FEA Data Communication in Color 3D

1.1 Application Description

The use of 3D Printing to output Finite Element Analysis (FEA) data improves communication among participants in the design process, regardless of training or experience. Discovery and understanding of design flaws early in the design process before they lead to manufacturing or functionality problems is a critical part of the design process. When a problem is discovered that requires an internal or external customer to reconsider and perhaps modify certain favored features, discomfort and friction can develop between the engineering team, the industrial designers and the end decision maker. The use of 3D color parts to express the findings of FEA firmly establishes the critical issues and the need for change, builds clarity and trust among the parties, leading to faster solutions and better products.

1.2 Case Example: Crown Cork and Seal

The following is an excerpt from Machine Design magazine's February 2002 Issue. In the article, Michael Mooney of Crown Cork and Seal describes his experience using Z Corp. concept models to communicate FEA data.

Our typical process involves choosing one or several FEA data sets to print in 3D and outputting the data to the VRML file format. We then import this data into MAGICS Z, a special software available with the Z Corp. 3D printer, and add color text labeling and highlights. Our customers are always concerned with confidentiality and it is reassuring to them to see their name and the words confidential stamped right on the part in color. The text labeling is also helpful in version tracking. We then export the data to the Z Corporation color file format and press "print" in the Z Corporation software. The Z Corp. 3D Printer can build several parts at once and typically takes several hours.

In meetings with our customers, we use these parts to explain issues and challenges in the design. Some more detailed case examples follow, but in general the reactions have been the same. The customers can more quickly understand the issues and consider the color parts to be more convincing "proof" of the problem than a computer screen or sheets of paper. The parts serve as excellent demonstration pieces to help explain the issues in detail to the customer—we find that we can educate the customer more in a two hour meeting than we could previously accomplish in a much longer period of time. This helps the customer understand the issue, but also presents our firm as a technology leader and a trusted expert in the field. Again, our customers see that we are finding and solving problems rather than creating them.

The challenges we face as a team are not unique to our situation or our industry. For example, we have a relationship with the engine development group at Ford and they are also well into using these tools to help spot and fix latent problems in designs. They are, for instance, color coding parts by wall thickness, so that members of the entire manufacturing process can look at the parts and immediately give input about potential issues in the fixturing or tooling process. They are also printing out other types of FEA data with their color 3D printer to communicate design challenges across the development process.

Conclusion: In our experience, using 3D color appearance models to represent FEA data is very effective in identifying problems, demonstrating the need for change and getting consensus on improved designs. This more effective communication helps strengthen our customer relationships and ultimately make better products.

Case Studies:

Vacuum Effects on Hot Fill Container. We use FEA to test the effects of vacuum for "hot-fill" containers or pressure for beer and carbonated beverages. Hot-fill bottles are filled with a liquid at or above 80°C (176°F) in order to sterilize the contents. When a liquid or semi-viscous product is heated to this temperature the volume expands. For water at 85°C (185°F) this expansion is just slightly more than 3%. For semi-viscous products this expansion is lower depending on the solids content. After these products are packaged hot they are cooled down with a water spray. The product volume then decreases by the 3%, causing a vacuum to form and the bottle to deform inward. If the vacuum effects pull the bottle out of round, this will have impacts on labeling, storage, shelving and customer perception.

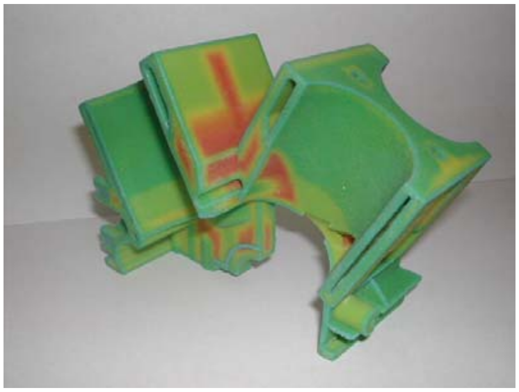
To combat this, bottles are thermally stabilized and designed with vacuum panels, which if designed correctly will expand and then contract without affecting the geometry of the rest of the bottle.

To determine if the bottle would successfully manage these vacuum effects, we ran FEA on the shape, revealing a problem. This picture shows that areas of the bottle other than the panels were being deformed by the vacuum, representing a problem. We saw that this would require a design change, so we printed the part in color and used it to explain the problem to the customer and propose the solution. The problem was immediately clear and we were able to agree on the necessary design changes the same day.

Buckling under Top Load. We also use FEA to check for buckling, which is when the plastic creases as a result of a top load. The bottle is exposed to a top load when the container is filled, capped, and stacked in several layers of boxes on a truck or stored in a warehouse. A poorly engineered bottle deforms under this top load and permanently creases the plastic, presenting a flawed product to the customer when it reaches the shelves.

The picture shows the bottle under the top load identified in the customer specification and demonstrates the failure mode. In this case the part clearly shows the impact both in the color data on the surface, but also in the shape of the bottle itself. Not only are we able to print Color FEA data on this model but we also can print deformed models to represent the actual affects under these top load conditions. This was especially effective in working with the customer—they had a very tangible sense of the problem and we were able to quickly agree on a good solution.

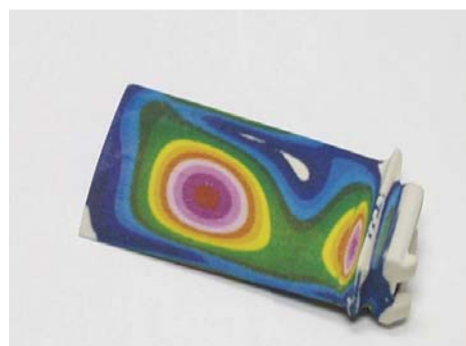
Additional Case Study from Ford….



Color-coding surface by wall thickness. Ford has developed a method for color-coding the surface of the part to represent the wall thickness of this section. This quickly lets members of the product team highlight potential problems and special production requirements for the piece.

….**and from Aerospace**

How do you send a 'hard-copy' of 3D data ? Consulting aerospace engineers wanted to communicate with clients in another location. But without the FEA software and the engineer to run it at the client's site, they could only send a 2D print out of their analysis. But, with the Z406, they easily printed multiple models at the important harmonics, and sent them to the client. This enabled their client to easily discuss and compare results. This also eliminated any potential problems with file compatibility and hardware, and communication and problem-solving could begin as soon as the client held the part.



1.3 Part Production Outline

With MagicsZ and the Z Corporation System Software, a user can import VRML files exported from FEA programs. The following is a partial list of FEA programs that can produce VRML files for direct import into Z Corp system software (v. 5.1.40 and above): Ansys, Cosmos, Moldflow, Solidworks.

The following programs produce VRML files that should be imported first into MagicsZ (or equivalent) and then exported in PLY format for use with Z Corp system software: ProE, ProMechanica, CATIA, SDRC Masterseries FEA, SDRC Ideas, and Patran.

As other software programs are verified, they will be added. Please send any prospective files to applications@zcorp.com for verification if there are questions.

For best color vibrancy, the parts should be waxed using the ZW4 Automated Waxer.

For more information, any questions or additional coaching, please contact our applications department at applications@zcorp.com.