Retractable Pool Cover

By:
Abdulhadi Alkhaldi, Zachary Keller, Cody Maurice,
Bradley Miller, and Patrick Weber
Team 12

Midpoint Review
Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design II – Spring 2016

Department of Mechanical Engineering
Northern Arizona University
Flagstaff, AZ 86011

Introduction

Our client, Mr. Brian Herzog, is a retired engineer who had his new house recently built in Flagstaff, AZ. He stated that he was looking for a pool cover that is rigid, automated, and strong enough to hold multiple people's weight. Unfortunately, he did not find a pool cover that is affordable on the market and satisfied his needs. He decided to hire mechanical engineering students at Northern Arizona University to design a pool cover that is stable and automated. Also, he would like to develop a business plan for the pool cover that will be designed by the team, in case we accomplish the project successfully. As a result, our goal for this project is to design and manufacture a retractable pool cover system which is: automated, easily maintained and installed, rigid, lightweight, and customizable to be aesthetically pleasing based on customer interests.

The team has submitted a proposal in Fall 2015 that illustrates the design of the retractable pool cover and all the components needed to build such pool cover. The team decided to use a vertical stacking system that is composed of plates, wheels, a motor, rails, hinges, and a pulley system. The plates are used to cover the pool area and should withstand the weight of the people standing on it. The wheels are used to let the plates slide smoothly through the rails during opening and closing of the pool cover. The hinges are used to connect the plates together and allow them to stack vertically when open. The force required to pull and push the plates is applied using a motor via the pulley system. This is the basic idea of the design, when the plates are fully extended, the pool is fully covered and the force exerted by the motor will stack the plates for either opening or closing.

The team has started building the pool cover and has encountered more difficulties than the expected. The purpose of this report is to mention the problems that the team faced during building and the estimated solutions to such problems. Each section of this report explains the parts needed of the design and addressing if there is any problem associate with the part.

Frame Design

The final completed pool cover will consist of fourteen plates hinged together. Each plate needs to have a strong frame in order to support the weight of multiple people. Each plate is one foot wide and seven feet long, and in order to maximize the strength the team came up with a blading design made out of aluminum seen in the figure below.

Figure 1: Aluminum Blading Frame

One inch wide by one eighth inch thick aluminum blading was used to build our first frame, and the welding was done in the machine shop on campus. The problem with using aluminum blading was that it did not have nearly enough strength and rigidity to hold its form under weight. The blading would bend under a small force when it was supported at the four corners. In order to increase the strength of our frame, we redesigned each plate with square aluminum tubing that was one inch by one inch and has a wall thickness of one eighth inch and can be seen in the figure below.

Figure 2: Square Aluminum Tubing Frame

The completed square tubing frame in Figure 2 was welded at the machine shop using three long seven foot sections of tubing supported with five one foot long sections of square tubing welded along the length. The material is high quality from Industrial Metal Supply in Phoenix, and the weight of the overall pool cover will be kept to a minimum while maintaining its strength using the tubing instead of solid square aluminum. In order to insure the safety factor of our frame, we ran a SolidWorks simulation for loading under 200 lbs which can be seen in Figure 3 below.

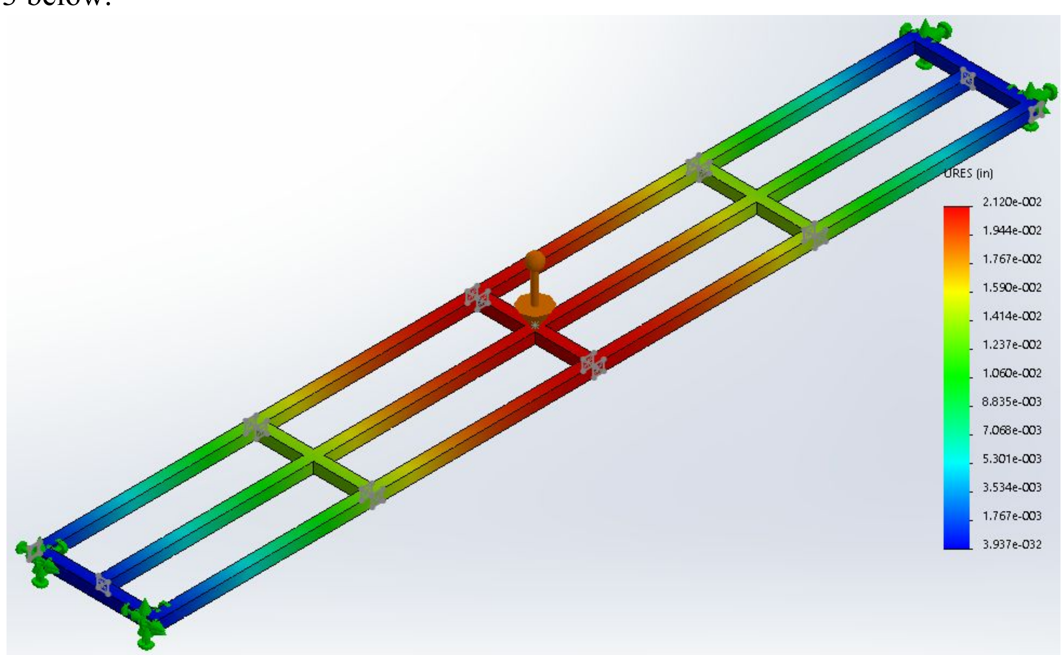

Figure 3: SolidWorks Loading Simulation Results

From Figure 3, the maximum displacement of 0.212 inches happens at the center of the frame under a 200lb load. The resulting frame is considered safe enough to withstand the weight of multiple people, especially when the fourteen plates are finished and attached to each other. Having multiple frames which can withstand 200lb with minimal displacement will insure that the finished pool cover will be rigid enough for people to walk on.

Panel Design

Each plate of the pool cover consists of the frame and a panel. Each panel is a thin sheet of perforated aluminum, that will attach to the top of the frame, as seen below in Figure 4. All fourteen plates will have an attached panel. Originally, the team talked to Mr. Herzog and he stated that he wants the panels solid. He wants a solid cover because without that, moisture will start to appear on the walls of his pool house. We discussed with him the benefits of using perforated aluminum sheets over solid aluminum because they are lighter and slightly less expensive. He agreed that we can use perforated aluminum sheets, but would like a vinyl hardwood placed on top of the plates, in order for the pool cover to match his decor and avoid excessive moisture on the walls.

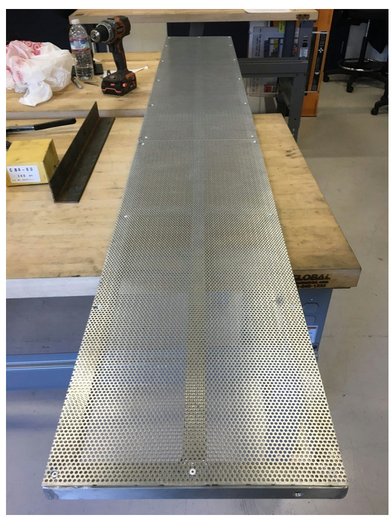

Figure 4: Perforated Aluminum Panels

To attach the panels to the frame we started out using corner brackets and riveting them into the frame. The team successfully riveted down the panel with one corner bracket; the other corners were more difficult because the brackets did not seem to pop. After some careful thought and looking for solutions, we decided to just use ⅛ inch rivets on the top outside of the frame to attach the panel. The rivets were placed about ten inches apart, and the panel is secured to the frame completing the plate design.

Hinges

The team is currently using spring loaded hinges to attach to plates together as shown below in Figure 5. Spring loaded hinges were chosen over regular hinges because when the plates are completely flat, there needs to be an initial buckle to start vertical stacking. The spring loaded hinges offer that buckle when a small pull force is applied to the horizontal plates. One big issue with the hinges was attaching them to the frame. The team used rivet nuts with screws to secure the hinges in. The problem with this is that many of the rivet nuts did not pop and after breaking many screws, we got them all to pop, but most of them are somewhat loose. The hinges need to be secured tightly to the frame so everything stays straight. In order to fix this problem we will look into two different options: using locktite with the rivet nuts or look for aluminum spring loaded hinges with the same strength in order to weld them to the frame.

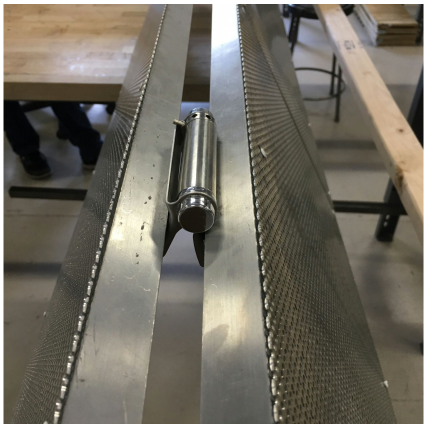

Figure 5: Spring Loaded Hinges in Action

The biggest issue that occurred with these hinges is that with a small force atop the plates, they will buckle inward causing unsafeness if people stand or walk on it. This buckling problem we have is shown below in Figure 6. The buckling problem and how we plan to fix this is discussed more in the "Next Steps" section.

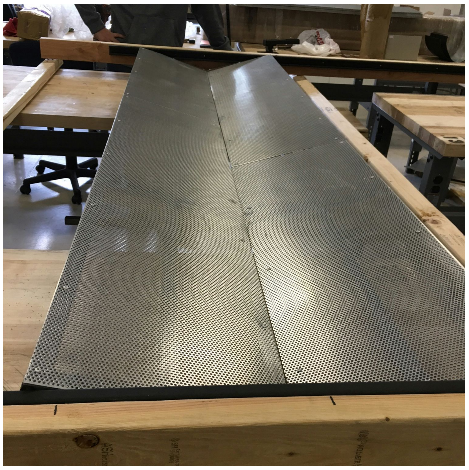

Figure 6: Buckling of the Plates

Rails & Wheels

The prototype we are currently working with has steel rails in the C shape, as you can see in the figure below, attached to a wooden frame. We are having problems with the wooden frame because of the warping of the wood. To fix this problem we are in the process of constructing an all metal frame to attach the rails to. Another problem that arose when attaching rails to the frame was the lack of pre-existing holes in the rail. New holes had to be drilled and they were not chamfered, so the screw heads did not sit flush in the rails, causing snagging problems.

In addition to the new frame, there are modifications that need to be made to the existing rail. We are experiencing a buckling problem as discussed above. This will be combated by adding four wheels to each plate instead of two. This modification means that the side of the frames that fold in the vertical direction will have wheels. This is a problem with the existing rails because they are closed. There are two courses of action, take the top off of the existing rails, or look at purchasing new grooved rails that do not have a top on them. The new grooved rails would have holes already tapped, and are made of stainless steel. The grooved rails solve our current problems and are a viable option.

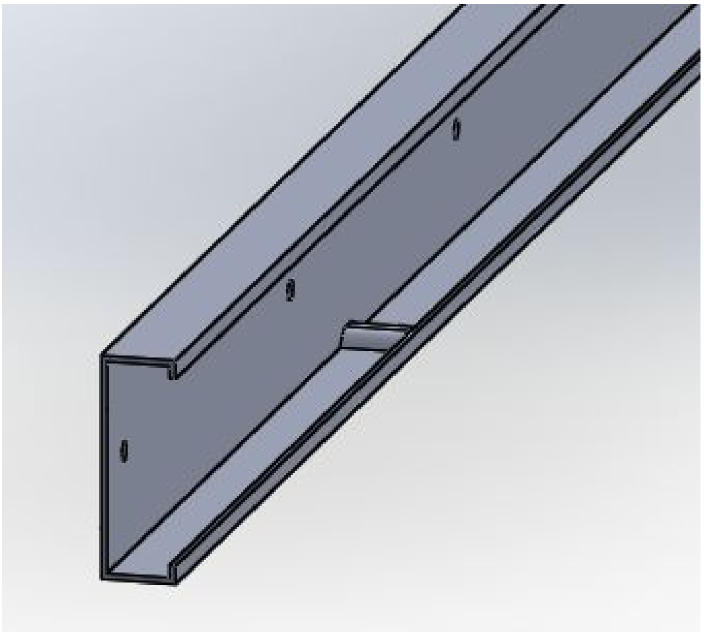

Figure 7: Railing CAD Drawing

The wheels currently being used are a stainless steel roller bearing wheel with a threaded stud. These wheels are attached to the frame using a threaded standoff. This allows us to adjust the length of the wheels, allowing for tolerances on the distancing of the rails. These wheels are currently working very well. However, if a change is made to new rails the wheels may also have to be replaced.

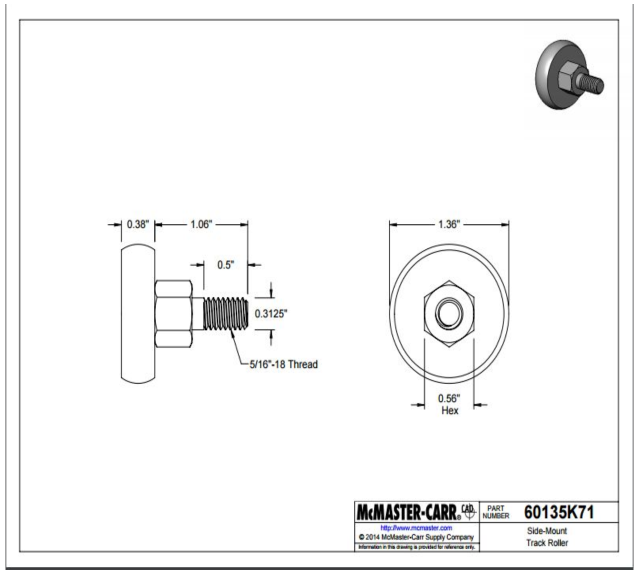

Figure 8: Wheels CAD Drawing

Next Steps

The next step for our team is to fix the problem we are having with the plates buckling. Once the plates have been inserted into the rails they do stay in the horizontal position that we are looking for. However, once any pressure is added to the plates they immediately collapse in on each other, breaking the horizontal position. This is a major problem as when they are in this position they would be completely unsafe to walk on as well as dangerous if someone was standing on them when the buckling occurs. In order to combat this problem, we are going to add an additional two wheels to each plate. Not only will this fix our stability problem, it will also place less stress on each of the wheels. However, this solution comes with its own problems.

In order for the plates to still stack and fold vertically, a new railing system needs to be determined. We are currently planning on getting railing similar to a "C" but without the top loop. This will allow for these additional wheels to move vertically. We will also make the base of the railing, where the wheels sit, wider to allow for a reduced risk of them coming off of the rails.

After this situation has been handled, our next step is to start constructing the housing that the folded plates will reside in. Additionally, we will need to determine what motor to obtain for the functionality of the cover and how to enable the retraction and deployment of the pulley system.

Conclusion

Currently, our design is nearly working how we designed it to. The spring loaded hinges allow the plates to begin folding once any force is pushed about its cross section. The plates sit within the rails correctly and flat under their own weight. Once the buckling problem has been addressed and fixed these should be able to withstand the weight that we have designed them for. Afterwards, an additional twelve plates will be crafted in the same fashion as to cover the entire area of the pool. The pairs of plates will be connected with linkages that will allow them to be retracted and deployed. While the plates are being constructed, the group will work on manufacturing the housing for the plates and develop the system that will move the cover.