Design portfolio

of

Prasanna Sridharan

M S in Mechanical Systems and Design
B E in Mechanical Engineering

<u>Projects</u>

Redesign of 'Arrow' Electric Staple/Nail Gun
Design of Switch Activated Ball Tosser
Design Automation using Pro/Engineer
Advanced Computer Graphics using OpenGL

Redesign of 'Arrow' Electric Staple/Nail Gun

Duration	-	January 2001 to May 2001
Place	-	University of Texas at Austin
Purpose	-	Requirement for ME 392M Engineering Redesign: Theory and Techniques
Advisor	-	Dr. Kristin Wood, Cullen Trust Endowed Professor in Engineering No.1

Scope of the Project:

The redesign of an electric staple/nail gun was undertaken as the semester project for the course - *Engineering Redesign: Theory and Techniques*. I chose the product, 'Arrow' gun, since it gave me a better opportunity to learn about both electrical and mechanical systems at the same time.

Figure 1 - 'Arrow' Electric Nail/Staple Gun

Design Methodology:

Background research

- # *Black Box model*
    - o The black box model was first drawn without any idea of the product structure, considering the input and output flows and energy.

- # *Customer Survey*
    - o The most important part of the design process was executed next, where 9 customers were interviewed and their needs were noted.
    - o The data was tabulated and prioritized in the order of the most important needs to the least important and all the needs were rated based on the emphasis that each customer placed on the need.

- # *Activity Diagram*
    - o The activity diagram was drawn to get a better feel for the product.

Hypothesized Functional Decomposition

- The functional structure of the product was drawn taking the inputs from the black box model and the path of each flow was traced until the boundaries of the product.
- This gave me an insight on how the product should actually function on the inside.
- I could conceptualize the "functional" view of the product.

REDESIGN OF NAIL AND STAPLE GUN

Customer Need Importance - Interview Data Method

Sample Size: 9 Customers
Average Customer: Male/Female, aged 20-22
Middle Class, Not a frequent user

Customer Needs	# of customers	Weight
1. Ergonomics		
A. Light in weight	8	5.75
B. Compact for easy storage	3	5.6666667
C. Comfortable to hold	2	7
D. Sturdy and long lasting	2	5
E. Non-bulky for easy use	2	4
F. Good grip for easy handling	3	5.6666667
G. Change material to reduce weight	2	5
2. Efficiency of use		
A. High cycle time	2	3
B. Fast handling	1	3
3. Manipulation		
A. Ease of loading	5	5
B. Improve the guide for loading	1	5
C. Adjustable handle for comfortable use	1	5
D. Simple and easy to use	6	5.6666667
E. Cordless Feature (Mobility)	6	4.6666667
4. Powerfulness		
A. Gives the required power	9	7
5. Dissipation		
A. Reduction of sound	5	7
B. Reduction of vibration	6	6.3333333
C. Increase cushioning	1	7
6. Safety		
A. Include an On/Off switch	1	5
B. Improve safety switch	5	8.6
C. Change position of lock	1	9
D. Include a protective hood around exit	1	[illegible]

Figure 2 - Rated Customer Needs

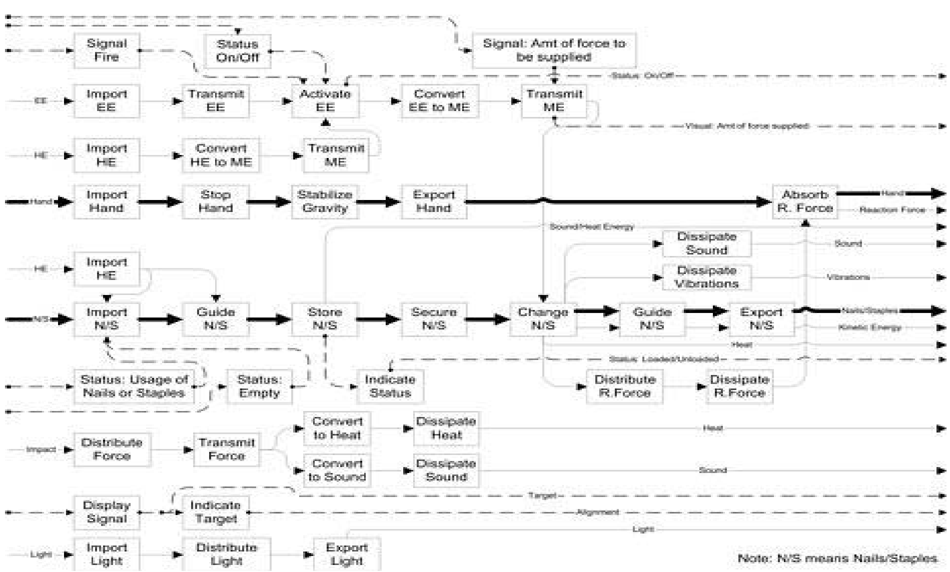

Figure 3 - Functional Structure

\# *Hypothesized Product Features*

- o A Cross-Sectional diagram of the product was drawn.
- o Function to form was executed.

\# *Product Disassembly*

- o The product was disassembled and the parts were examined.
- o The bill of materials was drawn.

Bill of Materials

Part No.	Qty	Function	Mass (g)	Dimensions	Material	Finish	Processing
A1							
1	1	Secures the nails & staples	26	3.1x3, 2x4, 17xϕ3, 5x15.5	Steel	Chrome	Sheetmetal, stamped, deburred
4	3	Holds A15 to A22	2	Standard			
5	**1**	**Encloses A11, A12, A13, A14, Atta**	**220**	**8x19.5, 10x4 t=0.1**	**Steel**	**Chrome**	**Sheetmetal, stamped, deburred**
A2							
1	3	Holds the two hands of A22	2	Standard			
2	1	Encloses A2 and A3	144	Injection molded	Plastic	Injection molded	
3	1	Prevents A24 from firing	1	Injection molded	Plastic	Injection molded	
4	1	Closes the circuit for firing	4	Injection molded	Plastic	Injection molded	
5	1	Brings A24 back to initial position	1	ODϕ0.6; IDϕ0.4; Ht=2; pitch=0.4	Standard		
6	1	Import, Transmit EE		Insulator; coated with plastic			
A3							
1	1	Hammers the nail & staple	11	11.2x2x0.1	Cast Iron		
2	1	Guides A34 into A35	9	7xϕ0.4	Cast Iron		
3	1	Brings A34 back to initial position	6	ODϕ2.5; IDϕ2.2; Ht=6.5; pitch=1.1	Standard		
6	1	Dampens sound and vibrations	4	3.5x2.5x0.5	Cork		
7	2	Holds A1 to A2, takes vibrations	28, 11	4.6x2x0.3	Steel	Chrome	Cut, Stamped, Deburred
8	1	Manages the timing of circuit	11	1.1x2x0.3	Standard		

Figure 4 - Bill of Materials

These were followed by the actual redesign methodology –

\# *Subtract and Operate Procedure*

- o The subtract and operate procedure was done to understand what the function of each part was and to check if there were any parts that were redundant.

\# *Force flow diagrams*

- o The force flow via the product was examined and possible redesign areas were assessed.

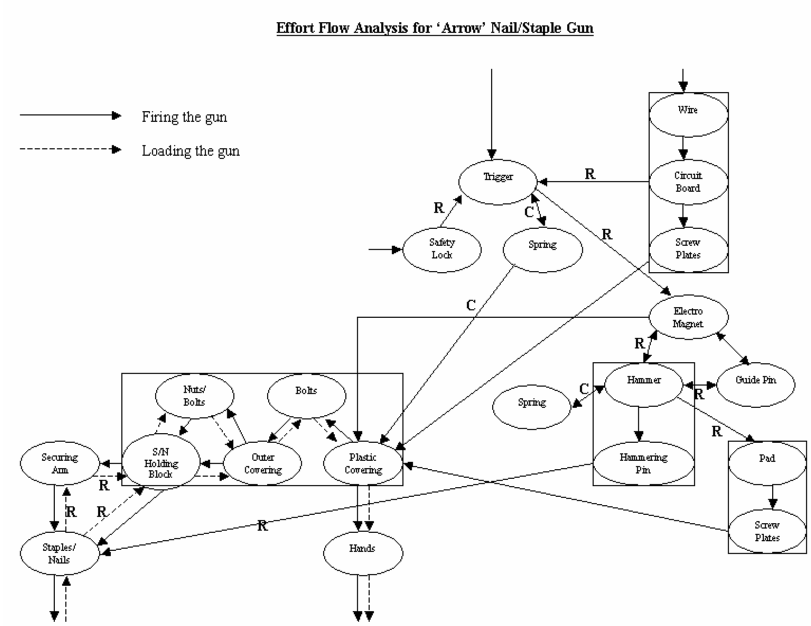

Figure 5 - Force Flow for 'Arrow' Gun

Morphological Analysis

- The morph matrix was then drawn with the help of a brainstorming session. The morph matrix had three solutions in different domains for each product function.

QFD

- The QFD matrix was constructed and the parameters that drove the main customer needs were obtained.
- Ideas of the target values were also obtained.

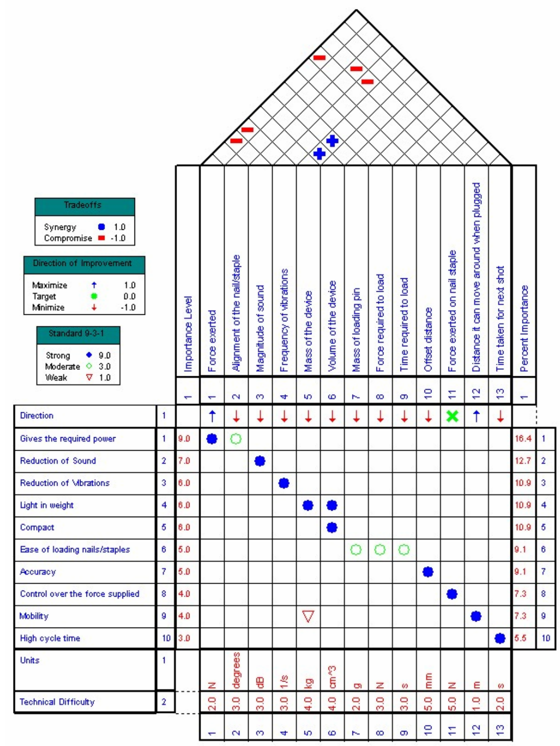

Figure 6 – QFD for 'Arrow' Gun

TRIZ (TIPS)

- TIPS methodology was applied to remove conflicts between two important needs, so as to avoid compromises in the product.

Parametric Redesign

- For parametric redesign, the boundaries were decided and the final equations were obtained from the balance equations.
- An optimization module was executed in Excel to determine the optimal weight of the solenoid.
- The optimized dimensions of the core were obtained.
- A FEM analysis was done on the bottom part to determine if it could withstand the load, when made of plastic.

Adaptive Redesign

- Brainstorming and 6-3-5 techniques were executed to get more product solutions.
- More functions were introduced into the product.

Constraints		Energy of the system (J)	20.07644	=	20.07
		Number of turns	341	<=	341
		Current into the solenoid (A)	2	<=	4
		The velocity of the core (m/s^2)	17.9	<=	25
		Average radius of the coil (m)	0.0155	<=	0.03
		Average radius of the coil (m)	0.0155	>=	0.01
		Length of the solenoid (m)	0.03277	>=	0.03277

Figure 7 - Constraints used in Excel

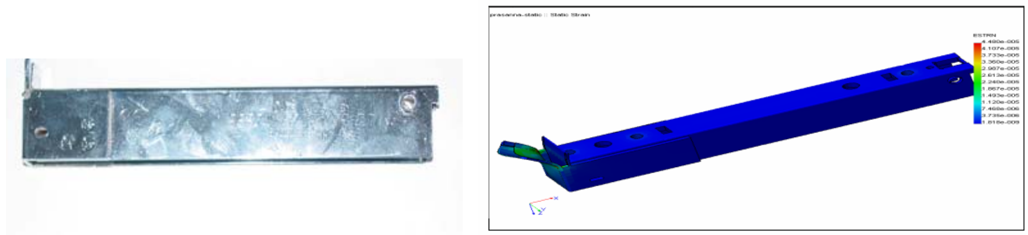

Figure 8 - FEM Analysis to analyze the load

After all these techniques, the results were integrated and the final form and functions of the product was obtained. The final BOM was presented.

Conclusion:

The whole design process took about four and a half months. I worked individually and this was a continuous process with work spread over the whole period. This exercise gave me an excellent idea of the whole design methodology and the way each of these processes should be approached. I also gained valuable insights about the intricacies of designing a product and the problems faced.

Insights:

This project was a great way for me to get an idea about the actual design process. Right from the collection of background literature, I got valuable understanding about the problems that are usually faced by designers. The function structure and the effort flow diagrams gave me lots of ideas about how a product ought to be designed. Further this being a redesign project, I had to approach it a little differently than the conventional design approach. The role of each part in the product was to be assessed and the "subtract and operate" procedure helped a lot in that regard. Working on my own made me learn all the processes by myself. I felt that this was also a disadvantage in one aspect as I strongly feel that "Ten heads are better than one".

I also used this opportunity to learn ANSYS, Solid Works and Pro/E. These software applications were used extensively to do the solid modeling and the FEA analysis. I used Excel solver to solve the optimization equations and other documentation. I also learnt the importance of QFD, TIPS and other brainstorming techniques improved my analytical skills.

I was definitely benefited from the whole experience and this reinforced the spark in me to become a designer.

Design of switch-activated ball tosser

Duration	-	August 2001 to December 2001
Place	-	University of Texas at Austin
Purpose	-	Requirement for ME 392M Product Design, Development and Prototyping
Advisor	-	Dr. Kristin Wood, Cullen Trust Endowed Professor in Engineering No.1

Scope of the Project:

The Rosedale School, a school for children with multiple disabilities, is located at Austin, Texas and is part of the Austin Independent School District. There are quite a number of students in this school, who are not able to lead the life that other students of their age do. An activity such as playing basketball or bowling is extremely difficult for these kids. To facilitate this, we decided to do a switch-activated ball tosser that could be used by these students. All the students had to do was push a switch and the device would fire the ball fed into it towards the basket.

Design Process:

In this project, I was a part of a team of 4 members. We spent the first week getting to know each other, which is very crucial for a team project. We also did some research on the market and manufacturing trends of a ball-tosser. Later on, I realized how important this period was and the importance of being comfortable with your team.

Customer Interviews:

The whole process started off with customer interviews and we contacted the teachers in Rosedale whom we considered as our primary customers. We also got to interview a couple of the students and a few parents. Our next step was to prioritize the data that we had collected from the teachers. We had assigned ratings to the needs of the customers and based on that, we decided which of the needs were important.

Functional Model:

The next step was to draw a functional model of the ball tosser. This was a very vital step in design as this gave us a good opportunity to understand how we wanted our product to function. We also had constant contact with the customers and had them up to date on our progress. We followed this by drawing QFD matrix based on the customer needs. Though we understood that this was not such an important step, as we were not measuring any competitor’s product against ours, we thought that this would give us a good idea as to which parts of the problem were solvable and we got an idea of the difficulty level of the task before us.

Generating Solutions:

Faced with the problem, we set out to work upon the solution. We used some conventional techniques like brainstorming and brain writing. We also used some innovative techniques like 6-3-5 and these techniques gave us a lot of new solutions that we normally wouldn’t have thought of.

Proof of Concept:

After this, we then embarked on a proof of concept where we prototyped one of our ideas to see if it would work. We thought of a spring mechanism that would propel the ball towards the basket. However, this proof of concept was a failure, as we did not obtain enough force to throw the basketball over a long distance. Though we were dissuaded, we later understood that this was a blessing in disguise. If we had not done the proof of concept, we would have gone on to manufacture this product, and then it would have been a failure.

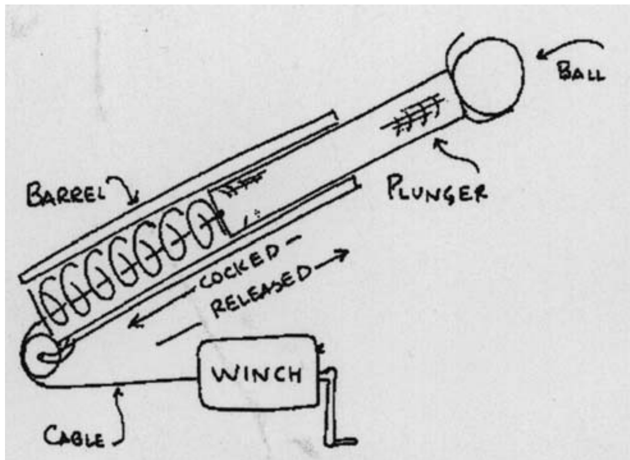

Figure 9 - One of our numerous solutions for which we did a proof of concept. It failed to give the desired force.

Prototyping:

After this, we did another proof of concept, using two wheels powered by motors to propel the ball. This worked and we started to work enthusiastically on this. We then spent the next month and a half fabricating the device that we had conceived. We had to put in a lot of hard work and we faced a lot of problems along the way. We finally were able to finish the alpha prototype and then moved on to the beta prototype.

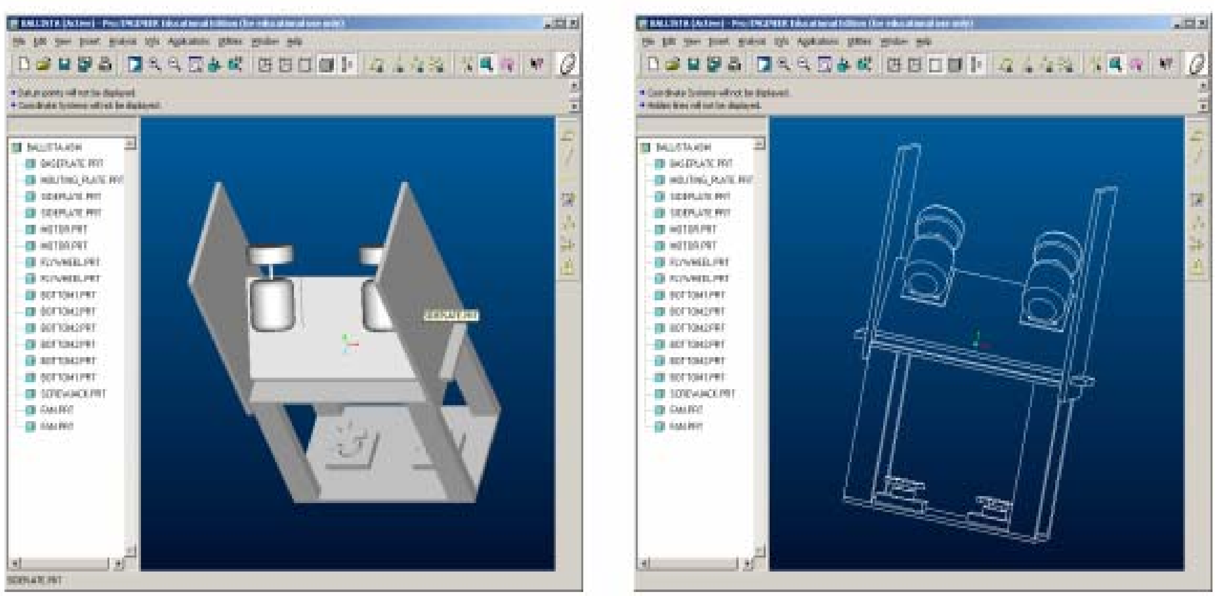

Figure 10 - Our alpha prototype as modeled using Pro/Engineer

Conclusion:

This was a great team project and I really enjoyed working a lot on this one. It involved the whole team to be inspired and motivated all along and I realized the importance of establishing a good rapport with the team members. We had our shares of arguments and fights and I learnt a lot about working in a team. Being the optimist in the team, I was responsible for keeping the morale of the team high and to motivate them through out. Our paper got accepted into the International RESNA Conference, 2002.

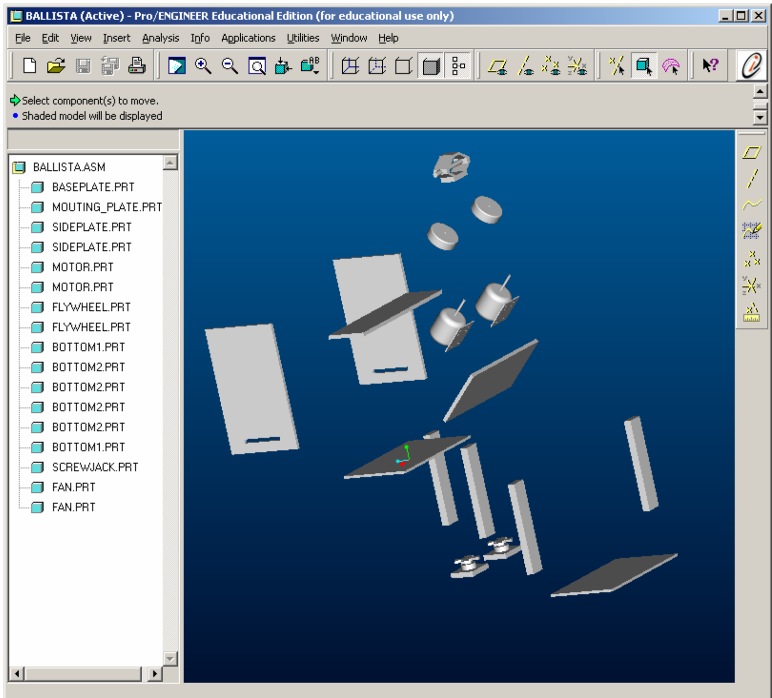

Figure 11 - Exploded view of our prototype

Insights:

This project helped me learn one main thing – to work as a part of a team. I realized how important it is for the team to stick together through tough times. I also learnt how actually prototyping a product is much more difficult than just putting forward a proposal. We had to "make" what we thought of and hence that required a very clear analytical mind. This gave me a lot of experience in prototyping and design and I am confident that with this project, I took another step to become a complete designer.

Tool Design Automation using Pro/Engineer

Duration	-	January 2000 to June 2000
Place	-	Design Automation Division, Lucas-TVS, Chennai, India
Purpose	-	Graduate Trainee,
Advisor	-	Mr. K. Dhanraj, Chief, Design Office, Lucas-TVS, Chennai, India

Scope of the Project:

Design Automation is a very important part of any manufacturing company. In Lucas-TVS, the problem was the design team was a small group and this small design team was catering to the needs of a huge factory. When a new design was required, it was put on hold until one of the designers was free. To avoid this, I was asked to use Pro/Engineer to program a generic design into Pro/E such that all the user had to do was open the Pro/E file and key in the driving parameters and run the program to obtain the final CAD drawings. This was achieved using the "family table" option in Pro/E 2000i[2].

Design Automation of Lamination Press tool:

Lucas TVS made motors with 5 different kinds of laminations. These five different types differed from each other in the kind of slots (open, closed), type of slot (oval, rectangular) and the presence of a key slot for alignment. The other main parameters were the outer and inner diameter of the lamination, and dimensions of the slots.

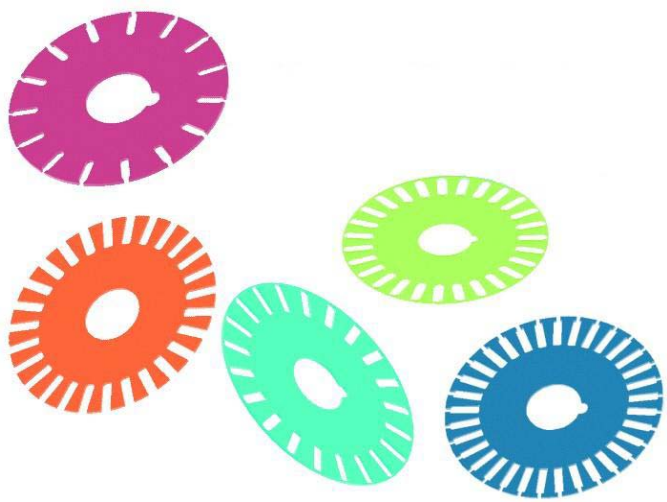

Figure 12 - Different laminations used in Lucas-TVS

The user opens the Pro/E file and types the values that he wants into the family tables and saves the file. He then opens the assembly and regenerates the assembly file. The whole lamination press tool of 85 parts is changed based on the input that he gives in the family table. All he has to do now is to open the drawing file; call the instance that he has created and the drawings are also ready.

This change is achieved by using the "Pro/Program" module of Pro/E. This whole program is supported by around 1000 relations, where the 10 dimensions that he specifies in the parent file drive each dimension in the whole assembly. As the user regenerates the file, the relations act on the dimensions and update all the dimensions in the assembly. It is also possible for the user to specify if he wants a specific feature like a cut or an extrusion. If he does not want that, all he has to do is to specify a "No" in the family table.

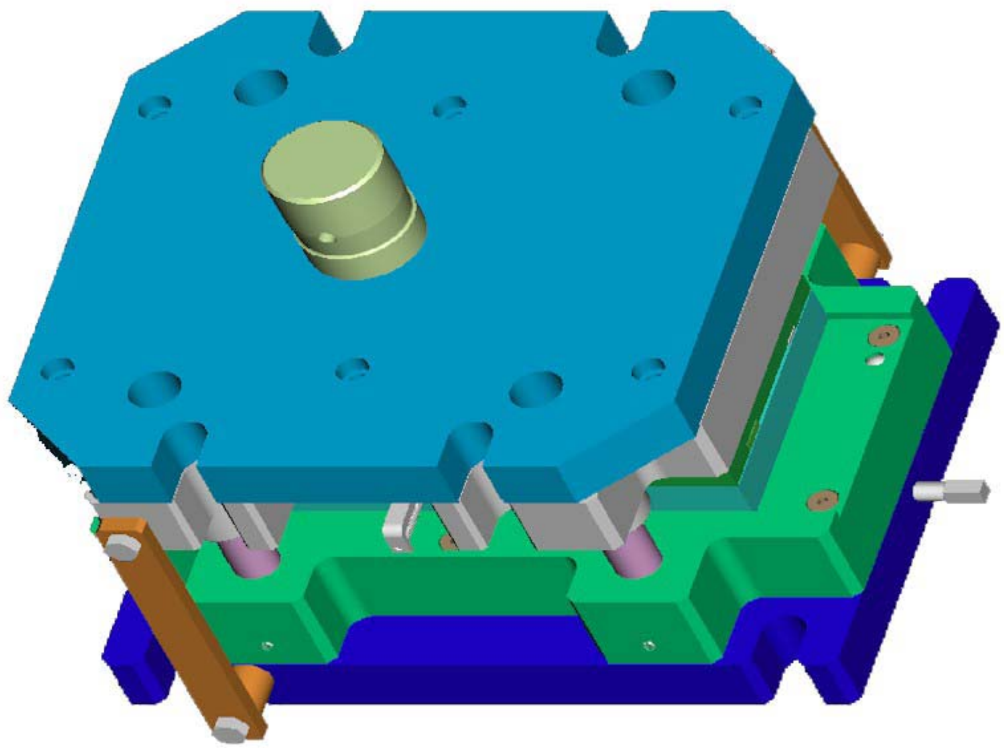

Figure 13 - The Assembly of the lamination press tool

In this case, the order in which the assembly is created becomes important. As we can see from the exploded view, the whole assembly can be divided into two parts, the top half and the bottom half. The lamination passes in between these two halves. Due to the number of parts that was involved, it was vital for the program to be very efficient. Hence, the parameters from the parent file were first passed on to the parts closest to it and its dimensions were updated. This then spreads on to the parts close to it and this whole process went on till the bottom-most and the top-most parts were reached. This ensured that the whole process was faster.

Design Automation of Gap Gauge:

The same process was followed to create a Pro/E file for a gap gauge. An automation file for a gap gauge was vital because the manufacturers were dealing with so many tools and products that they needed a gap gauge with a different dimension every month. This was also implemented using the same principles stated above.

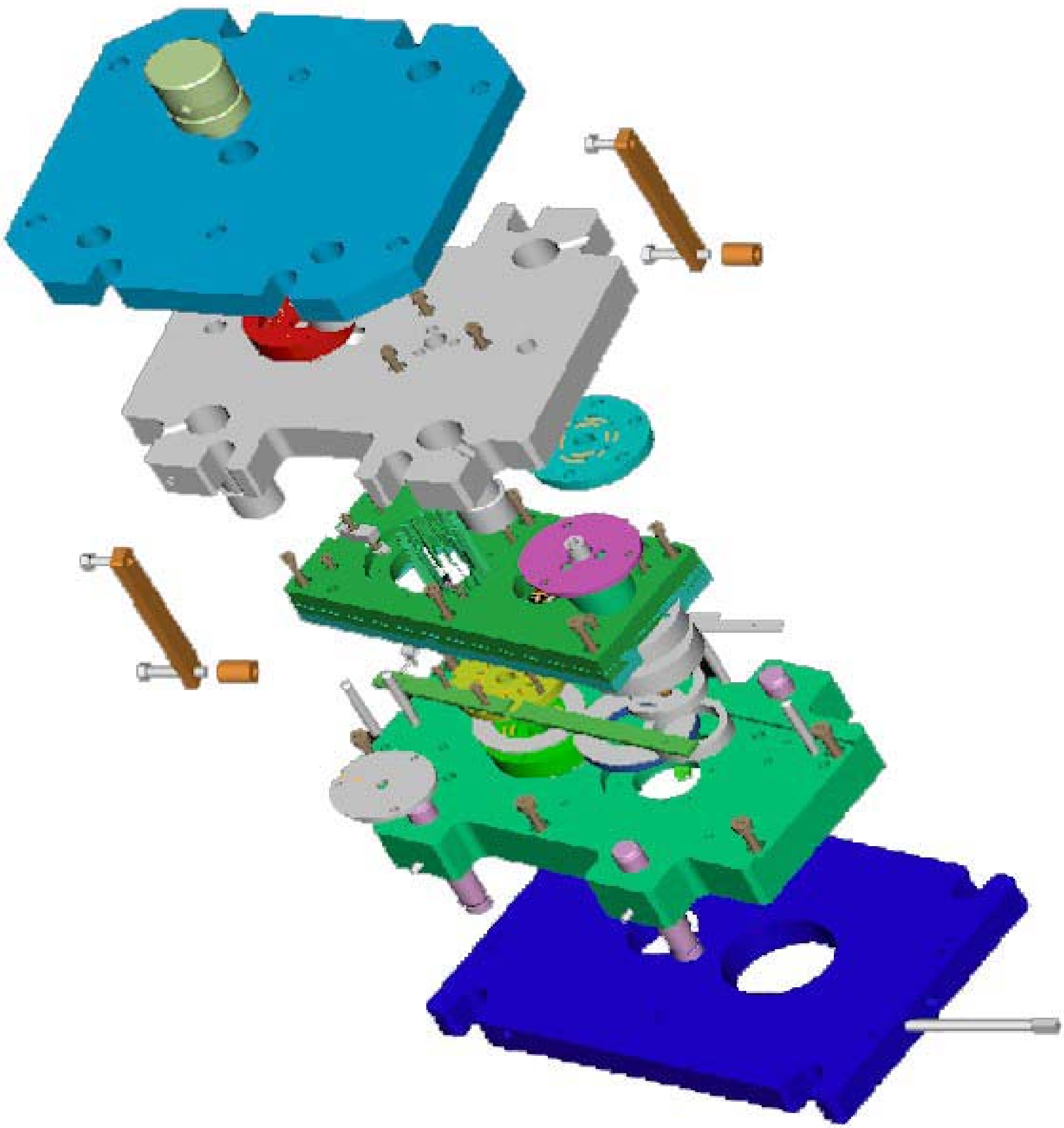

Figure 14 - The Exploded View of the Lamination Press Tool. This assembly contains around 90 parts that driven by 10 dimensions that the user specifies.

Figure 15 - A model of the gap gauge modeled using family tables.

Conclusion:

This project happens to be one of the most stimulating projects that I have ever done. The scheduled time for this was somewhere in May and I felt so excited about this, that I completed this by March. An online help document was also done and posted on the company's intranet. The lamination assembly tool was also design automated. These automation files helped the company a lot by reducing the design time drastically. The lamination press tool took nearly 2 weeks to design, but by using my file, it could be done in under an hour.

Insights:

As specified earlier, this was one of the best projects that I have happened to do until now. The first few weeks were bad as I had a tough time learning Pro/E and getting a feel of the design process. After the initial glitches, I learnt a lot about tool design and manufacturing. I got a taste about the actual problems faced in the industry. My biggest gain was that I became very proficient in Pro/Engineer. Working for 10 hours a day for 6 months in Pro/E made me feel real comfortable with the software and I got to know its effectiveness and its flexibility.

I gained a lot of insight on how tool design and product design are actually achieved in an industry. Being in the midst of all the action gave me such a lot of knowledge about design that I can never hope to acquire in years of college.

Advanced Computer Graphics using OpenGL

Duration	-	August 2001 to May 2002
Place	-	University of Texas at Austin
Purpose	-	Course Requirement for ME 392G, Advanced Engineering Computer Graphics
Advisor	-	Dr. Richard Crawford, Associate Professor, Roberta Woods Ray Centennial Fellow in Engineering

Scope of the Project:

These set of projects were done as part of a two advanced graphics course that I had taken during Fall 2001 and Spring 2002. The objective was to use OpenGL to create interactive graphic programs. This was achieved by understanding the fundamentals of graphics software and hardware. The projects were developed using OpenGL™ graphics library and the coding was done on Visual C++ environment.

Project 1 – Implementation of the Graphic Pipeline using OpenGL:

This project was my first experience with OpenGL programming. We created scale, transform and rotation matrices along with the aim and eye points. We read the data of points from a data file and ran each of those points through the pipeline that was created. The final points were then plotted on to a window. This was done in C.

Project 2 – Curve Drawing:

Here, we used OpenGL to draw the four main kinds of curves that are used in computer graphics. These were Algebraic, Parabolic Blend, Beziers and B-Splines. This was an interactive menu-driven program. The user had to choose the curve that he wanted to draw and could pick the datum points. Then he just clicked the '*draw*' option and the curve was drawn on the screen. This was also achieved using the OpenGL library.

Project 3 – Window to Viewport mapping:

This project simulated the gluOrtho2D function of OpenGL. The program read from a file that had the end coordinates and the Viewport coordinates in world coordinates.

Project 4 – Three Dimensional Renderer:

This was a very interesting project where I had to simulate a 3D – CAD program. Here, we gave the options of scaling, transforming and rotating to the user. The user could also achieve this by using the mouse and pressing control. The user can change the view by changing the eye and the aim point. There was also an option given to the user to come back to the default view. The popup windows were achieved by using a toolbox called "glui" that is supported by OpenGL. The coordinate axes were also drawn so that the user could know where he was.

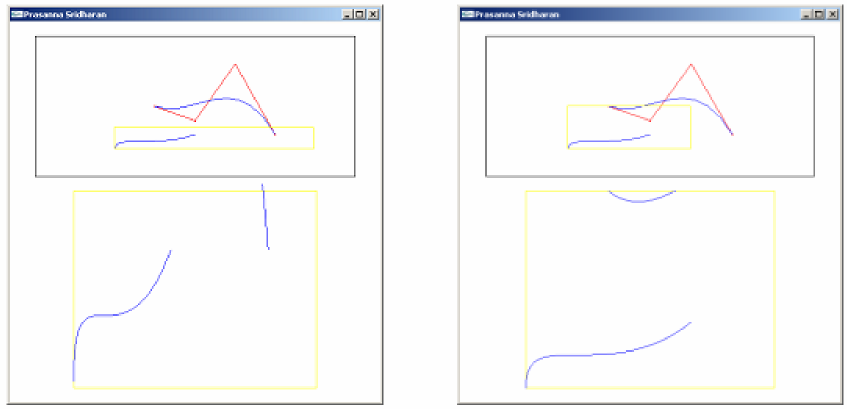

Figure 16 – Project 3: Two outputs where we can see the window to viewport transformation

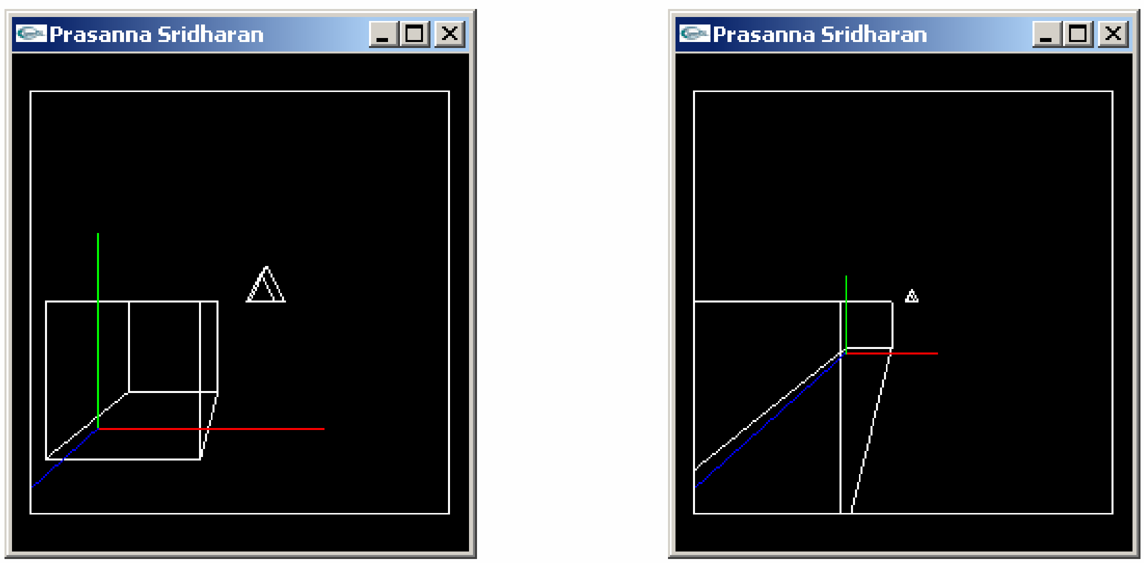

Figure 17 – Project 4: Interactive program where user can change the aim and eye points

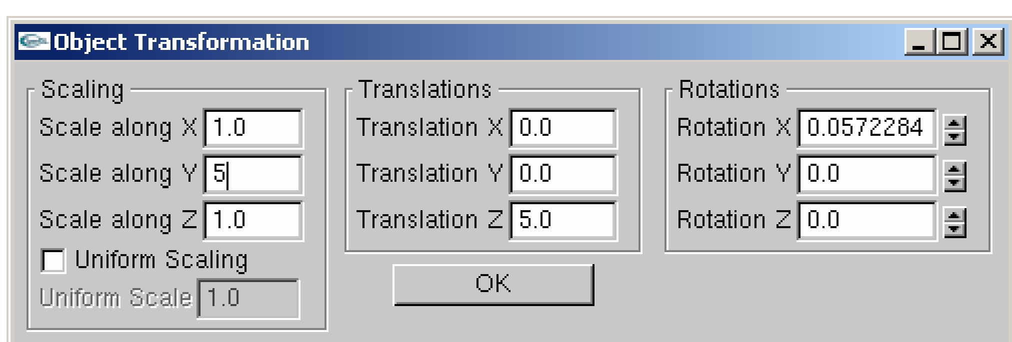

Figure 18 – Project 4: Menu where the user can change the Scale, Translate and Rotate parameters

Project 5 – Solid Renderer:

This project required me to take the standard ".stl" formats that are provided on any CAD software as inputs. I had to read the stl files and form a new file based on the data in that file. stl files just split the surfaces in the cad model into triangles and wrote them as a txt file. My program read this standard file and another data file that had the colors and other relevant info. Then the program ran these data through the OpenGL pipeline and redrew them. After that, the details in the data file were used to render the image. The final rendered image was then written into a bmp file.

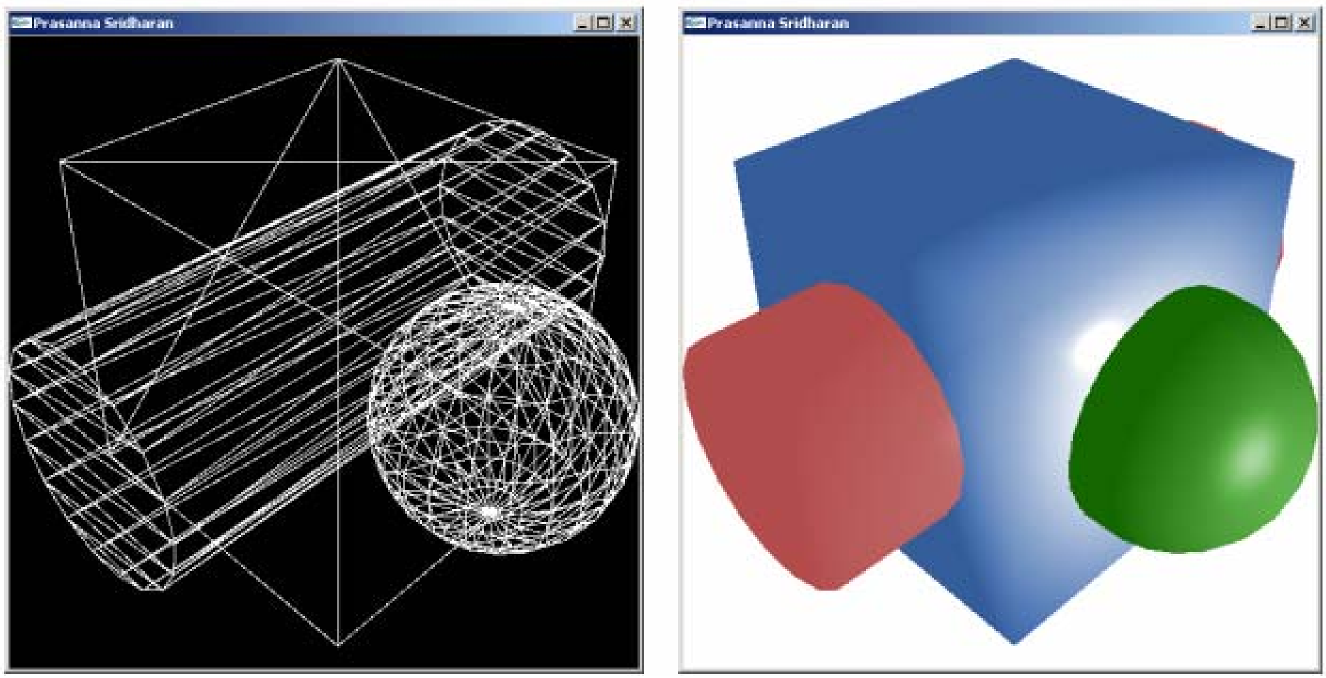

Figure 19 - Project 5: Wire frame renderer using .stl files

Insights:

I learnt a lot about the field of graphic design after doing these projects. I honed my programming skills and gained expertise on using the graphics library. This also instigated my curiosity in the amazing field of computer-aided design and I got a fair idea of how CAD software like Pro/Engineer and Solid Works actually worked. Getting to know things from this perspective was really startling.