Lightweighting

Example 1
by AnnMarie Thomas, Stefanie Koehler, & Shannon Rahkola (2011)

Comments:

Brainstorm Whole System Map: Stef, Shannon, & AnnMarie, very good job. Once again, the color-coding is good. It's less clear this time than it was the first time, though, because you're breaking down the physical parts of the chair and it's sometimes hard to tell the difference between those colors and the colors for other lifecycle stages; you could fix this by having very different palettes for the two sets of colors. (e.g. all blue/green tones for some, all orange/yellow tones for the other, or something.) A bunch of the ideas weren't about materials reduction per se, but about material substitutions (which we'll do later). Remember, even though you don't want brainstorm to squash ideas, you do want to stay on topic, steering whatever ideas into something about the problem at hand (here lightweighting.) But you did have a bunch of good ideas. Using a web net instead of the foam, Aeron-style; the rods and cable structure; the idea of a middle support determined by lines of force. Those're solid stuff. You could've even busted out and gotten a bit crazier. The hanging chair was a good wilder one.

The sketches you included with the brainstorm were great! Interestingly, one of them looks like a very novel folding design for the chair, which would let it be more efficient in transportation but still not require the effort of assembly by the user.

Final Recommendations: Excellent that you did a CAD model of the chair! It's a little unfortunate that the winning design was a materials substitution rather than a reduction of material. But once you chose your finalists, it was of course exactly right that you chose the winner by which one reduced eco-impacts the most. And it was good that you restated your business goal from your design brief, to keep your eye on the ball. I couldn't tell from this presentation what the biggest eco-impact components were, but seem to recall them being the plywood and foam from earlier analyses.

The presentation was great overall. Great that you got a better image of the chair, it looks much better. There was one serious typo ("LCAs are chosed") and a couple smaller ones (like "it's" instead of "its"), but the layout and design was great.
1. Get rid of all metal fastener in the frame and replace with slotting/dovetails/etc.
2. Get rid of the staples and instead design a way that the fabric can be tucked in and fastened by the frame.
3. Get rid of the wooden frame and replace it with an inflatable frame.
4. Get rid of the plywood frame and use bamboo instead.
5. Get rid of the foam and use inflatable cushions.
6. Three legged chair design.
7. Stools instead of chairs- no back needed.
8. Floor cushions- no frame needed.
9. Do a force analysis and see if we can remove unnecessary/overengineered elements from the frame, or reduce the size of any of the wooden pieces.
10. Replace the frame with hollow metal (aluminum?) frame.
11. Hanging chair-replace frame with a seat/backrest and hang it instead of having it stand on its own.
13. One back shared by two chairs (back to back).
14. A recycled composite material (100% recycled High Density Polyethylene-#2 can be recycled) rail held by two screws to hold fabric down.
15. Interior frame and chair legs made from recycled 100% recycled paper product to mimic look and feel of maple. (http://www.richlite.com/countertop/media/Combined%20Richlite%20Sustainability%20Brochure.pdf)
16. Use only fabric that can be composited: cotton, hemp, tencel, bamboo, or wool. Sourced and produced sustainably. Use only natural dying, metal free chemical dying, minimizing effluents and good water management systems.
17. No staples or screws used throughout. Frame is puzzle pieced together (similar to AnnMarie’s "sketch chair" concept. Foam for cusioning made with natural, organic, latex rubber. Can be composited. Fabric is slipcovered over. Customer puts chair together. (keeps similar look and feel of current chair)
18. The chair is made of sea grass woven around a recycled paper product created to mimic the look and strength of wood.
19. A felt frame made from recycled PET bottles that becomes S-shaped. To replace the plywood frame and metal legs weighs less can be recycled.
20. One circular seat that fits up to four. Tubular center (trunk) shared by users of chair as the chair back.
21. Use tension to hold the cushion and fabric tight to the chair frame - no staples or adhesives.
22. Design the fabric to be removable for easy cleaning, customized designs, customized materials depending on use (ie. fabric that repels dog hair, etc) - increased lifetime.
23. Include instructions for caring for the upholstery or even a "approved (low-impact) fabric cleaner"
24. Make the body frame and legs into one piece - not requiring the legs to be attached separately.
25. Use a laminated plastic 'honeycomb' sheet instead of plywood.
26. Use a biocomposite (soy plastic material) that can be injection molded into create an 'airy' frame.
27. Build a frame of thin metal tubes to create a frame structure of trusses and crossbars.
28. Create a network of springy materials as the cushion rather than PU foam.
29. Make a collapsible frame, removable cushions, and removable seat covers - the chair can be assembled by the distribution outlets or by the consumer.
30. Make an elastic web net as the cushion rather than the foam.
31. Create a cushion with multiple sections so that one can be replaced if it gets damaged - rather than replacing the whole cushion.
32. Use a fabric that repels water while being soft, similar to leaves with tiny 'hairs' on it that can repel water.
33. Create a 'hollow' frame of the rectangular form that can work like an accordion allowing the user to change the shape of the chair from convex to concave or straight.
34. Create a folded paper interior frame.
35. Use a series of rods and cables to construct the frame, held together with tension.
36. Follow 'lines of force' to increase support in the middle of the chair while reducing the support (and materials) on the sides.
37. Cut long 'natural' curved holes in wood frame to reduce the weight of the plywood frame.
Steelcase :: Modular Seating
Individual LCAs as performed through Sustainable Minds

LCAs are chosen from brainstorm ideas and narrowed down by ideas that best fit the business objective.

Business Objective:
To lessen the environmental impact of the chair through better material choice and product design, while not increasing its cost for either the manufacturing nor the consumer.

Top concept scenario:
The top concept scenario was chosen based on the biggest improvement as compared to the baseline LCA. The concepts will be explored through sketches and descriptions of the winning design and the reasoning behind the winning choice as it pertains to the business objective.

<table>
<thead>
<tr>
<th>Chair LCA Concept Scenarios</th>
<th>TRACI Points</th>
<th>Carbon Footprint</th>
<th>Sustainable Minds Scorecard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1.0x10^3 mPts/func unit</td>
<td>93 CO2 eq. kg/func. unit</td>
<td>baseline</td>
</tr>
<tr>
<td>Get rid of all metal fasteners in the frame and replace with slotting/dovetails/etc. Get rid of the staples and design a way that fabric can be tucked in and fastened by the frame.</td>
<td>950 mPts/func unit</td>
<td>92 CO2 eq. kg/func. unit</td>
<td>7.4% performance improvement</td>
</tr>
<tr>
<td>Interior frame and chair legs made from recycled paper product to mimic look of wood.</td>
<td>890 mPts/func unit</td>
<td>93 CO2 eq. kg/func. unit</td>
<td>13% performance improvement</td>
</tr>
<tr>
<td>Interior frame is made from “lightweight” metal tubes (using trusses rather than the current plywood frame. Changed frame material to secondary aluminum and recycled at end of life.</td>
<td>930 mPts/func unit</td>
<td>85 CO2 eq. kg/func. unit</td>
<td>9.3% performance improvement</td>
</tr>
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Winning Design

We have chosen to go with a design where the wooden plywood frame that forms the skeleton of the chair is replaced with material made from 100% recycled paper product.

As was viewed on the previous page, the LCA chart depicts that all three of our concept ideas that were settled on from our brainstorm list, resulted in a performance improvement. However, since we had to choose one “winner” at this stage we decided on the recycled paperboard frame as it had the lowest number of TRACI points. This concept would require minimal redesign of the manufacturing process as it would require the replacement of only one material, and thus should entail only minimal assembly line and tooling changes. This integration into the current manufacturing plant’s capabilities, makes it a more desirable choice economically and environmentally.

We have chosen to go with a design where the wooden plywood frame that forms the skeleton of the chair is replaced with material made from 100% recycled paper product. This product mimics the look and strength of the current wood material. It gives the visual look of maple. This material lightens the impacts on the environment over the wood products being used in the current chair design featured by Steelcase. By simply changing out one material for another with little change in the manufacturing process or the look and feel of the current design, we found a 13% overall performance improvement.

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<th>TRACi Points</th>
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<tr>
<td>860 mPts per total life</td>
<td>Total=93 CO2 eq. kg/func unit</td>
<td><strong>13% improvement</strong></td>
</tr>
</tbody>
</table>

A. Exterior chair resembles current design
B. Interior frame material redesign-product chosen is a paperboard based on the following material change benefits:
   - 100% Post Consumer Waste Paper
   - FSC certified
   - Contributes to LEED points
   - Uses an innovative and efficient WE™ (Waste-to-Energy) manufacturing system that captures toxins and re-circulates heat to greatly minimize fuel consumption, pollution and carbon emissions.
C. Leg will mimic the look of maple
D. Richlite [http://www.richlite.com](http://www.richlite.com)