2006-2659: REDEVELOPMENT OF A DESIGN COURSE FILLS A GAP IN THE CURRICULUM

Zhongming Liang, Indiana University-Purdue University Fort Wayne

Zhongming (Wilson) Liang is program coordinator and associate professor of mechanical engineering technology. He has been with Purdue University Fort Wayne since 1987. He has a number of publications in the areas of automatic control, mechanisms, and others.

Redevelopment of a Design Course Fills a Gap in the Curriculum

Abstract

There were some repeatedly exposed drafting and design problems seen in senior design projects in our mechanical engineering technology (MET) program. Also our students were not able to apply the solid modeling techniques in later courses. In fall 2005 we reactivated and redeveloped the junior-level course Computer Aided Tool & Fixture Design. As results, the students' abilities to use the solid modeling CAD system for mechanical design were significantly enhanced; they became much more familiar with the requirements and standards for professional drawings; they gained good knowledge and experience in design. We feel that the concept presented in this paper is a good approach to producing graduates with the appropriate skills[1].

Introduction

In the fall semester of 2005, at recommendation of the faculty and endorsement of the Industrial Advisory Committee (IAC), the junior-level course Computer Aided Tool & Fixture Design returned to the curriculum. The faculty and the IAC believed that the course should give students tool design knowledge as well as more computer aided modeling and drafting (CADD) techniques. In teaching this course, it was seen that the restructuring of this course actually played a big role of filling a gap in the curriculum.

For years we had seen some fundamental drafting and design problems in senior design projects in our MET program. This had caused great concern because these problems could be carried into their jobs. But we were not sure what were the major causes of the problems and what would be effective means to fix them. In teaching this tool design course, we surprisingly found out that much of the basic design knowledge had not been taught to the students when they came to the course. In other words, when without this tool design course as in the past, students went to the senior design course not fully prepared.

The mechanical design sequence of the MET curriculum had a 3-credit CADD course on AutoCAD, another 3-credit CADD course on Solid Edge by UGS Corporation, a 3-credit machine element design course, a 3-credit dynamics and mechanism course, and a 3-credit senior design course. The problem with the curriculum was, as found in teaching the tool design course, there was no design projects prior to the senior design. It has turned out that the tool design course, having a number of design activities and the term project, has filled a gap in the curriculum.

Also, many students were not able to apply the solid modeling techniques learned in the sophomore year to their study of later courses such as engineering dynamics and senior design. The new tool design course, with extensive CADD activities, substantially promotes students' abilities to apply CADD to design tasks. In this sense too, it has filled a gap in the curriculum.

Though this course had been offered in the past, it was substantially modified and enhanced this time. The lecture part now, all delivered with Microsoft Powerpoint, included general tool design, jig and fixture design, die design, welding fixture design and an introduction to GD&T gage design[2]. The lab part was completely redeveloped to include seven lab assignments and one project, all with CADD solid modeling[3]. Students were taught how to design and how to well document design. Basically it became a new course under the old title.

Students were interested in this course. Attendance rate was a good indicator of students' interest. Though the instructor did not give credit for attendance, the attendance was typically one hundred percent or very near each time. Also homework assignments, lab assignments and the project were turned in on time. It was demonstrated that the students' abilities to use the solid modeling CAD system for mechanical design were significantly enhanced; they became much more familiar with the requirements and standards for professional drawings; they gained good knowledge and experience in using design documentations[4, 5]. We feel that it was a successful experience in making the program better meet its educational objectives and accomplish its mission.

In the following we will show some of the lab activities to illustrate how this course helped students with design and solid modeling techniques.

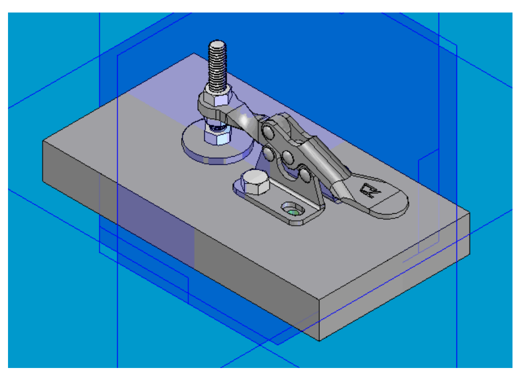
Enhancement of Solid Modeling Techniques for Design

<u>Associativity of part features</u>

A valuable feature in solid modeling is the designer can create associativity between geometric elements of different parts in an assembly.

The CADD course on Solid Edge did not have sufficient time to well expose students to the associativity feature. In tool and die design, this feature is very useful in developing geometric links between a fixture and the workpiece placed in the fixture, or between a die and a punch and the strip.

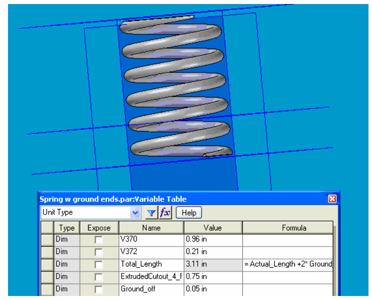
A lab asked students to work on a toggle clamp:

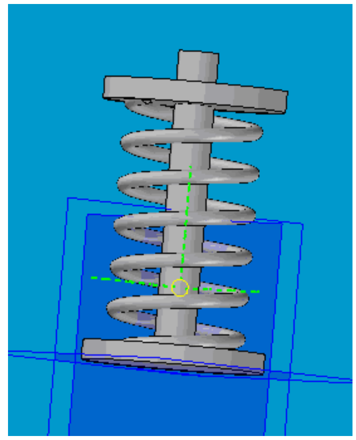


1. Study the self-locking feature of the toggle clamp by moving its links.
2. Create a plate with the associativity.
3. Insert four screws. (In the figure, only one screw is shown)
4. Place the toggle clamp spindle into the clamp
5. Place the workpiece on the base plate with assembly relationship
6. Apply assembly relationship between the clamp spindle and the workpiece so that the spindle holds the workpiece on the base plate.
7. Place lock nuts on the spindle

The lab activity helped students not only with techniques in solid modeling but also with knowledge of tool clamps and use of catalogs.

Springs assembly with automatically adjustable parts





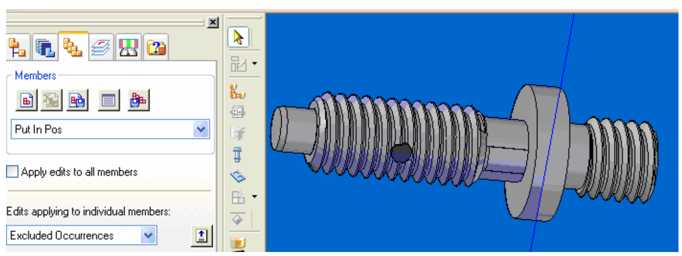
The lab activities shown in the figures asked students:

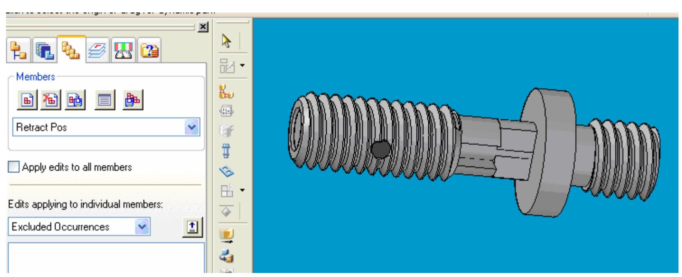
1. Create a spring model
2. Use the variable table and equations to develop relations between the spring length of the solid model and the spring physical length
3. Use the adjustable variable method in placing the spring into an assembly so that the length of the spring will automatically be updated to fit whenever the spacing in the holder is changed
4. Create a peer-variable relation between the spring length and the length of the center post so that the center post length automatically changes whenever the length of the spring is changed

Alternate assemblies

The spring plunger is another common element in tool design. The following activity was to familiarize students with this element and with the method of creating alternate positions of a solid assembly model.

This lab activity asked the students to create the put-in position and the retract position as two alternate positions of the assembly, one of which can be easily switched to the other.





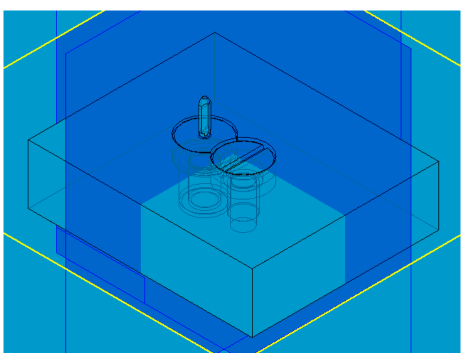
Development of Design knowledge and Experience

Some activities were focused on the design aspect. Since these activities were performed on the CADD system, knowledge of CADD was also promoted.

<u>Design an assembly with selecting proper parts from an industrial catalog</u>

In this activity, students needed to

1. Select a proper diamond pin from the CarrLane catalog and find in the catalog
    - Key dimensions, size tolerances and GD&T of the diamond pin
    - Dimensional information for seating the diamond pin in an assembly
    - Part numbers of the matching liner and lock screw
2. Find on the page of the liner and the page of the lock screw, respectively,
    - Key dimensions, size tolerances and GD&T of the two elements
3. Determine key dimensions and tolerances of the base plate
4. Place the key dimensions and tolerances of all the parts into a spreadsheet
    - Examine the relevant dimensions across the parts
5. Create the base part model
6. Create the assembly model



	Diamond Pin		Liner		Lock Screw		Plate
Part No.	CL-123-DLT		L-32-8		LS-1		
Catalog Page	p. 161		p. 32BU		p40BU		
Diameter	Head	.1235 -.0005					
	Shank	.3125 -.0002	ID	.3125 +.0001/+.0004			
	Concentricity	0.0005	OD	.5000 +.0017/+.0014			
	Shoulder	0.625	Concentricity	0.0003	Top	0.625	
					Thread	5/16-18	
Length	Shank	0.484	Total	0.5			
	Shoulder	0.266			Above Thread	0.25	0.281
	Step	0.125			Middle Section	.138/.132	
					Thread	0.375	
Radius	Notch	0.3182			Top	0.3125	
Center Distance							0.5156

.

This lab provided students with following design knowledge and experience:

- How to use a catalog for design
- How to select proper fits and tolerances for assemblies
- How a lock screw functions in this assembly: it should prevent the pin from rising up but should not constantly press on the shoulder of the pin to make it tilt slightly.

<u>A complete assembly production drawing</u>

This lab taught students how to make good production drawings. This lab included the following:

1. Use Copy-and-Paste as well as other commands to expand the solid assembly model in the previous activity. The new model has one workpiece completely located with a base, a round pin and a diamond pin. – This is also a good exercise on the fixture locating principle.
2. Create a 2D production drawing of the assembly model. The production drawing must
   - Not to miss important details such as center lines and center marks (which were often overlooked by students), overall dimensions, scale, default tolerances.
   - Be well readable. For example, spacing of the section lines must be appropriate for the size of the drawing
   - Have part information, including part names, materials, document numbers etc, linked to what is in the part models
   - Show the workpiece with the proper font in the tool design assembly.

The Term Project

After seven lab activities, which went with lectures, students were given a term project. The term project requirement was to design a fixture for machining a feature in a given workpiece on a given type of machine at a stage of its manufacturing process. The required project work from students included one or more design sketches at the beginning, an assembly model and its production drawing, all part models of the assembly and their production drawings, and a writing to explain and justify the design.

The instructor's help did not stop at the time of assigning the term project. Instead he closely monitored students' progress and discussed additional topics that he found students needed. In that regard, the term project process provided an immediate feedback to the instructor on the course topics and gives him opportunities to take improvement actions before the semester was over. The discussions he added during the project included:

1. Why the 3-2-1 principle in tool design allows us to use more than three (3) physical locating points for the primary datum. To fully explain the concept, the instructor discussed how the workpiece would be inspected after the operation in the fixture and, to further make his points, he referred to the ASME GD&T standard.
2. How to specify part tolerances based on the ANSI tolerance tables.
3. How to specify GD&T tolerances based on the ASME GD&T standard.
4. Why we should not have a locating surface much larger than the datum feature of the workpiece.

We feel that the concept of using the term project to diagnose difficulties and provide basis for immediate corrective action during the semester is a novel approach[6]. Students appreciated this in-time and effective approach and showed their gained knowledge from this approach in the project. The criteria in evaluating the project included all those discussed in the corrective action.

Conclusion

Lecture topics, lab activities and the term project of the reactivated tool design course have been introduced to show how they have helped students with basic design skills and better solid modeling skills. It has been seen that the course has filled a gap in the mechanical design sequence in the curriculum and will help the graduates better for their jobs. Students enjoyed the course as they commented: "This was a very enjoyable project to do and will relate to many people's jobs in industry. Many things were learned from doing this project and it related very well to much of the homework that was done previously in the semester."

Version 18 of Solid Edge, which came to us in the spring of 2006, has the first time the capability of performing simple finite element analysis (FEA). When the tool design course is offered in the fall of 2006, we will include force calculations and analysis.

Bibliography

1. A peer reviewer of the paper for this ASEE conference publication, 2006.
2. Fundamentals of Tool Design, fifth edition, Society of Manufacturing Engineers, Dearborn, Michigan, 2003
3. Solid Edge version 17, UGS Corporation, The PLM Company, 2005
4. Catalog and CAD part library on the website, CarrLane, Inc., 2005.
5. Catalog and CAD Tooling Component Library, Jergens, Inc., 2005.
6. Another peer reviewer of the paper for this ASEE conference publication, 2006.