Clocking on

Enhancing CAD through education and industry partnerships

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Increasing the use of resources and inspiring students are among the great challenges a design and technology department faces on a daily basis. Any incremental step in improving the students' experience through enhancing the quality of provision is always a positive element to celebrate, especially if it is done in partnership with industry.

Technology department profile

Langley's extensive technology centre is divided into four main areas: two design suites (upper and lower school), a clean area/electronics workshop and a main workshop. The design suites have state of the art facilities, housing 29 new PC workstations with software for project planning, computer aided design (CAD) and research work, including access to the internet. Eight computers are also interfaced for control exercises. The electronics and modelling room houses modern equipment for modelling, plastic forming and electronics work: a printed circuit board (PCB) layout design on a computer can be directly transferred on to board using ultraviolet photo-etch techniques. Computer aided manufacturing (CAM) facilities for lightweight material is also based here. Finally, the main workshop is fully equipped with multi-media manufacturing facilities and a new heat treatment bay, enabling the fabrication of products by a range of techniques using metals, plastics and wood based materials.

The following report outlines the experiences of two students: Kristen Gratze and Jessica Shiach.

The challenge

The design challenge given to the team was in the typical form of a design brief:

'To design, manufacture and evaluate a prototype clock targeting teenagers. A prototype will be presented to a board of directors for consideration for the inclusion within the current product range'.

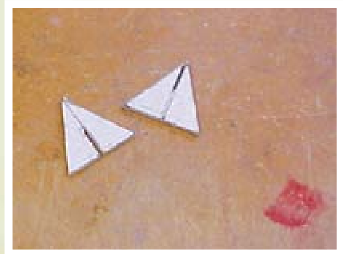
The team then participated in a brainstorming session investigating, linking and recording ideas for further analysis. They spent some time looking at some existing products being sold by the company (last year's students' projects). This was to identify strengths and weaknesses that may exist in the design and manufacturing process that they had been through, highlighting the companies' design and manufacturing ability (schools knowledge and resources). The students were encouraged to try and design something quite different to what had been designed before.

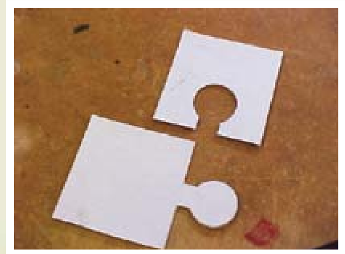
Existing products (last year's school projects)

The next stage was the formation of a specification. The main design constraints were based around the size of the clock mechanism: 56 x 53 x 17mm. The shaft length can be increased up to 21mm. It should be noted that Year 9 students are not required to design and manufacture the working parts of the mechanism. This is only required at Years 12 and 13.

A range of initial ideas were explored by the students, Kristen originally thought of the shape of a sun. He thought that the product would give the psychological effect of well being, like the sun rising in the morning. This idea eventually gave the product its initial form.

The team created some interlocking shapes that created more of a 3D form. They became interested in methods of fixing parts together like a three dimensional puzzle. As their project leader (teacher) I offered the challenge of a glue-less structure that possibly could be flat packed and put together by the customer!





Samples of some early designs

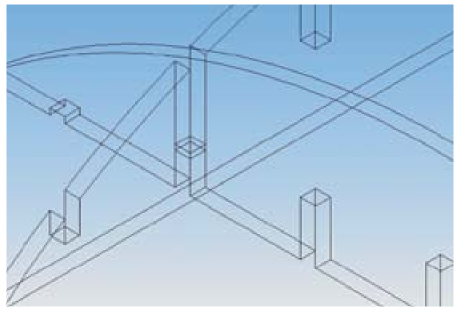
At this stage of the project one of the team members had found a picture of a clock on the internet designed in Japan called 'Grid Clock'. The team liked the shape and decided the final form of the clock based on this.

Modelling

The team used their card model to design the centre section of the clock using Computer Aided Design. They also designed the clock mechanism and hands in preparation for assembly checks, making sure that their final design will accommodate all the standard components. Initially two pieces of the design were made in acrylic using CAD templates and manual skills. At this stage the team were using Pro/DESKTOP as a method of producing model data. It was decided that because Rapid Prototyping would be used the students need to make the model using SolidWorks. This is because the accuracy of model data when converted to STL format is adjustable within SolidWorks making the process more accurate. At Langley we generally use Pro/DESKTOP up to Year 9 and SolidWorks in Years 10 to 13.

It was decided that the first design for the team to evaluate would be made in white acrylic and that the final design would be presented in Rapid Prototype form. This would enable the company directors to check physically how the parts fit together using accurate dimensions. The team was advised that if the design was manufactured in volume then injection moulding would be used, not the methods used in school.

Overcoming design problems



Clock pieces being checked for slot position and interference

Slot positioning

Because SolidWorks was used for the modelling process it enabled the team to visualise where the joints came in contact and make any adjustments as required. Interference checks where used to ensure that the parts would slide together correctly.

Slot thickness variation

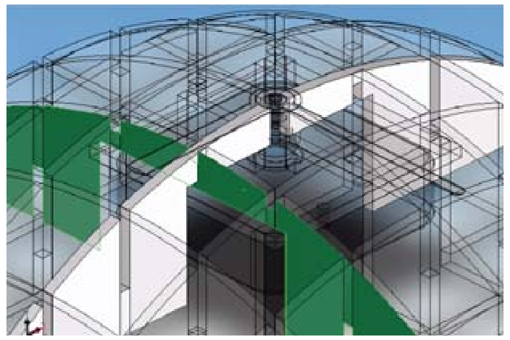
Students soon realised that acrylic sheet comes in a variety of thickness due to manufacturing tolerances. They had included a 3mm slot gap on the design but black acrylic was 2.9mm and white 3.1mm. This made the clock pieces easy to evaluate for the correct slot positioning but hard to evaluate to ensure the design is glue-less. The white acrylic was used to initially evaluate the pieces interlocking. Design relationships were then added to the model to vary the slot widths in relation to the material thickness. This enabled the CAD model data to be changed before manufacturing. This would only be useful in producing the product at school, and injection moulding would remove this issue in batch production. Our industrial sponsors, NTCADCAM were contacted to seek advice on how to modify the design to incorporate relationships between model extrusion (material thickness) and slot gaps. This gave the students access to expertise otherwise generally not available.

Accommodating the clock mechanism

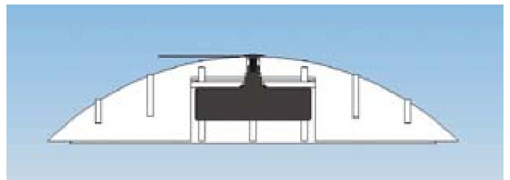
Initially the team manufactured the clock with no facility to hold the mechanism. This gave them the freedom to experiment with a number of ways to accommodate the mechanism without compromising the aesthetics and ease of construction.

Centre square modification

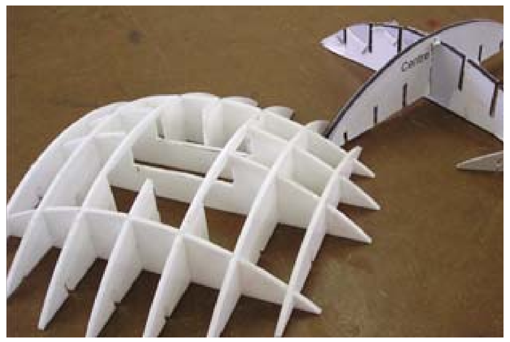
Two types of centre cover were designed. One was vacuum formed to cover the whole of the face of the clock mechanism and another was square and covered just the face of the clock. The face cover was selected as the best option based on ease of manufacture and design. The piece would not have to be made from a separate material and the whole clock could be manufactured at once.



Accommodating the mechanism and hands



Section view of mechanism and hand clearance



Some development

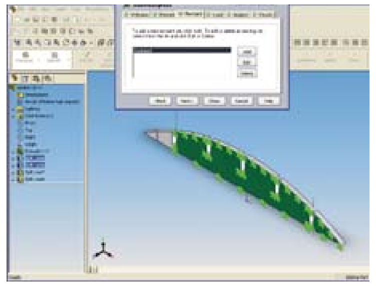
Manual Stress Test Part V4

written by Kristen Gratze

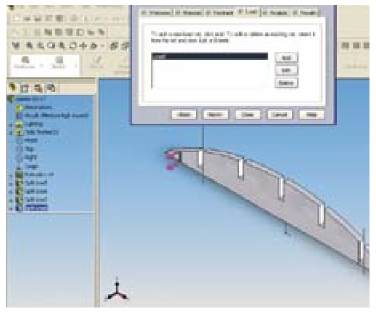
When we were making the clock we had come across a problem when we stuck a piece of acrylic to the milling machine using double-sided tape. We used this to hold the acrylic firmly in place so that when it was being cut out it would not move about. When the machine had finished it was time to collect the pieces from the machine. Each time we did, one end of the part would sometimes snap as we removed it from the machine. Mr. Daly asked me to test the joints in my science lesson for their strength around the area which kept breaking. Before I had done this Mr. Daly tested the parts on a program called SolidWorks using Finite Element Analysis. This programme is a professional CAD package which students use at Langley. Instead of me testing on SolidWorks I had to test with weights to find out the Newton force of which the joints could withstand. My results are as follows:

Part (V4)	Results (1.5cm from slot)
1	20N until break (Thin end) 3mm
2	40N until break (Thick end) 2mm

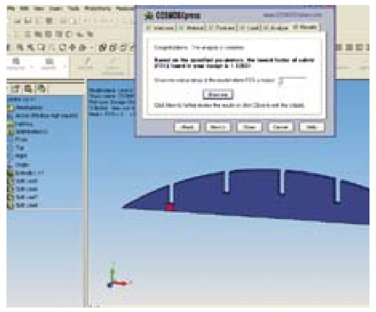
These results are almost as accurate as the SolidWorks programme tested. This now means we can now change the thin ends thickness so that it can with stand up to 40 - 50N of force.



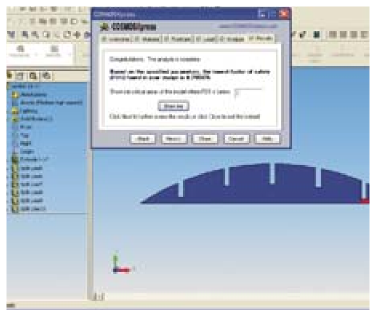
Constraints: The green simulates where the part is held on the milling machine



Load 50N: Simulates the force applied during the removal of the part from the machine bed



Results factor of safety of 1.1 (Pass)



Factor of safety of only .7 (Fail)

Stress analysis CAD

SolidWorks uses Cosmos Express for product analysis. This programme is ideal for students to evaluate the static forces that are present on parts to aid the design process. Focus is generally placed on model dimensions to aid product optimisation in shape and minimise the possibility of failure.

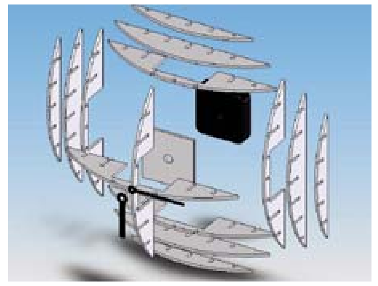
Students in Year 9 can use the software and apply forces to parts to see if they will pass or fail when a specific force is applied to them. This can be checked by the colour of the part when analysing the results. Blue is a pass and Red is a fail. The process builds in a factor of safety so the students can build in how safe the part needs to be.

Results of our test

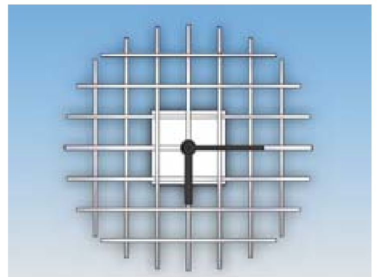
The results show that the slot must have a thickness from the bottom edge (red) of a minimum of 3mm to withstand a load of 50N offering a factor of safety of 1.1. Below a Factor of Safety of 1 the part will fail. This allowed the students to modify the dimensions of the part and check the rest of the assembly to stop any parts breaking when being removed from the milling machine bed saving time and cost.

Final Design after Changes

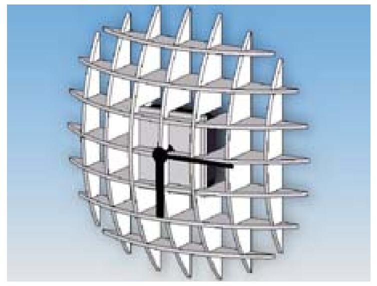
This is the final design of our clock after all the changes have been applied; the design includes the mechanism and hands.



Exploded view



Front view



Isometric view

Langley School would like to thank our industrial sponsor, New Technology CADCAM Limited for their support.

In the next issue of DATA Practice we will follow the students' visit to NTCADCAM where they used the 3-D Rapid Prototyping machine and saw other examples before going on to complete their clocks. Look out for issue 5.2005 on August 30th.