Water/Shock Resist Watch Winder

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by

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ABSTRACT

Even smart watches are very popular today, a lot customer still prefer mechanical watches for the beauty of nice mechanism. But the drawback of most automatic mechanical watches is power reserve length, most of them needed to be winded or has to be worn in order to keep the spring loaded, that’s where winders come to place. There are lots of winders on the market, but I always wanted a portable and also durable winder but couldn’t find it on the market. So I decided to build a watch winder that contains all the necessary winding opinions but also contain portability, durability in a reasonable price point.

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PROBLEM STATEMENT.

Automatic mechanical watches need to be worn during daily activities or manually wineded in order to keep running. Most of the ones on the market, including high end market, has less than 48 hours of power reverse. So if the owner left the watch alone for a weekend, it will stop running. That is why watch winders are created, they are able to perform the motion that is able to keep automatic watches running so when owners need to use the watch right away they do not have to worry too much about adjust time, date and other functions.

There are many watch winders on the market these days, but during my recent research I found that there is no tough/durable as well as portable watch winders exists on the market. There are high end watch winders that have very high level security system and armor case but they are huge so they cannot be moved around easily. There are also battery powered watch winders out there, but they are all covered by plastic, leather or wood case, so they cannot survive tough working environment.

So my idea is to build a durable and also portable watch winder that can help people travel with their time pieces to more extreme environment. My target customers are, for example, some divers(because the watches that hold the depth records are all mechanic watches, and mechanic diver watches generally has better water resistance than a lot quartz or electric watches) that travel a lot on small boat that are not as stable as large ship, so they can use my device to help their diving watches wineded up and ready to be worn : or adventurer that travels a lot in tough environment, so they do not have to worry about their watches to run out of power because of winder failure. Even for the general public, it will be nice to have a durable and portable winder so they can worry less about winder problems while traveling and having fun.
My product will have a water/shock resist exterior design as well as redesign some mechanical movements inside the winder to be able to against forces. It will also be able to have the basic/common functions from other portable winders, such as adjustable turns per day and adjustable turn directions.

**BACKGROUND**

How does automatic watch work?

**AUTOMATIC MOVEMENT**

An automatic, or self-winding, movement is a mechanical movement first marketed in the beginning decades of the 20th century. It winds itself while worn on the wrist, eliminating the need for daily hand winding. However, if not worn for some time, the watch will stop and require a manual winding. This does not include taking the watch off before bed.

**How automatic movements work:**
1. Movement of the wrist turns the rotor, which winds the mainspring. Turning the crown also winds the mainspring.
2. The gear train transfers the energy to the escapement.
3. The escapement meters out the energy into regulated parts.
4. The balance wheel uses this regulated energy to beat back and forth at a constant rate.
5. Every certain number of beats, the dial train transfers the energy to the hands of the watch.
6. The hands advance.
**RESEARCH**

I made QFD according to the responses to my survey. My target customers do not care much about the price of the product, but they want a reliable and portable winder the most. Besides that, they are also interested in the shock resist and water resist design, and they did not care too much about ease of use either. So among all my engineering approaches, Rugged Impact/Water resist shell, reliable winding module, and portable battery power source are the most important parts I have to take care of.

**DESIGN**

*Basic Winding Function*

So according to my selected engineering approaches, since I don’t have electric background, I decided to build my winder with a complete winder module because it’s going to be more reliable and even cheaper than building my own module.
**EXTERIOR SHOCK AND WATER RESIST DESIGN**

For exterior design, I created couple models in solid works.

Model No 1:

The idea of this design comes from jewelry box and honeycomb. As we all know, hex shape has strong resist against strength. That’s why I combined hex shapes with typical jewelry box design in to my exterior shell design. However, considering manufacturability as well as possible difficulty to replace batteries. I started working on another design that is going to solve those two issues.
Model No 2:

The idea of design number 2 comes from my telescope case as well as submersible. This design looks similar to a submersible so it should be able to survive pressure environment under water easily as well as containing a lot round surfaces to increase impact resist. The rubber straps in the bottom will protect the bottom draw latch from impact as well as providing grip. The purpose for the nylon handle on top is also protect top draw latch as well as making it easier for customer to carry around. The reason of making a back cap is to provide water resist to batteries which locate at the rear side of the shell.
Model No 3:

The idea of model number 3 comes from food containers, they are cheap, able to survive impact and able to stop outside air contacting the food inside. So for my exterior case, I am using polycarbonate plastic due to high impact resistance. There are two stainless steel draw latches on each side in order to lock the front and back cap. In between the middle section and front/back cap, I am installing rubber O-ring in order to make the case water resist. On top and bottom of the case, I use trended high strength neoprene rubber in order to provide better cushion as well as better grip. On both sides of the case, I installed nylon handles for two purposes: protect draw latches from side impact, as well as easier for user to carry the winder.
**INTERIOR SHOCK RESIST**

I redesigned a watch pillow in order to provide better grip and protection for the watches inside my winder. Normal watch pillow is filled with form in order to hold watch on it. Mine pillow uses spring inside instead of form in order to provide more force against the watch around it for better grip. However, I will still wrap the pillow assembly with soft fabric material in order to provide cushion as well as avoid scratching watch case and bracelets.
DECISION MAKING

Both model No 2 and No 3 looks good, so in order to decide which final model I am going to make, I listed all the important factors in my project. The following is the weighted matrix method I used to help me make dissection:

<table>
<thead>
<tr>
<th>Weighted Matrix</th>
<th>Weighting Factor</th>
<th>Design 1</th>
<th>Design 2</th>
<th>Design 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable Winding Function</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Portable Design</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Shock Resist</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Water Resist</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Low Price</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Exterior Design</td>
<td>1</td>
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<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td><strong>83</strong></td>
<td><strong>99</strong></td>
<td><strong>109</strong></td>
<td></td>
</tr>
</tbody>
</table>

So from the matrix we can see that both design 2 and design 3 are pretty good for my project. However, the manufacturability of Design 3 will be better than Design 2 because of the simple component shapes. So the prototype I am going to build and test will be based on design number 3.

Here is the final case design modified from design number 3:

1) Modified case caps and middle sections are more compact in order to be more travel friendly.
2) O-rings are added between caps and middle sections and designed to be pressed after locking the draw latches in order to provide better water resistance, a more secured closure and fit, as well as absorbing impact force.
**DESIGN ANALYSIS**

I used Solid Works Simulation to perform stress test to my exterior shell.

This is the result I got by having 100 N load all around both top and sides of the case.

From the test result we can see that model 2 side wall design has very good strength resistance, and model 3 structure has good strength as well. But top wall from model 2 and side walls from model 3 are suffering from the exterior force. That’s the reason why I installed my handles on those locations in order to strengthen those weak walls from both models. However, this is just the result form solid works, I am going to make both exterior shell and do more research/test on the prototypes with draw latches and handles.
MANUFACTURING AND ASSEMBLY

The Case and panels of the winder prototype were made by ABS plastic via 3D printing because of its accuracy as well as lower cost compared with creating a plastic mold. But during mass production, the manufacturing method will be mold and the case material will be TPU plastic because of its durability as well as higher toughness and flexibility.

All the exterior thread holes are filled with Loctite water resist silicon sealant for improved water resistance.
All the connection spots between bolt on exterior components and shell are filled with Loctite silicon sealant and secured by bolts and nuts as well.

Install two layers of different density rubbers in order to provide better cushion as well as better surface grip.

Install multiple layers of rubber spacers between gearbox and plastic panel in order to provide cushion protection for the critical mechanical parts from impact force.
Install the components from completed module to the back panel. Connect the wires to the board and install batteries then perform test runs before bolt the back panel onto midsection. After bolting on front and back panels, install o rings at the front and back edge of the midsection to prevent moisture and water from damaging the electrical module.

After assemble the unit, test the function keys from back panel, then close both front and back cap using the draw latches to make sure the draw latches are working properly as well as making sure o rings are pressed by front and back caps little bit.
TESTING AND INSTRUCTION

Testing

After assembled the unit in April 13\textsuperscript{th} 2016, I put an automatic watch on it for testing. The watch I used for testing is an automatic watch made by Shanghai Watch company, it winds bi-directional and has a power reserve of 38 hours.

So far the watch has been on the winder at 650 turns per day and bi-direction setting for over two weeks and it never stopped. So I believe that the winding function is working properly.

Also after assembled the prototype, I filled up my bathtub with cold water and placed the winder in the bathtub. The winder was floating on the water so I pressed it down to the bottom of the bathtub for about 1 minute, my bathtub was filled with water around 15 inch in depth,

So the pressure at the bottom of bathtub was around 1.038 atm. The winder was still working underwater and after leaving the bathtub, I opened front and back cap and there was no sign of water inside the winder. I did not plan on leaving it for longer period of time underwater since 3-D printed materials are known for having tiny holes inside them, so water would find its way through 3-D printed materials in a matter of time. But at least my sealing designs were working against pressured water during the 1-minute test.
INSTRUCTION

1) Open the front cap by releasing both draw latches on the side and take out the pillow.

2) Squeeze the pillow and place watch on the pillow. Then place the pillow back on to the holder and put the front cap back on.

3) Open the back cap and you will see the control panel.

TPD (Turns per day) setting: Rotate 650, 950, 1250, 1850 turns in a 24-hour period. Direction setting: CW (Clockwise), CCW (Counter Clockwise) BOTH (the winder will perform half of the TPD in clockwise and half of the TPD in counter clockwise)

For more information about TPD and direction: Please refer to the movement detail page in your watch manual or ask your watch manufacture about winder setting.
Either connect AC/DC Power adapter with power outlet, or install batteries into the battery box. The batteries will power the winder for about three to four months upon usage.

When running on AC/DC Power, please do not close the back cover.

When running on battery power and ready for travelling. Close the back cover for protection against water/moisture and impact.

Here is a link for common watch manufacture’s movement details: http://orbita.com/2010_web/NEW/WatchmakersWebs.htm
CONCLUSION AND LESSONS LEARNED

After complete the prototype, so far it is performing as designed. The winding function has been tested for over two weeks and was working great, water resistance also passed my test. The only part that I wasn’t able to perform a test is the shock resistance part because the quite expensive case of the prototype was made by brutal ABS plastic instead of TPU plastic used in my design. I did pay two different vendors (University of Cincinnati and another lab I found on 3D hub) to make two cases in order to perform a drop test on either one of them. However, the quality of the case made by the lab on 3D hub was very disappointing, the three sections were not even close to fit, as you can see in the picture to the left. So I end up only made one complete exterior case with the 3D printed parts made by university of Cincinnati 3D printers. Fortunately, the accuracy and quality of the parts made by UC were excellent and they did hold well during my water resistance test. So my lesson learned on 3D printed component is – you get what you paid for, the 3D printed components made by UC costed around $400 and the three sections made by the other lab were $60 in total, big price difference, yes. But the quality from professional grade 3D printers are far superior than cheap printers. So my suggestions for students who are planning are using 3D printers for their project, be aware of the quotes that are much lower than average cost and make sure to contact the labs asking about the printers they use because the quality of parts coming out from professional printers are much better than those made by non-professional printers. Also another lesson I learned during my senior project was, do more research on manufacturing cost before you set your final budget. My budget was set at $400 dollars since the modules I planned on purchasing was only $49 and $120, the hardware I looked up on McMaster-Carr was also cheaper than $100 in total. I did not do much research on the cost of 3D printing parts and thought they were just cheap plastic parts. I ended up spending around $700 in total on my senior design project and majority of the cost actually was 3D printed parts. So my suggestion about setting project budget is doing more research about
manufacturing cost instead of calculating just parts cost before setting the final budget. Also I suggest when designing 3D printing components, making the parts thinner will reduce the cost significantly, because 3D printers build parts layer by layer, thicker parts will cost a lot more material and time to be printed so they generally cost a lot more than thinner parts. So making the parts thinner or actually leave some slots and spaces inside thick walls of your 3D printing parts will decrease the printing time as well as reducing cost.

Overall, my prototype is carrying the designed functions and performing pretty well. So I am satisfied with the result. From the lessons I learned during the whole creating idea – brainstorming – designing - manufacturing – assembly – testing – troubleshooting process, I now have a much better understanding about the R&D and manufacturing process of new products and I am sure the knowledge will help me a lot later on in my engineering career.
WORKS CITED

APPENDIX A
Exterior Dimensions of the winder design model 2

Exterior Dimensions of the winder design model 3
Exterior Dimensions of the final winder design
The purpose of this Survey is to better understand customer needs for watch winders in order to improve the product I am developing.

How important is each feature to you in a watch winder?

<table>
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<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td>Ease of use</td>
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<tr>
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How satisfied are you with current portable watch winder design?

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APPENDIX C

QFD

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<th>Rubber Exterior Shell</th>
<th>Shock Absorb Structure</th>
<th>Special Watch Holder</th>
<th>Rugged Gear Design</th>
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<td>Rubber Exterior Shell</td>
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