Concurrent design and engineering has been credited for increasing productivity and reducing costs.[3-4]

There will be many benefits for students if the concurrent engineering approach using virtual design tools is adopted in the classroom. First, it will be easier for students to visualize their design and to communicate their ideas with the instructor. Second, students can detect problems in their design by performing an interference analysis between parts, by performing an assembly sequence study, or by watching a motion animation.

However, due to the time constraint in the classroom setting and the lack of the tools needed to quickly create solid models, introducing the concurrent design and engineering concept into the machine design class is still very difficult, if not impossible. As a result, in previous machine design classes, only simple models of some individual parts of a mechanical system were created. They were not detailed or complete enough to perform important system analyses such as interference, manufacturability, or assemble-ability studies.

Last year, Autodesk released its latest version of MCAD software called Autodesk Inventor 10. In Inventor 10, there is a module called the Design Accelerator, which provides templates for creating basic machine parts such as gears, shafts, springs, and bearings. The Designer Accelerator not only allows the user to create basic 3D machines parts quickly but also allows the user to perform engineering calculation on these machine parts.[5] This provided an opportunity for the author to integrate the concurrent design and engineering with the teaching of machine design.

Autodesk Design Accelerator

The Design Accelerator provides various templates for the user to create basic machine parts. The software considers three types of users; designers, engineers, or experts. An expert is someone who knows the design requirements and the engineering calculations. A designer can create a machine part by entering mainly the geometric information. An engineer can obtain a machine part by entering loading information first. An expert can obtain a machine part by entering both the geometric information and loading condition. This provides some flexibility for the students. At the beginning, students can use the Design Accelerator as a designer when they don’t have enough engineering knowledge about the part that they design. They can later modify their design as an engineer user or as an expert user as they gain more engineering knowledge and experience.

Appendix A contains a series of screen shots taken from the Design Accelerator to demonstrate how basic machine parts are created.

Figure A-1 is a template that shows how a roller bearing is created. Bearing life is a major criterion for selecting a bearing. In Figure A-1, the bearing highlighted has a bearing life that is higher than the calculated bearing life. If one selects a bearing whose calculated bearing life is less than what is required, the Design Accelerator will produce a warning in red such as the one shown in Figure A-2.

Figure A-3 shows how a compressive spring is derived using the Design Accelerator. Both spring load and spring dimension information is needed to create the spring. Figure A-4 shows detailed spring information after performing an engineering calculation.

Figure A-5 is a template showing how to design a step shaft as a designer. The user can decide how many steps the shaft should have and whether and where to add keys or grooves or some other features to the shaft. Figure A-6 indicates how to apply loads to a shaft as an engineer.

Gears are usually designed in pairs. Figure A-7 is a template showing how a pair of gears is created. Figure A-8 shows detailed information about one of the gears created. Once the basic geometry of the gears is determined by the Design Accelerator, the user can add more features to the gears.

Integration of the Design Accelerator - Machine Design Project

With the help of the Designer Accelerator, it was possible for the students to finish an in-depth design project in one semester. This provides an opportunity for the students to practice concurrent design and engineering. A typical gearbox design project, such as the one shown in Figure B-1, was assigned to each student. Students were required to perform all necessary engineering calculations as well as to create each part of the gearbox. Students were then required to create an assembly of the gearbox and to check for interference between parts and to create an animation of the gearbox.

Since a gearbox consists of many parts, it gave the students an opportunity to learn the intricate relations among parts. During design, students need to answer questions such as how bearing dimension affects the geometry of the shaft and the housing and how the gear dimension affects the design of shaft as well. Can the parts be assembled together? What should be the correct assembly sequence? How are the parts manufactured?

During the creation of each machine part, students were reminded to pay attention to the relationships among the machine parts and to utilize the geometric information they obtained while creating one part to create geometry of another part. For example, the geometric information during the design of bearing leads to the design of shaft and housing geometry. This reinforces the idea that machine design is really a system design and not the design of unrelated parts.

Figure B-2 shows a finished design of the gearbox design project.

Conclusion

Design Accelerator is an effective design tool and can used to enhance the teaching of machine design. Designer Accelerator not only reduces the part creation time but also helps the students understand the importance of the concurrent design and engineering concepts.

References

[1] M.F. Spotts, T. E. Shoup, and L.E. Hornberger, "Design of Machine Elements", Eighth Edition, Prentice Hall, 2004.

[2] Joseph Edward Shigley, Charles, R. Mischke," Mechanical Engineering Design", fifth Edition, McGraw-Hill, Inc., 1989.

[3] Jean Thilmany, "Pushing Productivity – Computer Technology Has a Hand in Cutting Cost and Raising Profits", *Mechanical Engineering, Vol.123/No.12 December 2001*.

[4] Bill Evans, "*Improving Competitive Advantage through Industrial Design*", Medical Device & Diagnostic Industry (MDDI), November 2005.

[5] James D. Bethune, "Engineering Design and Graphics with Autodesk Inventor 10" Autodesk Design Institute Press, Prentice Hall, 2006.

Appendix A

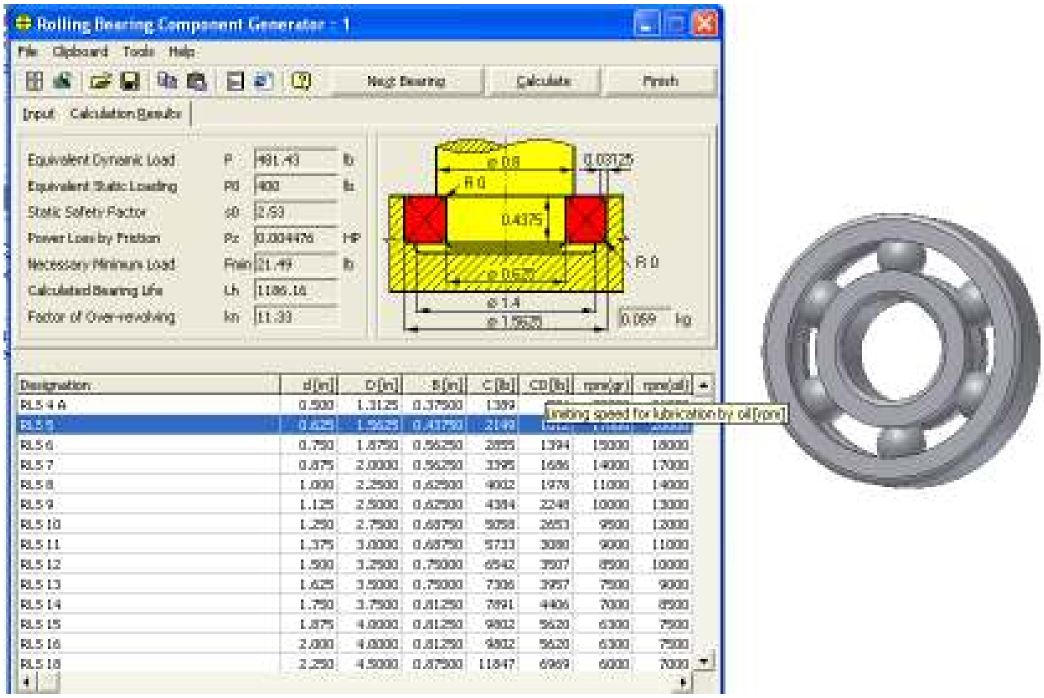

Figure A-1. Bearing Design Using Autodesk Design Accelerator

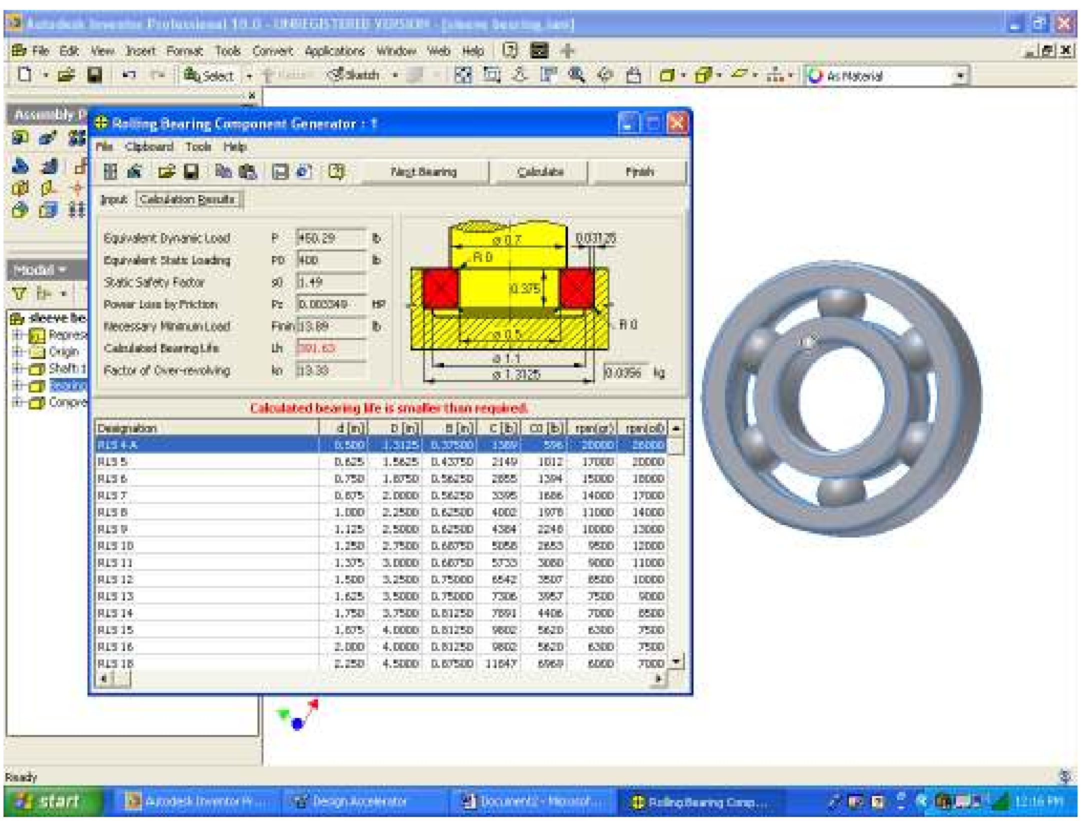

Figure A-2. A Bearing Selected with a Calculated Life that is Smaller than Required

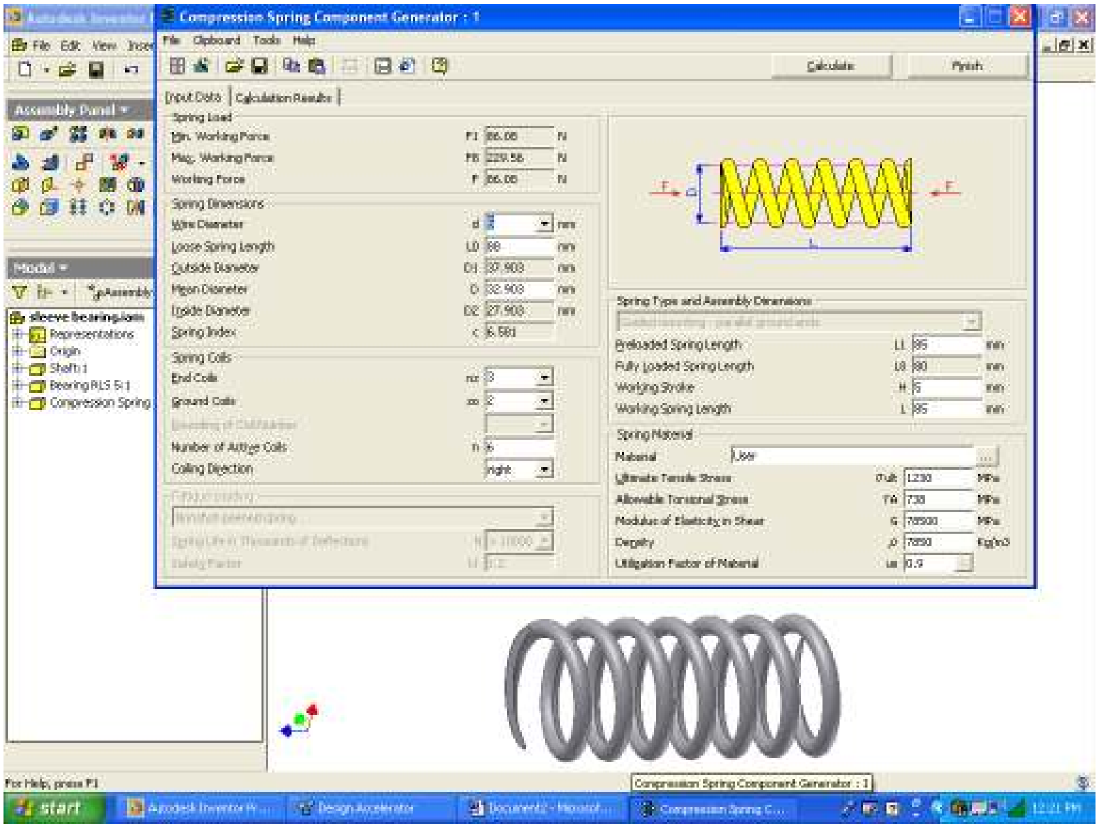

Figure A-3. Design of a Compressive Spring

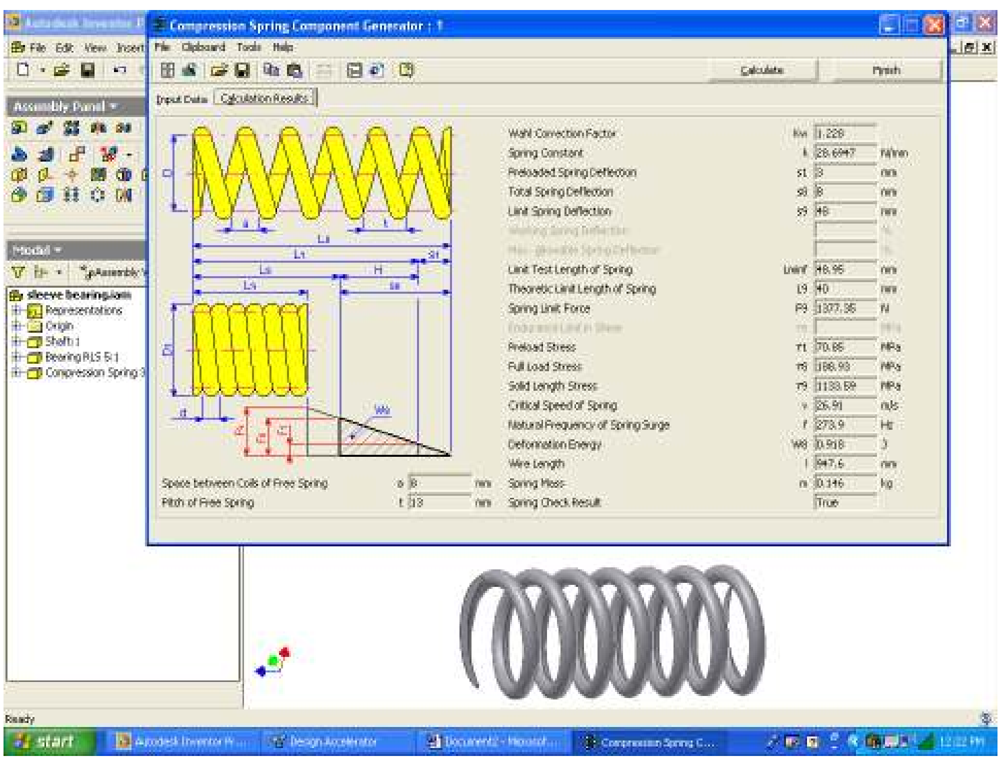

Figure A-4. Detailed Information of a Compressive Spring

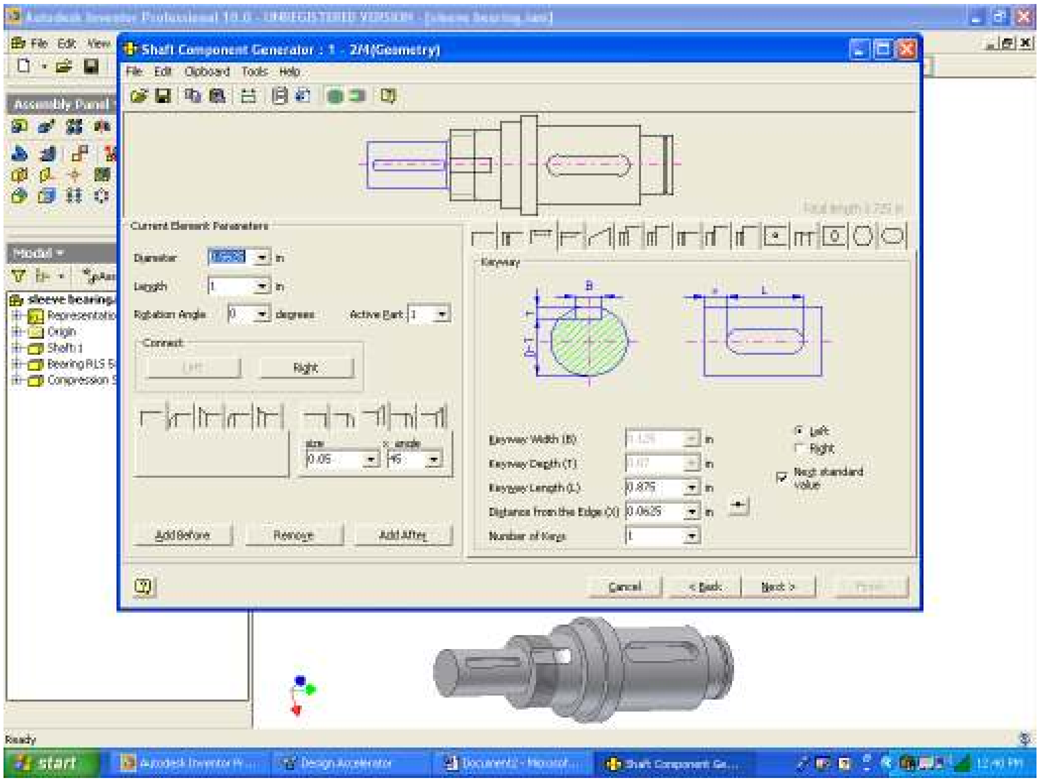

Figure A-5. Design of a Shaft as a Designer

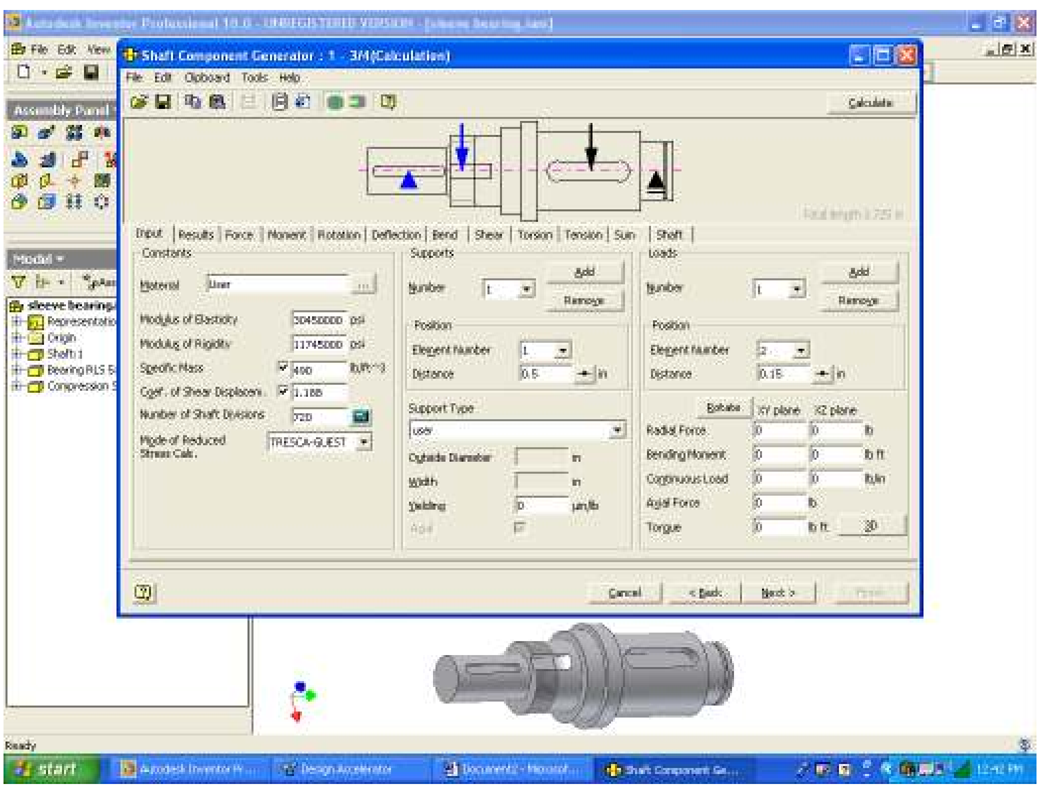

Figure A-6. Design of a Shaft as an Engineer

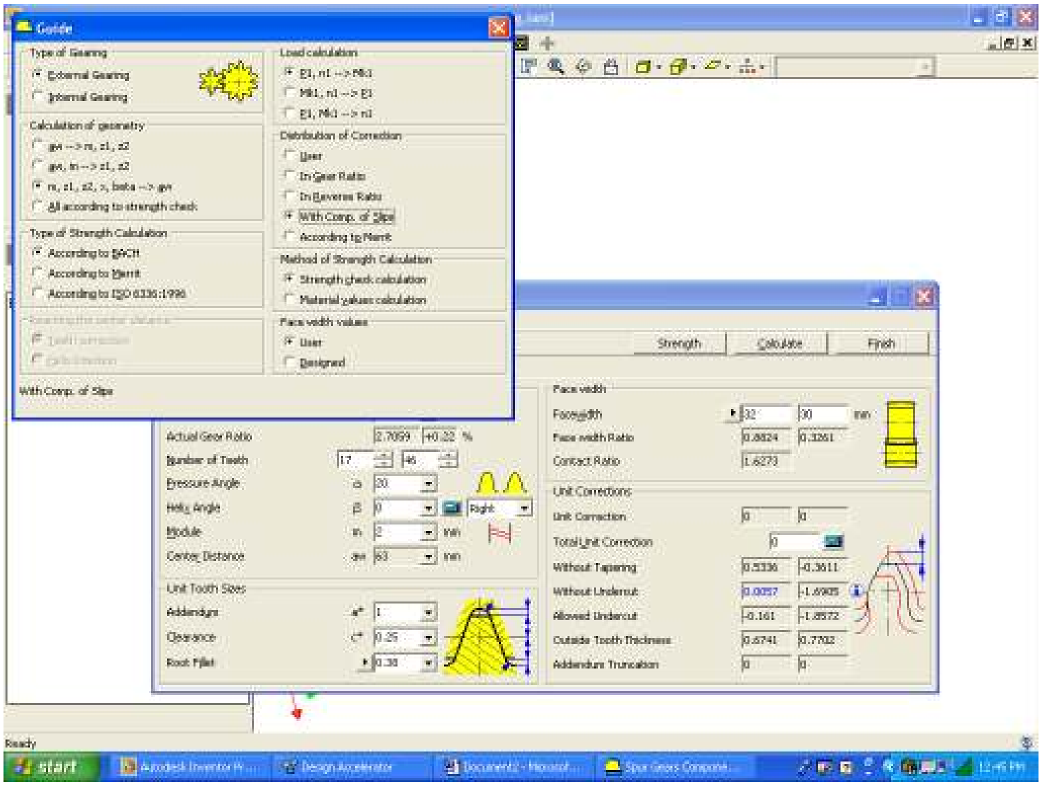

Figure A-7. Design of a Pair of Spur Gears

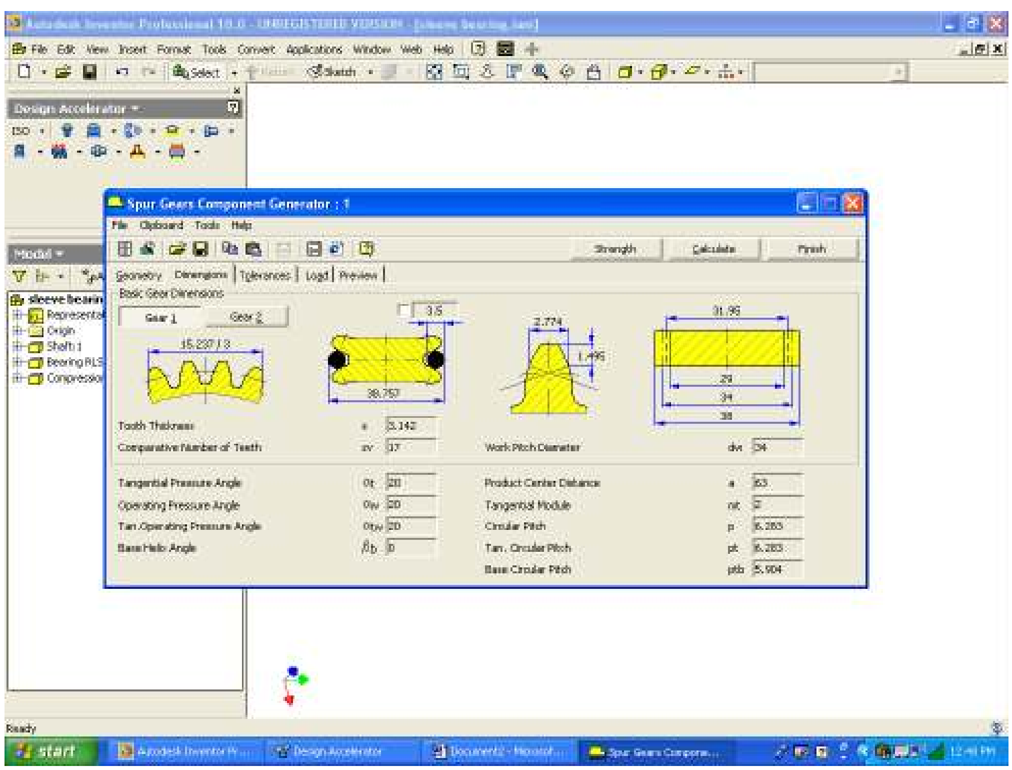

Figure A-8. Detailed Geometric Information of a Gear

Appendix B

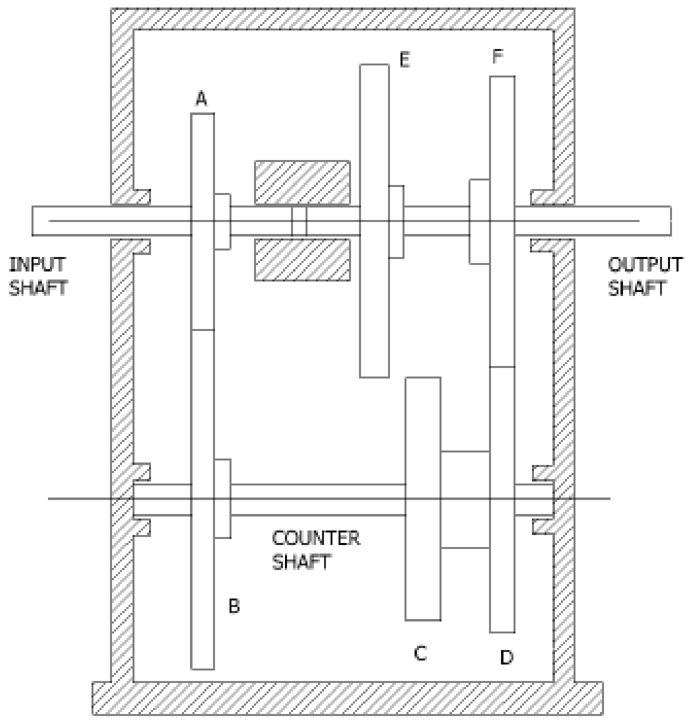

Figure B-1. A Gearbox Design Project

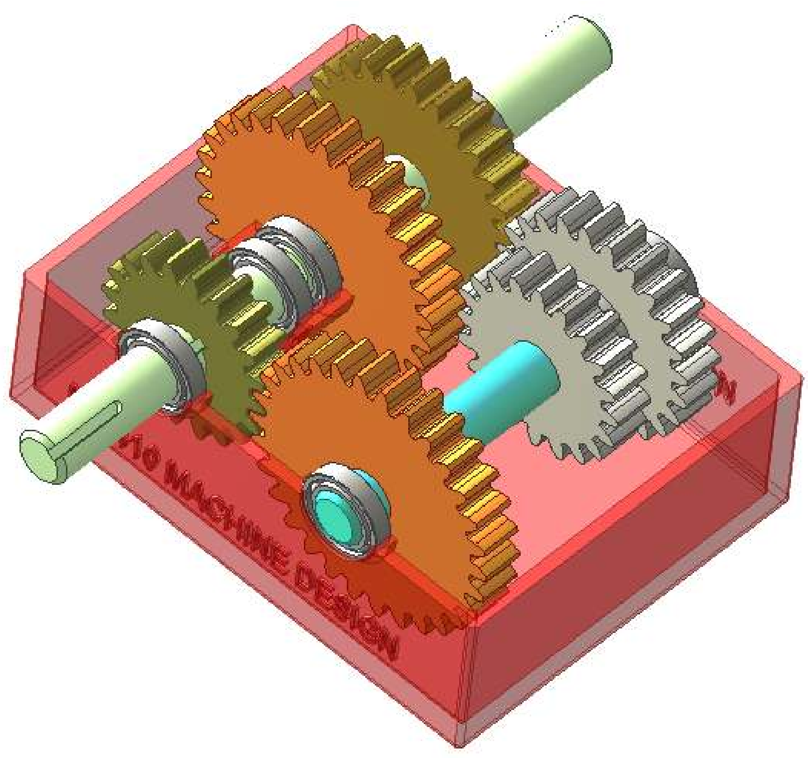

Figure B-2. A Finished Design of the Gearbox Design Project