Putting into Practice – Surface Modeling Exercise Using Kayak Project: Experience with Advanced CATIA Course

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Abstract- Computer Aided Design (CAD) systems with constraint based modeling features have become a design tool for engineering graphics and advanced CAD courses in the department of engineering technology at Western Washington University. The department currently offers both Advanced CATIA and Pro/ENGINEER courses. The goal of the Advanced CATIA course is to extend students’ modeling skills in both solid and surface modes. The course allows students to extend the use of different modules in CATIA V5R13 such as Generative Shape Design, Ergonomics Design and Analysis Model.

Kayak surface modeling project was used as a group design project. A tour of a local kayak manufacturing facility was arranged for the students to conceptualize the entire engineering design process. Key speakers were invited to the classroom to provide more information about kayak technology. The students applied their surface modeling techniques to the kayak design project. The students were required to utilize the Ergonomic Design Model to ensure that their kayak model fit a real person.

I. Introduction

The Department of Engineering Technology at Western Washington University currently utilizes two high-end constraint-based 3D modeling software programs: Pro/ENGINEER® Wildfire 2.0™ and CATIA® V5 R13© for engineering graphics and advanced CAD courses. During the spring quarter of 2004, an advanced CATIA® course was offered to junior and senior students in the department. The purpose of this course was to enable the students to develop an increased knowledge and proficiency in the use of CATIA® V5 R13©. Dassault Systemes CAD software CATIA® Version 5 is an integrated suite of Computer Aided Design (CAD), Computer Aided Engineering (CAE), and Computer Aided Manufacturing (CAM) applications for digital product definition and simulation (IBM, 2004). Students may use the integrated suite to model a part, generate engineering drawings, and then analyze the mechanical properties in a finite element application. Students may also generate machine code within the NC manufacturing application, or use kinematics to simulate motion.

II. Advanced CATIA at Western

The advanced CATIA course was first offered to the junior and senior Manufacturing (MET), Plastic (PET) Engineering Technologies, and Industrial Technology (IT) majors in the spring of 2004. The course was offered as an elective. The prerequisite of both advanced CAD courses are Engineering Design Graphics (EDG) I and II. The EDG sequence is introduces students to fundamental skills in the area of visual communication, creative problem solving, project management, teamwork and self-learning skills (Newcomer et al., 2001). In addition to addressing student learning objectives, the EDG sequence is intended to develop a concurrent and integrated engineering environment in the ETEC department. It
also directs student to be familiar with constraint based modeling applications.

The advanced CATIA course strives to strengthen students’ CAD skills and to provide an opportunity to explore other applications in the CATIA package such as Generative Shape Design and Ergonomic Design & Analysis. The following table shows the course outline with kayak project activities and exercises designed to acquaint the student with the concepts, operation procedures and process.

<table>
<thead>
<tr>
<th>Week</th>
<th>CAD Lab</th>
<th>Kayak Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Update and brush up with CATIA V5 R13&lt;br&gt;-User Interface&lt;br&gt;-Part Design and Drafting</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Brush up (continue)&lt;br&gt;-Assembly Design</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Intro to Surface Modeling&lt;br&gt;-Surface Definition and Terms&lt;br&gt;-User Interface&lt;br&gt;-Surface Design Process</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>Wireframe Features&lt;br&gt;-Point, Line, Plane, Circle&lt;br&gt;-Corner Features, Splines&lt;br&gt;-Projection, Intersection&lt;br&gt;-Parallel Curves&lt;br&gt;-Boundary and Joined Curves</td>
<td>Guess Speaker: Kayak history&lt;br&gt;-World record&lt;br&gt;-Project Intent&lt;br&gt;-Measure body</td>
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<tr>
<td>5</td>
<td>Surfacing Technique&lt;br&gt;Surfaces Toolbar: Extrude, Revolve and Sphere&lt;br&gt;Offset Surfaces and Planes&lt;br&gt;Fill Surfaces&lt;br&gt;First Abstract is due</td>
<td>Guess Speaker: Production Process&lt;br&gt;-Material Tech</td>
</tr>
<tr>
<td>6</td>
<td>Complex Surfaces&lt;br&gt;-Swept Surfaces&lt;br&gt;-Loft Surfaces&lt;br&gt;-Blended Surfaces</td>
<td>Plant Tour&lt;br&gt;Kayak Mfg</td>
</tr>
<tr>
<td>7</td>
<td>Advanced Surface Design Tutorial Exercise&lt;br&gt;Group Project Working Week</td>
<td>Kayak Ideation&lt;br&gt;Sketch Concept Design&lt;br&gt;Design Process</td>
</tr>
<tr>
<td>8</td>
<td>Intro to Ergonomic Design and Analysis&lt;br&gt;Working Week&lt;br&gt;-Group Project&lt;br&gt;-Individual Project</td>
<td>Surface Model</td>
</tr>
<tr>
<td>9</td>
<td>Working week&lt;br&gt;-Group Project&lt;br&gt;-Individual Project</td>
<td>Ergonomic Model</td>
</tr>
<tr>
<td>10</td>
<td>Project Presentation&lt;br&gt;Second Abstract is due</td>
<td>Presentation Discussion</td>
</tr>
</tbody>
</table>

Table 1. Advanced CATIA course outline with kayak project activities

III. Why a Kayak Project?

Western Washington University is situated within a vibrant kayak community. Olympic Gold medal winners can be occasionally found at the weekly match races on local Lake Whatcom. One of the world’s fastest surf-ski kayaks, the Twogood Mako series, are hand fabricated a few miles from campus. Both Ocean Kayaks and Necky Kayaks are designed locally.

The authors met two recent additions to the kayak community, Brandon and Heather Nelson. This remarkable team has paddled around Lake Baikal, the largest lake in the world. They also race and won a stormy event around Michigan’s Lower Peninsula. Brandon is planning an attempt on the twenty-four hour distance record set by a kayak on moving water. Brandon describes the attempt as a sprint race. His enthusiasm and energy became an inspiration for the course and the students.

The authors structured the team design component around Brandon’s quest. Brandon was the client. The
students began by gathering the project requirements, including taking paddling lessons and Brandon’s physical joint measurements. The client’s anthropometric data was added to CATIA’s Ergonomic Design Model to aid the design process.

With Brandon’s help, the authors arranged for leading kayak builder Sterling Donalson to explain kayak design and construction to the students. Two racing kayaks were provided for students to measure and analyze. Local kayaking legend Reg Lake attended as well to discuss various design philosophies. Students compared section data from each hull form to generate a baseline for their own designs.

A tour to the local Necky and Ocean kayak facilities allowed students to view how retail recreational kayaks are marketed and sold. In addition, the students learned about high performance materials for composite kayaks from an aerospace composite material expert. These meetings provided students with motivation to tackle their team design projects.

VI. Modeling Procedures

Each of the student teams provided a team member to gather ergonomic data from the client (see Figure 1).

Figure 1. Measuring client

Two kayaks were brought to campus. The students measured the kayak station forms to provide a design reference for their own computer models.

CATIA requires particular modeling procedures to create hull shapes. Step 1: Students created planes at distances appropriate to the kayak design. The sketched profiles were added on each plane to capture the changing hull shape (see Figure 3).

Figure 3. Planes and kayak profiles

Step 2: Students used the blend feature to blend from profile to profile (see Figure 4).

Figure 4. Blend between profile to profile

Step 3: Students used the fill tool to close the ends of the boat so that there are no open spaces (see Figure 5).
Figure 5. Fill feature for closing the ends of kayak

Step 4: The surfaces are joined together as a single surface then converted into a solid. A shell command may be used to remove material from the solid to meet the thickness requirements (see Figure 6).

Figure 6. Join surface and convert to a solid model

Step 5: Create a cockpit profile on top of the kayak body and extract the cockpit profile from the shelled surface. Then, protrude sections in front and behind the cockpit to seal the cockpit from the rest of the boat’s hull.

Figure 7. Create a cockpit profile

Step 6: Create a small shaft at each end of the kayak to smooth the surface.

Figure 8. Create a small shaft at each end of the kayak

The following picture shows one of the kayak that designed by the students in Advanced CATIA class.

Figure 9. Complete model

Ergonomic design and analysis module has been used to create a human model to verify that the client would fit inside the kayak (see Figure 9).

Figure 9. Human manikin model to verify client fit
VII. Conclusion

The involvement of local area experts provided the students with a rich experience. By focusing on an individual client, the students became more engaged in their team project. The students’ enthusiasm for the project was strongly indicated by their questions and long sessions with the experts. The client centered approach provided motivation for the students to develop and expand their surface modeling capability. They also became exposed to design techniques used in human factors engineering.

The project has continued as a series of independent studies involving the construction of a kayak mold and plug. Currently, a plug is being prepared to aid in the construction of a second mold. The authors hope that students will be able to test their kayak against the fastest boats on local Lake Whatcom.

X. References


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