Sustainable Reflective Aluminum

Solar Lighting System

Sustainability Project Sponsored by ALCOA

EDSGN 100, Section 010, Team #1

Submission Date- 12/9/2013

FIG. 1. Group Picture

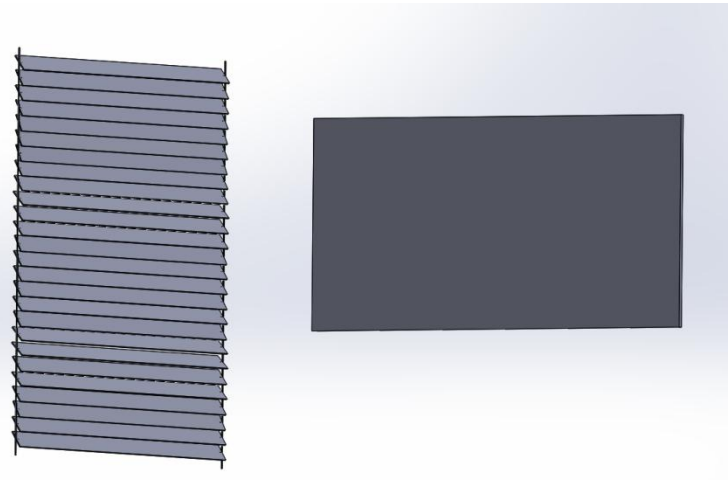

FIG. 2. Solidworks Model of Prototype

Submitted by: Nublan Abd, Thomas Rominski, Jake Covell, and Rob Smith

Submitted to: Professor Xinli Wu and ALCOA

http://personal.psu.edu/txr5116/edsgn100_fall13_section10_team1_dp2.pdf

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Abstract

This design report covers the entire process that Team 1 went through in order to imagine, design, then create and present our version of the ideal reflective blind system. Our report contains everything from project schedule, and initial brainstormed-ideas, to final design, prototype pictures, efficiency, and cost-benefit analysis.

Introduction

This semester (Fall 2013), all EDSGN 100 classes were assigned a second engineering design project, which focused on the sustainability of aluminum. Thanks in advance to the ALCOA Company for sponsoring this project! The purpose of this project was to identify opportunities across the campus to take advantage of aluminum's intrinsic properties for the purpose of increasing the efficiency or sustainability of products and product systems. Through brainstorming and use of the design process, the team created a reflective aluminum blind system which also includes an aluminum-covered ceiling reflector. The main idea of the system is that the blinds reflect sunlight from outside at an angle towards the ceiling. The ceiling component consists of reflective ceiling tiles that, subsequently, reflect light downward, similar to ceiling lights. The key advantage of this system is that it would create a more efficient way of lighting various types of rooms in Penn State.

Description of Design Tasks

Problem Statement:

The problem is that natural sunlight that shines through windows is not currently being utilized as efficiently as it could be to minimize the amount of electricity that is required for ambient light in rooms.

Mission Statement:

The mission is to provide a product, which will reduce the amount of electricity a room requires for artificial lighting, by redirecting sunlight to create more ambient light.

Design Specification:

- The window blinds should be easy to install.
- The window blinds should be easy to operate.
- The window blinds should be user-friendly.
- The cost of the reflective blind system should not exceed $100.
- The return on investment period should not exceed 3 years.

Design Process/Approach

Gant Chart

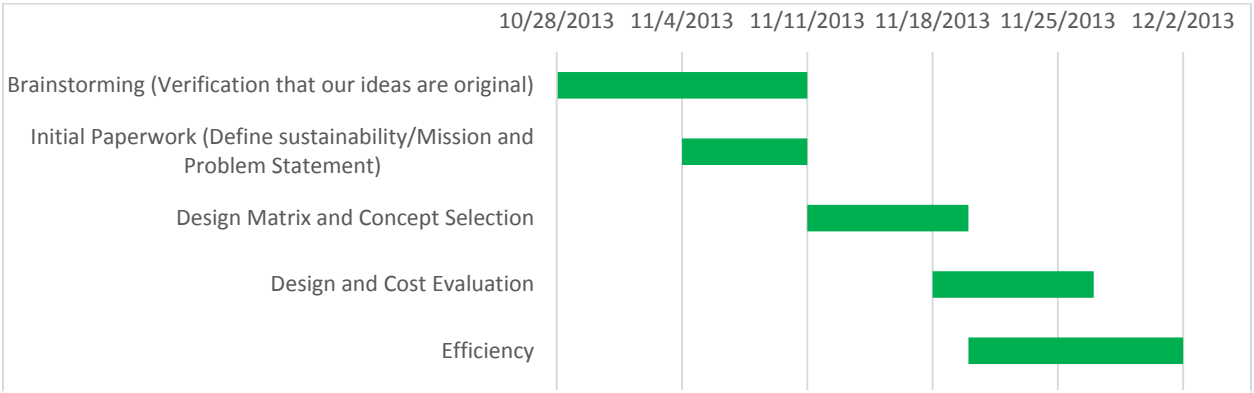

Table 1. Gantt-chart (project management)

Concept Generation

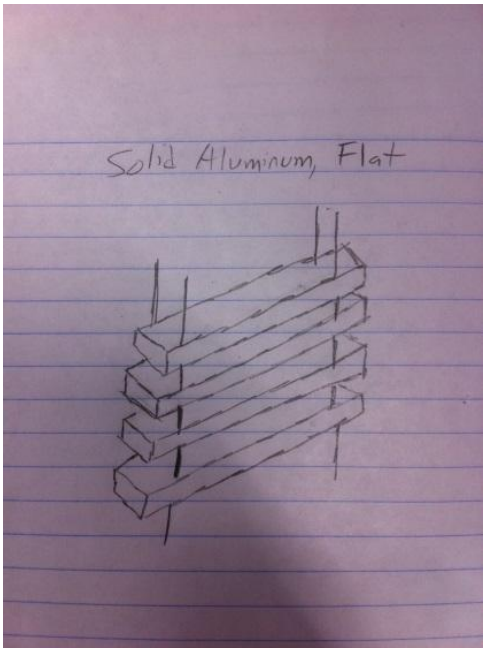

FIG. 3. Solid Aluminum Flat Model

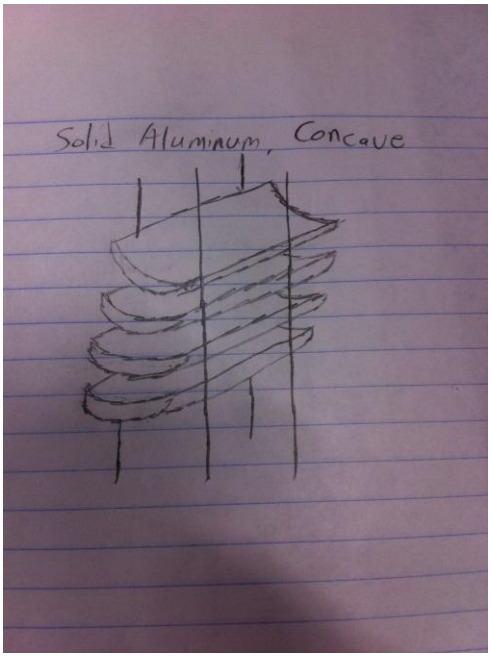

FIG. 4. Solid Aluminum Concave Model

Solid Aluminum Flat/Concave

The original idea was a set of blinds in which each individual slat would be made of solid aluminum. With solid Aluminum the deterioration of the blinds and their effectiveness would be minimal. Although this was a factor, which would increase the life of our blinds, the cost-effectiveness proved this to be not as efficient as our other ideas. The other aspect to the blinds was the shape of the blinds themselves. Both concave and flat blinds were considered in design approach but in conclusion, flat blinds proved to be the most efficient in dispersing sunlight.

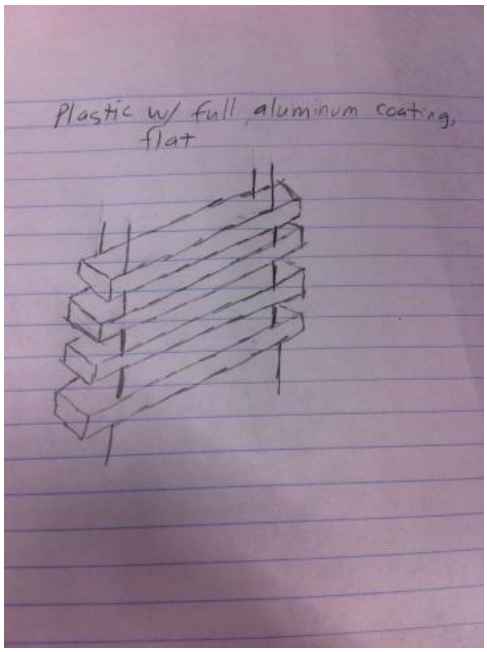

FIG. 5. Full Aluminum Coating Flat

Full Aluminum Coating Flat

Very similar to the Plastic with Aluminum coating, this design differed only in the aspect that both sides of each blind would be covered with the aluminum coating. It was originally thought to be the best design because it would help remove the small bit of durability that would be lost when using an aluminum coating on the plastic blind instead of solid aluminum. This was because the blinds could be flipped if one side of the blinds had deteriorated. With the research that the team accumulated, it was obvious once again that the durability of the

coating was very strong and that coating both sides of the blind would be a misuse of budget.

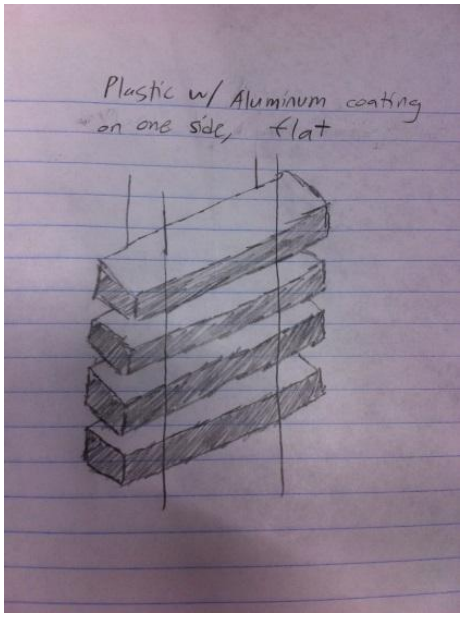

FIG. 6. Plastic w/ Aluminum Coating Flat Model

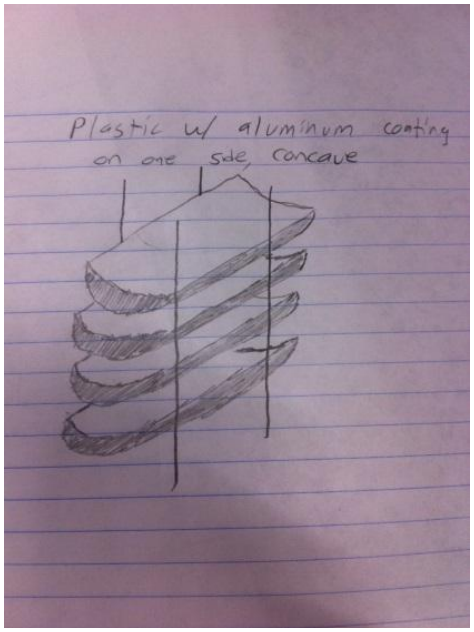

FIG. 7. Plastic w/ Aluminum Coating Concave Model

Plastic with Aluminum Coating Flat/Concave

Through our selection process, it was determined that developing a blind made of plastic with an aluminum coating instead of a solid aluminum blind would remarkably cut prices remarkably. Although the price itself was much less for the coated blinds, a small bit of durability was lost. After extensive research on the durability of the cover for the types of aluminum coating, it was determined that it was the durability which would be lost was very insignificant, reassuring the initial thoughts that the aluminum coating would be much more cost-efficient. Only coating one side of each of the blinds would once again be much more economical than coating both sides of the blinds. When comparing the two shapes, the same conclusion was found. Flat blinds would disperse sunlight more adequately than concave blinds.

Design Selection Matrix

Blind type Criteria selection	Solid aluminum flat	Solid aluminum concave	Plastic with aluminum coating on one side, flat	Plastic with aluminum coating on one side, concave	Full aluminum coating flat
Light Dispersion	+1	-1	+1	-1	+1
Cost	-1	-1	+1	+1	-1
Durability	+1	+1	-1	-1	+1
Pivoting	+1	-1	+1	-1	-1
Compact Folding	+1	-1	+1	-1	+1
Installation	-1	-1	+1	+1	-1
∑ points	2	-4	**4**	-2	0

Table 2. Design Selection Matrix

Best Design Selected: Plastic with Aluminum Coating Flat

This model was selected for its cost-efficient efficient design, strong durability, and its sunlight dispersion efficiency. Plastic blinds with an aluminum coating were much less expensive than the other option, which was solid aluminum blinds. Flat blinds proved to be much more effective in dispersing sunlight than the other option which was concave blinds. Coating only one side of each blind proved to be much more economical than coating both sides. Lastly, coating plastic blinds in aluminum as opposed to using solid aluminum blinds demonstrated minimal differences in durability and strength.

Final Design/Prototype

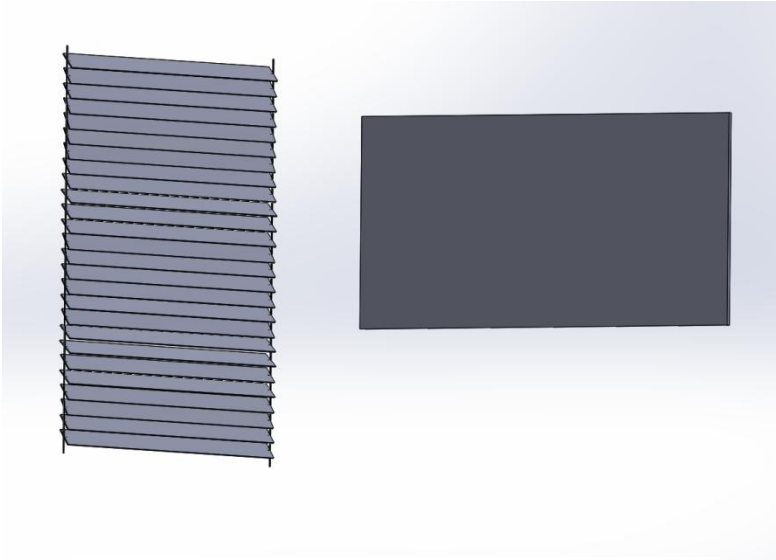

FIG. 8. Solidworks Model of Final Design

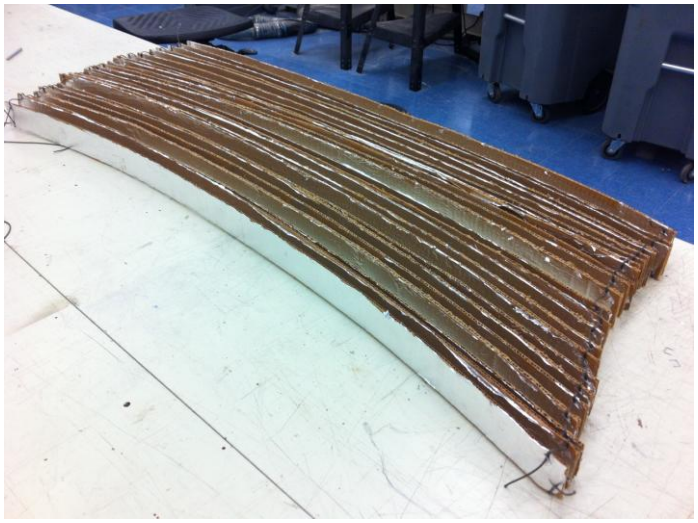

FIG. 9. Image of Assembled Prototype

FIG. 10. Image of Prototype
(shows reflective side)

Final prototype scale is approximately 1:1

Design Features/ Operation

The final design of team one's blind system is comprised of flat plastic blinds that are coated with a thin layer of reflective aluminum. Another significant part of the design is the aluminum coated ceiling tile which plays a huge role in the operation of the system. Basically, the system works by reflecting sunlight from outside off of the side of the blind which is coated with the reflective aluminum. The sunlight is then reflected into the room at an upward angle towards the ceiling. The reflective aluminum ceiling tiles then redirect and disperse the light downward, just as artificial ceiling lights do in most rooms. An important feature that team one focused on while brainstorming ideas was easy installation and operation. This was accomplished, as the reflective blind system operates the same way most blind systems do. This is beneficial as it would not be confusing for users because much of the public is already familiar with adjusting the average blinds. The main difference is the reflective surface of the one side, as well as the ceiling tile which is necessary for the system to be fully operational. One last feature that is worth noting is the fact that users could also use the blinds in the opposite way. By angling the reflective surface towards the outside, they could affectively darken a room by bouncing sunlight away from the window. Similar to the reflective windshield covers people put in their cars, this system could also serve the purpose of preventing a room from overheating in higher temperature seasons.

Analysis

Definition of Sustainability

Sustainability: the efficient use and re-use of natural resources in ways that minimize negative effects and impacts on the environment.

Rationale for Selection

The team decided that the implementation of a device to reflect sunlight into rooms would reduce the need for artificial lighting during times of the day when there was abundant sunlight. The reflective ceiling tiles facilitate light dispersion throughout a section of the room.

Equipment/Installation/Maintenance Cost Estimate/Analysis

At retail prices, the cost of one set of blinds and one ceiling tile totals roughly $200. However, on a mass production scale, this cost would be reduced significantly. Installation could be performed by in-house maintenance crews, thus reducing installation cost to effectively nothing. Maintenance cost for the product should be minimal as well, due to the fact that it is not implemented in a particularly high-wear environment.

Assessment of Efficiency Advantages

One set of window blinds has about 1.5 square meters of reflective surface. On very sunny days, sunlight reaches Earth's surface with the power of about 445 Watts per square meter. Therefore, the blinds reflect about 686 Watts of sunlight, which equates to a luminous intensity of just over 11,740 lumens, which takes into account the 95% reflectivity of the aluminum. The fluorescent tube light bulbs in the Hammond building consume 32 Watts and generate about 3,000

lumens. It can be concluded that one set of blinds is equivalent to about four Hammond light bulbs. The cost of electricity in State College is about 7 cents per kilowatt-hour. If the reflective blinds were used for an average of two hours per day in place of the fluorescent lights for an entire year, about $100 would be saved. If the production cost of the blinds could be reduced to $100, one set of blinds would have a return on investment in just one year.

Implementation Plans

The reflective aluminum coated blinds could be installed on any window on campus that receives ample sunlight for a portion of the day. This design is specific to Hammond Building windows and ceiling tiles, however, they could be constructed with varying dimensions to accommodate different window sizes.

Summary/Conclusions

There were several goals that team one set out to accomplish with the design of a reflective aluminum blind system. Team one wanted to create a sustainable design that would be easy to install, easy to operate, user-friendly, relatively cheap, and worth-buying it in the long-run. Ultimately, team one is proud to say that all goals have been accomplished. The design of the blind system is certainly easy to install. The system can be installed in the same way traditional blind systems are installed. The reflective blind system is also easy to operate and user-friendly. As explained earlier in the report, since the blind system works in the same way most current blinds work, the public would already be familiar with its operation. Lastly, all of these important features were designed within a reasonable budget. Although the initial cost of the blinds might be more than the average set that consumers would buy, the report's cost analysis described how the blinds would be worth it in the long run. Consumers could consider the blinds as an investment that would pay itself off in the next year or so, and then begin creating additional savings for the consumer.

References

"Anolux Miro IV." Anomet. N.p., 2013. Web. 7 Dec. 2013.

"Lumen (unit)." Wikipedia. Wikimedia Foundation, 4 Oct. 2013. Web. 07 Dec. 2013.