

Comsol MP and “The Library of Babel”

- **William T. Vetterling**
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> Jorge Luis Borges

- In 1941, the Argentinian author Jorge Luis Borges published a work entitled “The Library of Babel” in a collection of short stories “The Garden of Forking Paths”.
- **On the Nobel Prize:** “Not granting me the Nobel Prize has become a Scandinavian tradition; since I was born they have not been granting it to me”

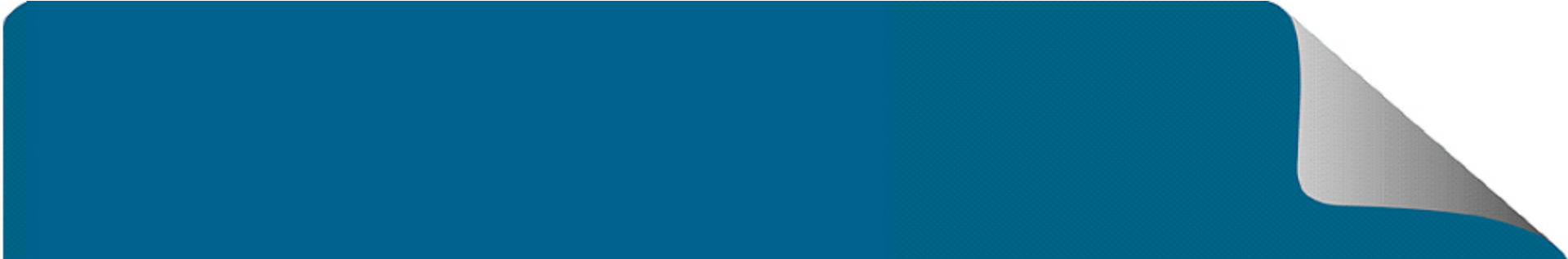


> The Library

- **The work describes an ancient library, with a 3D array of hexagonal rooms, each having four walls of books**
 - “ There are five shelves for each of the hexagon’s walls; each shelf contains thirty-five books of uniform format; each book is of four hundred and ten pages; each page, of forty lines, each line, of some eighty letters which are black in color. “
- **Explorers had penetrated the far reaches of the library, and had concluded that no two books are the same.**
- **In fact, scholar believed the collection to contain every possible book, having every possible sequence of letters and punctuation in every possible order.**
- **Most of the books were pure gibberish, but it was believed that the library also contained every coherent book that had ever been written, *and every book that ever would be written.***

> Contents

- **For example, among the classics in this library are such works as**
 - “King Lear”, by Svante Littmark
 - “Apology to Svante for Plagarizing his Work”, by William Shakespeare
 - “Real Gnik”, by kramttiL etnavS, etc...
 - “Ljoh Mfbs”, by Twbouf Mjuunbsl (next letter substitution)
- **You cannot conclude that any books that appears to be nonsense is not a critical work of science that is in code, or translated to some language that you do not know.**
- **“One which my father saw in a hexagon on circuit fifteen ninety-four was made up of the letters MCV, perversely repeated from the first line to the last. Another (very much consulted in this area) is a mere labyrinth of letters, but the next-to-last page says [Oh time thy pyramids.](#)”**

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- **For every book in this library, there are millions just like it, each having 1 spelling error.**
 - **... and there are almost a trillion with two spelling errors.**
 - **The library has a lot of books! ... but not an infinite number.**
 - **Your next research paper is also in the library, with my name as author, Whatever you are working on, I apparently already thought of it thousands of years ago. Unfortunately, I don't quite remember the details or I would be glad to help you out.**

> The Meaning of Life

- **There are Monks in the library that spend their lives searching for the meaning of life, which is clearly and correctly explained in one of the books.**
- **... and they are looking for:**
 - The cures to the great epidemic diseases
 - The sources of food for hungry populations
 - How the world began and how it will end
 - Their own personal missions and futures
 - Means for controlling weather
 - Knowledge of whether we are alone in the universe

> ... in short

- **Unfortunately, there are also quite a few books that contain the meaning of life but with a few errors. For example, one of them lists the 10 Commandments as:**
 - Thou shalt not lie.
 - Thou shalt not steal.
 - Thou shalt not pay any parking fines.
 - Your neighbors wife is a babe. Give her a call! ... etc.
- **So in short, let us accept that this library contains all human knowledge,**
 - in all languages,
 - in all coded forms,
 - forward and backward
 - and spelled in every possible way.

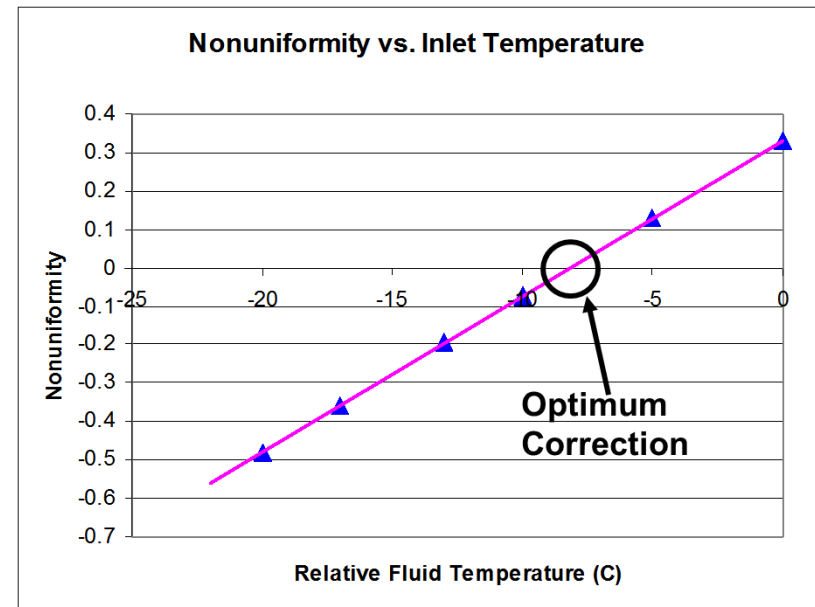
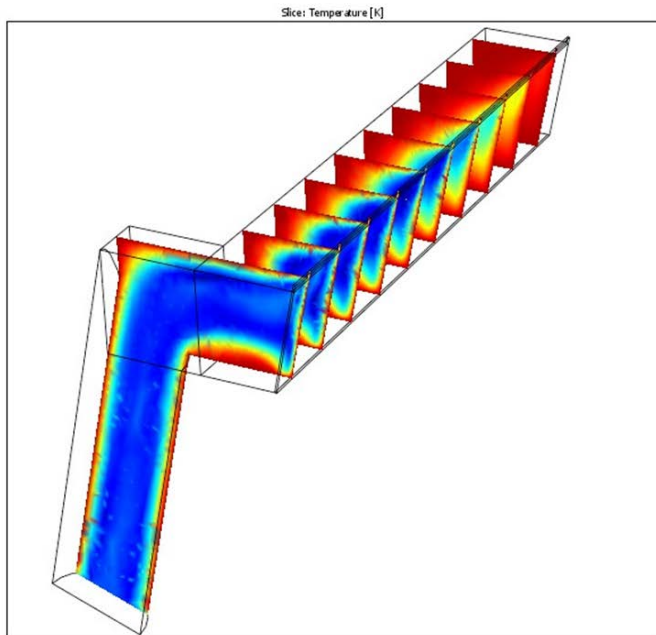
> A diversion ...

- **Let us put aside the Library of Babel for a moment and talk about something completely different!**
- **When I first encounter Comsol MP in 2004, we were working on the invention of a thermal print medium that could print in full color.**
 - We licensed Comsol MP to calculate the heat flows that allowed up to select the color in a medium with a dozen individual layers

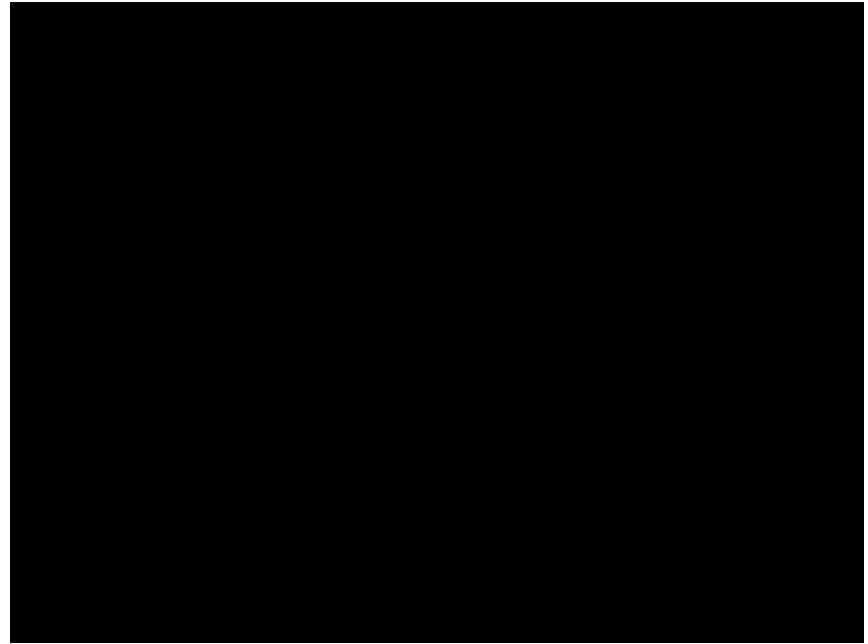
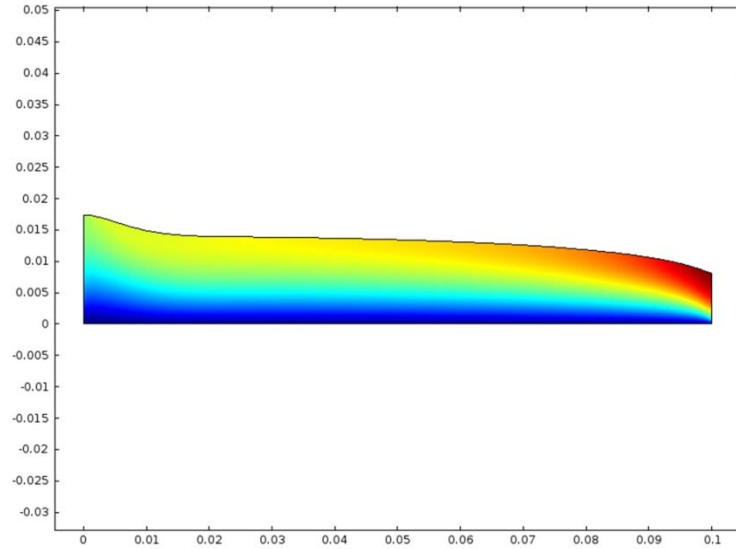


> Coating the Media

- When we had that problem under control, we started using the software for other things;
- **Manufacturing:**
 - Coating a dozen layers of accurate thickness with a curtain coater



> Curtain Coating

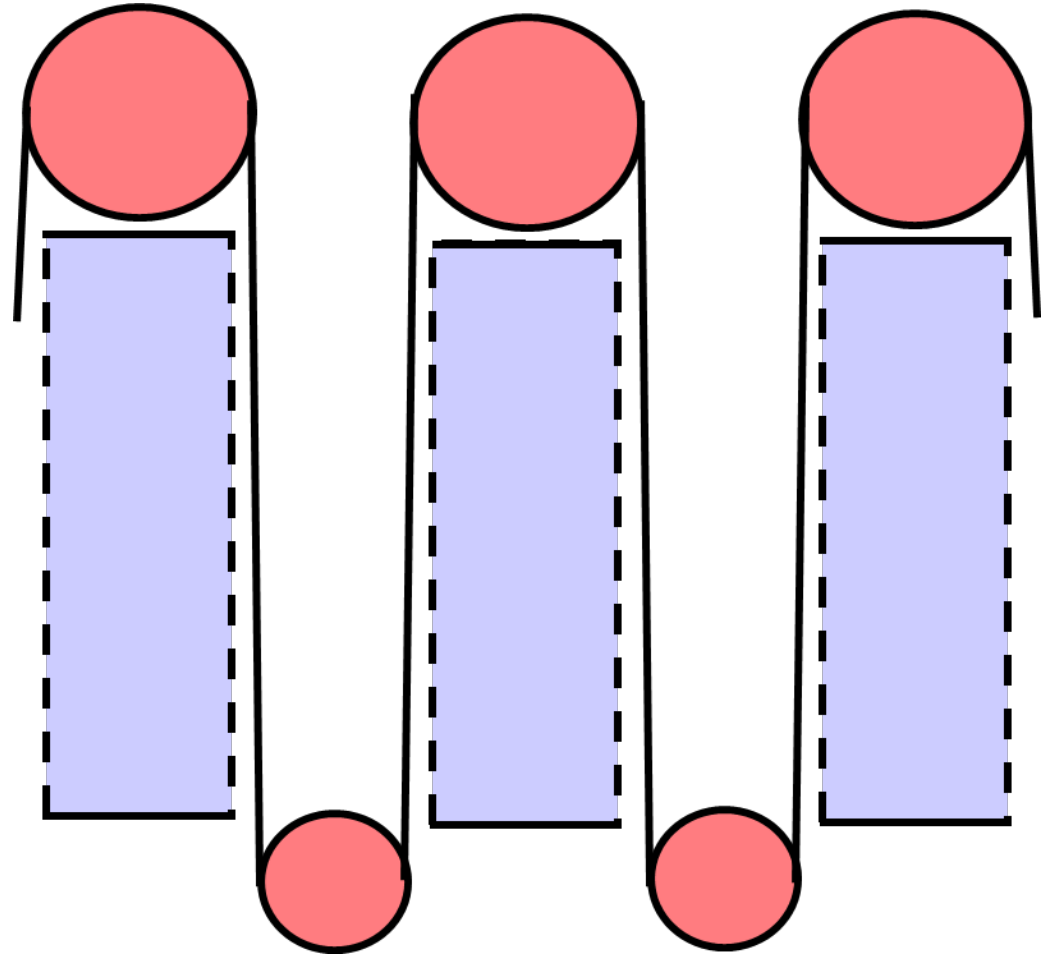


> Media Drying

After coating, the media has to be dried. We have a series of about ??? plenums, each about 2 stories high, blowing hot air on the media to remove water.

When we first did this, the air jets caused thickness variations the showed up in the photos.

We used Comsol to design air-foils for the jets to equalize the pressure on the coating.



>Media Winding

At the end of the machine is a winder that ought to simply wind up the coated media into a spool.

If you are not careful, though, the spool can end up looking like this side view. Again these imperfections can be detected in photos by the discriminating eye.

We used Comsol to analyze the pressure and tension variations in the roll and it is wound up, to help avoid winding conditions that will lead to the “cinching” that caused this crumpling of the layers.

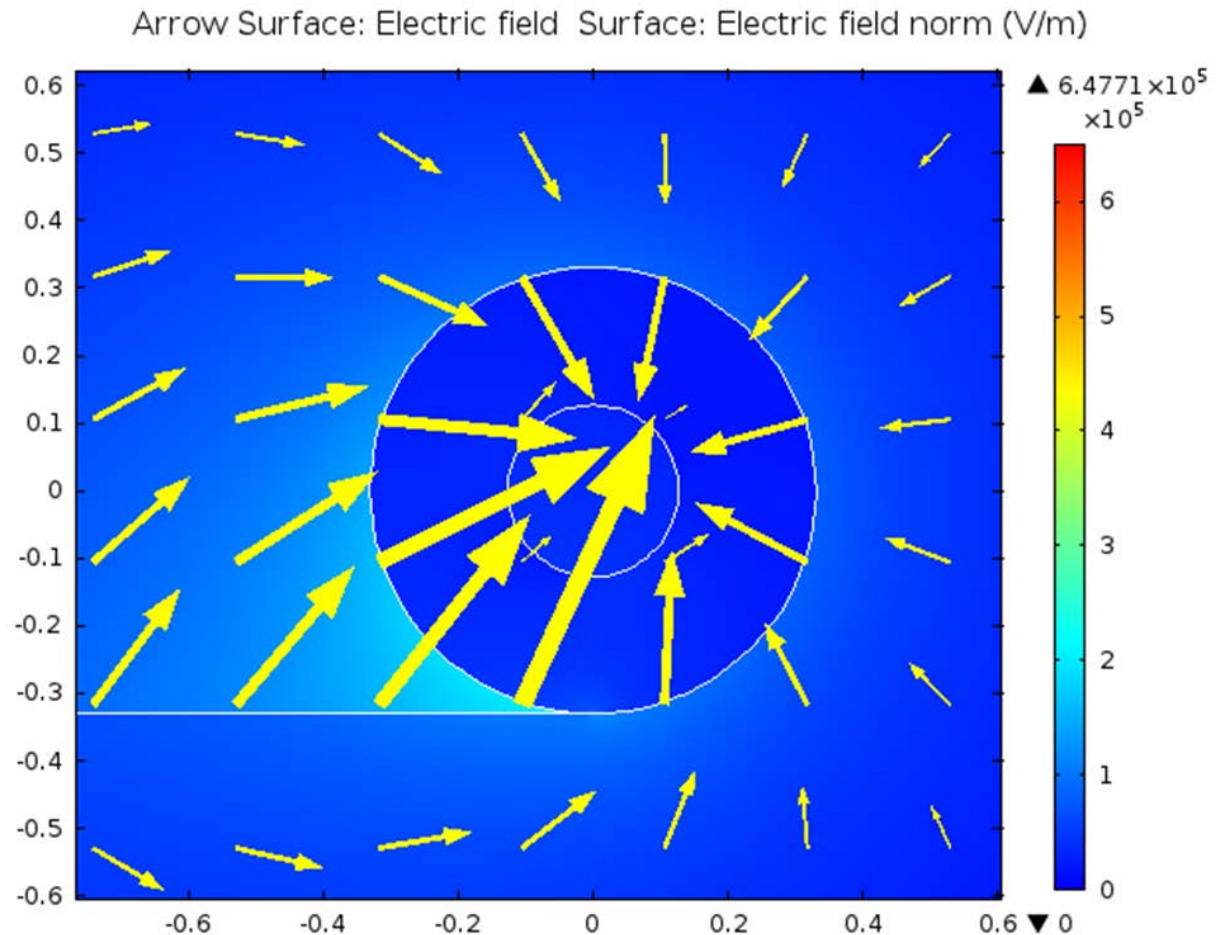


> Controlling Static

For some substrates and coatings, when we unroll the media, a huge static charge is generated, as in a Van der Graaf generator.

It is fascinating, and dramatic, but ultimately destructive to the coating.

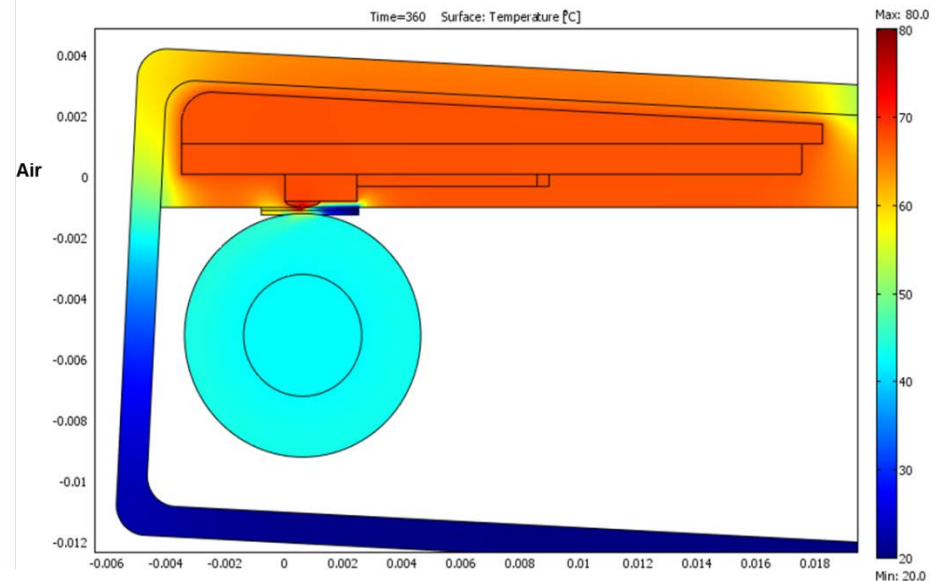
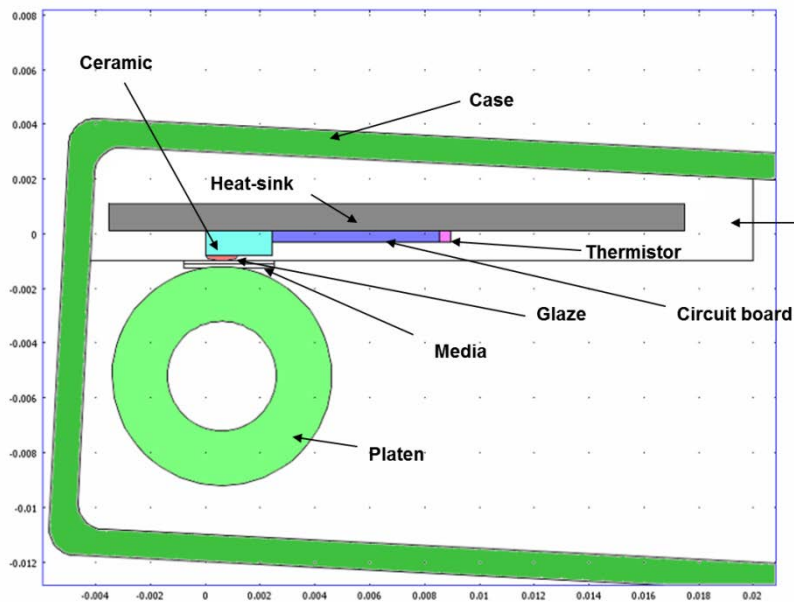
We used Comsol to calculate the fields generated by unwinding, and used it to design a charge removal system that removed the charge removal method that was safe and unobtrusive.



> Product Design

When the media was ready, we had to create printer designs that made use of its novel properties. This led to use Comsol to analyze and modify our hardware designs.

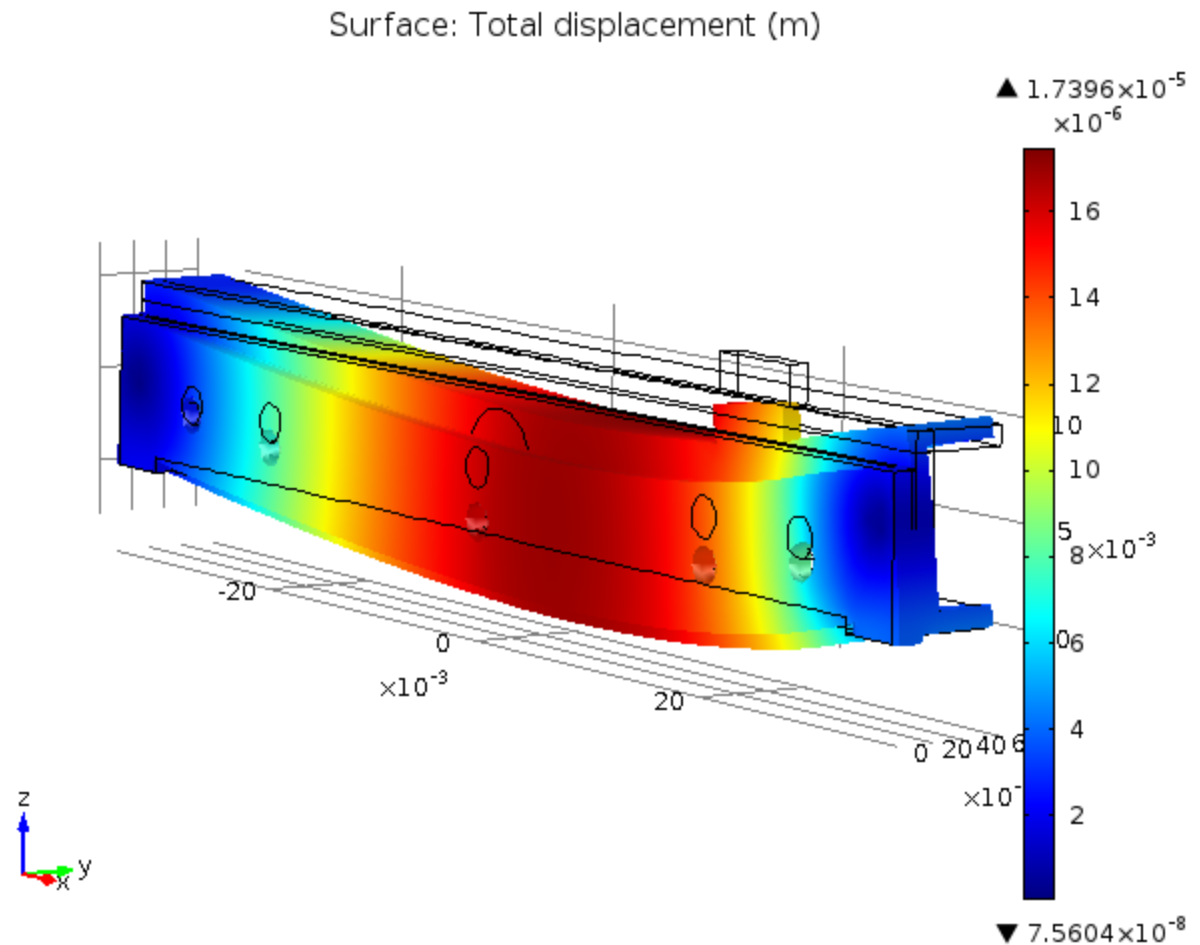
This is a picture showing how the heat generated by a print head ends up being distributed over the case of a small portable printer. Comsol was used to select materials for the case and distribution system so as to keep everything at a comfortable temperature.



> Media Cutter

In another product we had a roll media with a Guillotine kiss-cutter to produce prints of variable length.

When the cutter did not function properly, we used Comsol to analyze the shape changes in the blade support during the cut to determine how to minimize bending.



> Choosing Printhead and Platen

For best printing, we need the media to conform snugly to the heaters on the print head. The choice of print element length and material properties of the rubber on the platen was guided by a Comsol model that computed the media shape and media/print-head contact length under the load of the print-head.

> Durometer, Stiffness

... and speaking of platens and media properties reminds us that the instrument used to measure these quantities often have bizarre units. We have used Comsol models on occasion to model the instruments themselves, to find out what MKS units correspond to the instrument readings.

A Durometer measure the durometer (hardness) of paper, plastic, rubber , etc. in units of “durometers”.



A Gurley Stiffness meter measures the stiffness of sheets of paper, plastic, etc in “Gurley units”.



> New Products - Laser Writing

> Comsol == Hammer??

- **My message is that since 2004 I have been using Comsol MP for *everything*. Thermal, mechanical, fluid, electrical**
- **You might just say: “When you have a hammer, every problem starts looking like a nail”.**
- **... but I think it is more than that.**
- **The principle laws of science and engineering are all second order differential equations,**
 - E&M, CFD, mechanics, chemical reactions, electronics, heat, diffusion
- **or**
 - 1st order differential equations, which are a special case, or
 - Algebraic equations, which are an even more special case, or
 - Assemblies of 2nd order PDEs, also solvable with Comsol
 - Higher order DE's, which can be written as systems on 2nd order DE's

> Why do I bring this up???

- **If you agree with that, then you will also agree that for science and engineering, Comsol MP *is* the Library of Babel!**
- **Somewhere within its enormitude, are world-changing solutions to the great problems of humanity**
 - The past and future of the universe
 - The cures for epidemic diseases
 - The fate of the oceans and atmosphere
 - The sources of energy and how to find, store and use them
 - Everything you have invented or ever will invent!
- **These solution to these problems are sitting on your lap-top right now! ... and instead of solving them, you are listening to me babble about the Library of Babel!**

> ... we are the Monks!

... spending our lives peeking at solutions to see if any of them spell out something important, like “**Oh time thy pyramids**”.

It's like trying to train a cat to jump through hoops!



> Lessons from the Library

- **The thing you have to watch out for is the vast number of solutions with 1 error, with 2 errors, with incorrect boundary conditions, with the equations all backwards, etc...**
- **One of the themes from the Library of Babel is that a library that contains all possible information can be just as problematic as a library that contains no information at all.**
- **The library has many job openings for:**
 - Explorers
 - Cataloguers
 - And very, very patient monks!