Retractable Pool Cover

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

Concept Generation and Selection
Document

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Department of Mechanical Engineering
Northern Arizona University
Flagstaff, AZ 86011

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1. Introduction

Our client, Mr. Brian Herzog, has hired us to build a retractable pool cover for his indoor pool here in Flagstaff, Arizona. The problem with existing pool covers is that there are very few that are rigid and support the weight of multiple people when extended over the pool. The pool covers that are, are found in the market for at least $50,000. Mr. Herzog is looking for our team to design a pool cover to go over his in-ground infinity pool and wants the pool cover design to be rigid, automated, and able to support the weight of multiple people. The cost of the pool cover needs to be kept as far under $50,000 as possible in order for Mr. Herzog to develop a business plan and bring this product to the market, if the design is successful. The project has been progressing as expected with the project plan, and the next step in the design process is to come up with the conceptual designs for the pool cover and evaluate those concepts for a final design based off different criteria.

2. Functional Diagram

In order to come up with different concepts for the pool cover design, our team first had to make a functional diagram to understand the different operations that will occur with the automated pool cover. The basic operation for the automated pool cover is shown in the functional diagram below.

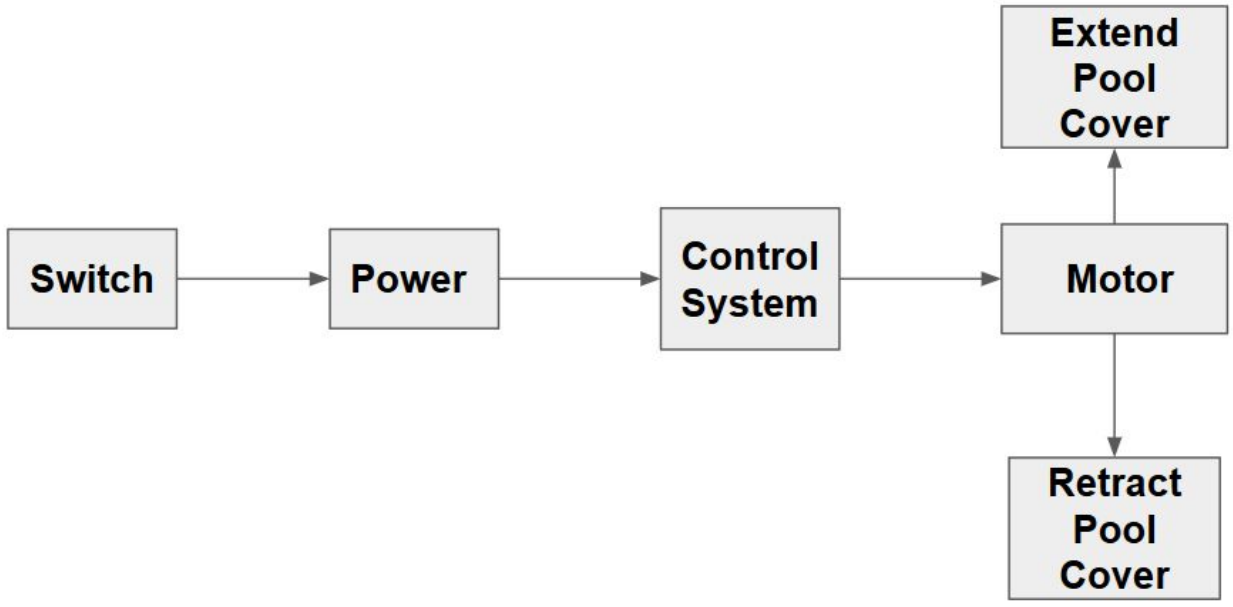

Figure 1: *Functional diagram for automated pool cover.*

Each box represents a different functionality for the pool cover design; it is a useful tool when coming up with different conceptual designs. The main functionalities that the team focused on for the project design are the switch, the power, the control system, and the motor. Another design aspect that the team had to focus on was the housing for the pool cover because there is a maximum volume that our design is constrained to. The next task that our team focused on was the criteria for each functionality which is important in evaluating the different conceptual designs.

3. Criteria

Our team came up with different criteria in order to evaluate the different designs for the motor, the design for the pool cover itself, the control system, and the materials used in building the pool cover.

For the motor, the team came up with the following criteria:

- Power output
- Safety
- Price
- Lifespan
- Manufacturability

The power output of the motor that goes into the final design has to be enough to extend and retract the pool cover. The pool cover itself will be exposed to a large amount of water and the motor will be within close vicinity of the pool. There will have to be a properly enclosed housing unit that is safe enough to not have any electrical problems or cause injury. The price of the motor must be reasonable to stay under the total budget of $50,000 that Mr. Herzog set out for our team. With the goal being to take the design to market after it is completed, both ease of manufacturability and lifespan need to be optimized for mass scale production and long term usage.

For the design for the pool cover, the team came up with these following criteria:

- Volume
- Ease of retraction
- Maintainability
- Manufacturability

The pool cover must fit within the space at the end of Mr. Herzog's infinity pool, and the cover has to easily retract and extend to be used with the motor that the team chooses. The pool cover will ideally have minimal maintenance required, and if a problem occurs it should be easy to access the pool cover and remove it for inspection. The manufacturability for the final design is important because of the mass scale production for selling the product to consumers.

The team came up with these following criteria for the control system:

- Response time
- Ease of use

The control system will be what the user operates to extend and retract the pool cover. Mr. Herzog gave our team a requirement that the cover must extend or retract within 1 minute. The controls must also be simple enough for anyone to operate the pool cover.

In order to evaluate the materials for building the final design of the pool cover, the team came up with the following criteria:

- Price
- Water resistance
- Yield strength

The price of the material is important because there will be a large amount of material used for the pool cover. The material chosen has to have a high water resistance and be

non-corrosive, because the pool water is filled with chemicals that will cause corrosion in certain metals. In order to support the weight of multiple people, the material will have to have a high enough yield strength in order to resist bending or deformation.

4. Concept Generation

Our team brainstormed different concepts for each functionality and then evaluated them further in the report using decision matrices.

Motor

For the motor, our team decided to either use an electric motor or a hydraulic motor to power the extension and retraction of the pool cover. Either choice will have enough torque to rotate the pool cover out on the guide tracks to cover the pool. The main differences between the two choices are the price and safety criteria that our team chose to evaluate them with. The two choices are evaluated further on in the decision matrix section of the report.

Pool Cover Design

The team came up with four different conceptual designs for the pool cover which include stacking, rolling, garage door, and a meet in the middle design. The stacking design is an idea that includes different sized slabs that stack back and forth on top of each other inside the housing unit, and when extended, they each unstack and unroll out to cover the pool in one solid piece. The rolling design consists of having the pool cover be able to roll up into the housing unit, and that will be a challenge if the material used is metal because the volume that the housing can take up is more rectangular than square, and having metal roll up will turn out more square than rectangular. The garage door idea involves using a garage door motor with a pool cover that will be built into a sliding area on the side of the pool, but building this design will require additional construction around the pool area to hold the pool cover as one unit. Having a meet in the middle design will require two motors with housing units at each end of the pool, essentially cutting the volumes for each housing unit in half.

Control System

For the pool cover to retract and extend, it needs a control system telling it to either open or close. Our designs that we came up with include a key start, a remote start, a button/switch, or a lever start. The key start is connected directly to the motor and could be installed near the pool on the side of the wall and works with a key that will either turn the motor on and extend in one direction or retract in the other. The remote start will be more challenging to design electrically, but will allow the user to turn the automated pool cover on and off from anywhere within the pool house. The button/switch idea will be a simple on or off button/switch on the wall near the pool that controls the pool cover that way. Building the lever design will be challenging as well because it will operate based off the user pushing it up and extending or pulling it back and retracting.

Materials

The materials chosen for the final design will be what the pool cover is made out of. Our choices for materials that we came up with include stainless steel, aluminum, brass, some sort of

polymer, and fiberglass. The criteria used in evaluating the materials and the final choice for the pool cover can be found further in the decision matrix. The main two criteria that have to be met for the material choice are the water resistance and the yield strength.

5. Decision Matrices

Our team developed four decision matrices for each component of our design based on the criteria chosen. The criteria for each component was scored and given a weight which is shown in the column left of the criteria. Each concept is given a number on a 1-10 scale, 1 being the worst and 10 being the best, and the team rated each concept for each component on which best suits that specific criteria. The scaled value and the weight for each criteria for the specific concept is multiplied to get a final weighted score for the criteria. These are all added up to get a final score for the concept; the highest scored concept for each component is chosen as best suitable for our design based on the decision matrices. Tables 1-4 show the decision matrix for the motor, pool cover design, control system, and material, respectively.

Table 1: *Decision matrix for motor.*

Motor					
		Electric		**Hydraulic**	
Criteria	Weight	Scale	Weighted Scale	Scale	Weighted Scale
Power output	0.245	10	2.45	10	2.45
Safety	0.4118	4	1.647	8	3.294
Price	0.1015	7	0.711	6	0.609
Lifespan	0.1128	7	0.79	7	0.79
Manufacturability	0.1289	8	1.031	8	1.031
Sum	**1.0**	**36**	**6.629**	**39**	**8.174**

Table 2: *Decision matrix for pool cover design.*

Design									
		Stacking		**Rolling**		**Garage Door**		**Meet in Middle**	
Criteria	Weight	Scale	Weighted Scale	Scale	Weighted Scale	Scale	Weighted Scale	Scale	Weighted Scale
Volume	0.3662	7	2.563	7	2.563	9	3.296	4	1.465
Ease of retraction	0.2783	7	1.948	7	1.948	5	1.392	8	2.226
Maintainability	0.2056	9	1.85	8	1.645	7	1.439	6	1.234
Manufacturability	0.1499	9	1.349	7	1.049	6	0.899	4	0.6
Sum	**1.0**	**32**	**7.71**	**29**	**7.205**	**27**	**7.026**	**22**	**5.525**

Table 3: *Decision matrix for control system.*

Control System									
		Key Start		Remote Start		Button/Switch		Lever Start	
Criteria	Weight	Scale	Weighted Scale	Scale	Weighted Scale	Scale	Weighted Scale	Scale	Weighted Scale
Response time	0.5915	10	5.915	9	5.234	9	5.234	9	5.234
Ease of use	0.4085	9	3.677	10	4.085	10	4.085	8	3.268
Sum	**1.0**	**19**	**9.592**	**19**	**9.319**	**19**	**9.319**	**17**	**8.502**

Table 4: *Decision matrix for materials.*

Materials											
		Aluminum		Stainless Steel		Brass		Polymer		Fiberglass	
Criteria	Weight	Scale	Weighted Scale	Scale	Weighted Scale	Scale	Weighted Scale	Scale	Weighted Scale	Scale	Weighted Scale
Price	0.2165	8	1.732	4	0.866	6	1.299	4	0.866	5	1.083
Water resistance	0.2461	8	1.969	9	2.215	7	1.723	9	2.215	10	2.461
Yield strength	0.5374	9	4.837	9	4.837	8	4.299	6	3.224	10	5.374
Sum	**1.0**	**25**	**8.538**	**22**	**7.918**	**21**	**7.321**	**19**	**6.305**	**25**	**8.918**

The best suitable concept for each component is highlighted in yellow in the decision matrices. Based on the criteria, respective weights, and score of the concepts, the best-suited components for our pool cover are: a hydraulic motor, a stacking design, a key start control system, and fiberglass as the material.

6. Updated Project Plan

The full updated project plan can be found in Appendix A. Everything that was laid out initially in the plan has been followed week by week as expected and the progress bars up until week 8 can be seen in different colors. The project plan will continue to be updated week by week with our progress as a team.

7. Conclusions

As a team, criteria was chosen for each component to best represent our client's needs. These criteria were scored and weighted based on which our team thought was more important. For each component, we thought of two to five concepts that could possibly feature in our final pool cover design. These concepts were scored in a decision matrix based on their respective scores and the weighted criteria. According to the decision matrices, the final design will include a hydraulic motor, a stacking design, a key start control system, and fiberglass as the material. These may not be the official concepts that make it into the final design, but this gives us a great start to prototyping and experimenting for which concepts work best together, starting with our

chosen concepts. The project plan has stayed true thus far and our team will update it along the way. The next step is to build a prototype and test whether our design choices will work as intended.

8. Appendix A