Low Pressure Hose Reel for Reelcraft

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Senior Design White Paper

Project: Low Pressure Hose Reel for

Spring 2012

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Submitted to:
Professor Liang of MET 494/499 Senior Design & Analysis
Mechanical Engineering Technology Program
College of Engineering, Technology, and Computer Science
Indiana University-Purdue University Fort Wayne
Dear Professor Liang,

Please accept this final report as our submission for our senior design project. It is a technical report describing the engineering work behind our project of a spring retractable hose reel for Reelcraft Industries.

In this report you will find the requested information such as: calculations, bill of material, CAD prints, photographs, charts and reference material, and technical descriptions of our project.

If you have any questions, comments, or concerns, please contact us at peacock199@aol.com.

Sincerely,

Daniel Peacock, Kevin Eubanks, Chris Scherschel
Senior Design White Paper

Project: Low Pressure Hose Reel for

REELCRAFT

Spring 2012

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Abstract

The purpose of this project was to design a hose reel assembly that would be able to hold 100 feet of 1 inch I.D. (inside diameter) hose. The hose reel assembly will be able to transfer mediums of gasoline, diesel fuel, air, and water at working pressures up to 250 psi. The hose reel assembly will also utilize an arbor spring, which will allow extraction of the hose and retraction of the hose by a single operator. The hose reel assembly is designed to use standard parts to lower the cost of producing the hose reel assembly.

The knowledge areas that were utilized in designing our hose reel assembly were:

- Statics and Dynamics
- Solid Edge 3D CAD
- Fluid Dynamics
- Advanced Materials
- Strength and Materials
- Engineering Economy

The experience we gained in completing this project was in failure analysis, designing a cost effective product, project planning, implementing of a project design in an engineering environment, and team dynamics.

We had a strong group dynamic and were there for each other whenever a person had a question or needed help. When we were working on the project, each person would work on a different part. Then we would come together and discuss what each of us did so that everyone would know what they had accomplished and it gave the other team members an opportunity to give additional input into that particular piece of the project.

We receive support from Ed Walter, the Director of Engineering at Reelcraft Industries and the other engineers that support him. Josh Braun, the Director of Manufacturing at Reelcraft Industries, assisted our team in assembling and performing the tests on the hose reel assembly.
Introduction

Background
The purpose of this new hose reel design was to meet a growing market demand for a hose reel assembly that was capable of holding 100 feet of 1-inch I.D. hose, and to use as many standard parts as possible. The 9000 series vehicle mounted hose reels are a series of reels designed to be mounted on a service truck or a permanent platform. They are designed to carry mediums like gasoline, diesel fuel, air, and water. They all feature a torsion spring to assist in extraction and retraction. The reels are designed to handle a 1 inch I.D. (inside diameter) hose. The different models also vary in how much hose length can be housed on the reel. We are going to focus on the reels that are able to handle one inch I.D. hose. The current models are designed to only handle 50 feet of hose. The market research conducted proved that there was a demand for a hose reel that could contain more than 50 feet of hose.

Solution
The solution was to design a hose reel frame that could potentially be exposed to vibration, shock, impact, and environmental conditions in both on and off-road applications. The hose reel will also incorporate a retractable spring that will have a spring tension coefficient that will assist in the unwinding and retracting of the hose. The reel must also be designed to accommodate a 100ft hose with a 1 inch inner diameter. The mediums that the hose will be exposed to are air, gasoline, diesel fuel, and water at a maximum pressure of 250 psi. The hose reel will be designed with a safety factor of 4-1 (excluding hose) which meets Reelcraft’s safety requirements.

The methods we used to complete the initial design of the hose reel assembly were to research existing product in the 9000 series produced by Reelcraft. We troubleshooted previous attempts at producing a 100 ft. hose reel with a 1 inch I.D. to found out what problems arose with those designs.
Initial Design Specifications

- The reel should be able to be mounted to a vehicle
- Able to hold 100 feet of 1 inch inner diameter hose
- Carry mediums of gasoline, diesel fuel, water, and air
- The fluid path should be able to withstand working pressures up to 250 pounds per square inch
- Be weather resistant
- Able to withstand on and off-road applications
- Utilize a Power torsion spring that allows the reel to be able to retract the hose with little or no assistance from the operator
- Have a torsion spring fatigue life of 7300 cycles or more
- Utilize a roller guide assembly to assist in hose extension and retraction

The specification to house 100 feet of 1 inch I.D. hose is one of our most important criteria that needed to be meet with the hose reel design. This is due to an unfulfilled market demand for hose capacity of 100 ft. This length is the most requested in the spring retractable market at Reelcraft in the Engineering Product division. The reel being spring retractable is very important because it not only saves space but also eliminates the need for an external power source. This allows for a slim, low profile designed reel that will reduce the amount of space used when in the field. The one inch inner hose diameter is also important because typically it is used in the petroleum products field. Customers were requesting this size due to its larger flow rate capacity. The powder-coating requirement is important because it provides a better protectant coating as compared to wet or spayed on paint. The powder coated finish is more durable and has more resistance to corrosion especially when exposed to the weather elements and the work environments the reels are subjected to specifically in the petroleum industry.
Design & Fabrication
Calculations

Loads on Shafts

\[ P = \frac{w}{2} \]

\[ P = 129.764 \div 2 = 64.88 \text{ lbs.} \]

Moment of Inertia

\[ I = \frac{\pi(D^4 - d^4)}{64} \]

\[ I = \frac{\pi(2.5 \text{ in}^4 - 2.25 \text{ in}^4)}{64} = 0.6594 \text{ in}^4 \]

Moment at Free End

\[ \Delta_{\text{max}} = \frac{\rho b^3}{3Ei} \quad \text{b= length} \]

\[ \Delta_{\text{max}} = \frac{(64.88 \text{ lbs})(5 \text{ in}^3)}{3(30000 \text{ ksi})(0.6594 \text{ in}^4)} = 1.369 \times 10^{-4} \text{ in.} \]
Diagrams & Graphs

**600388-0.062" Thickness Torque vs. Number of Turns**

This spring was the original spring used in the hose design. It was a standardized product that had been utilized in similar hose reel applications and was deemed adequate for this application by our support staff at Reelcraft. We were able to pretension this spring several wraps so that we were utilizing the upper portion of the torque curve and would not have a large drop off of power at the end of the retraction process. After performing the pressurized extraction and retraction test, we discovered that this spring did not produce enough output torque due to the rigidity added to the hose after pressurization. We did not have a resource that could give us the amount of added rigidity for the hose under pressure.
Above is the second spring that we utilized that was 0.01" thicker than the first. The new spring has a higher input and output torque as shown in figure 3. This spring resulted in better torque performance at the top end of the spring but had a disadvantage due to the fact that we could not add as many pretensioning turns. This factor lead to a large drop off of power at the end of the retraction process.

In the combined torque curve graph as seen in figure 4, it is very easy to see that the thicker spring was able to produce significantly greater power at the top end of the torque curve, but at the lower end of the curve there was a greater drop in power.
CAD Drawings

All of our drafting and design prints can be found in Appendix 1.

Fabrication & Assembly
Below is a list of parts and a description of how they are used to assemble the hose reel. See Appendix 2 for an image of the hose reel assembly and the bill of materials (BOM).

1. Frame: The frame is the base of the reel that the spool rests on. It is also the portion of the reel that will be mounted to the vehicle. The frame is constructed of carbon steel and has a red powder coat finish.

2. Pillow Block: Also known as a bearing. A portion of the reel's shafts rest in the pillow block and allow the reel's shafts to spin freely.
3. **Inlet Tube Assembly**: This is the fluid path of the reel. The area that the mediums travel through to get to the hose. The inlet tube assembly is made of galvanized carbon steel and can withstand pressures up to 1200 pounds per square inch.

![Inlet Tube Assembly](image8)

4. **27001**: Is the ratchet of the reel. The ratchet is made from cast aluminum which is corrosion resistant. The ratchet is a key part of the hose reel assembly that lets the reel lock into place every 15 inches.

![Ratchet](image9)
5. Head: The heads are the part of the reel that helps hold the hose in place. They are made of carbon steel with a powder coat finish. The heads have a 31-inch diameter.

6. Ratchet Mounting Plate: The plate is made from carbon steel and is used to secure the head to the shaft of the reel on the ratchet side of the hose reel.

7. Drum: The drum is the portion of the reel that the hose is wrapped around. The drum is made from carbon steel and has red powder coat finish.
9. Snap Ring Shaft Assembly: The snap ring shaft assembly is made up of a nickel plated carbon steel tube with grooves in it for the snap rings. The snap rings are used to secure the location of the drum in respect to the frame to ensure that the drum can spin freely with no inferences with the frame.

10. Arbor Spring: The arbor spring is made from cast aluminum and is used in the tensioning of the spring assembly when the reel is turning. The spring is designed to disengage if the reel is turned too far in one direction. If the spring would come off, it will automatically re-engage when the spool is turned in the proper direction again.
11. Arbor Plate: The arbor plate is made from carbon steel and has a red powder coat finish. The arbor plate is the part used to secure the head on the spring side of the reel.

![Arbor Plate](image)

12. Spring Case Assembly: The spring case assembly is made from carbon steel with a red powder coat finish. The spring case assembly houses the torsion spring which provides the retraction action of the reel. The spring case assembly is bolted to the frame.

![Figure 16](image)

![Figure 17](image)  ![Figure 18](image)  ![Figure 19](image)
13. Latch Pawl Assembly: The latch pawl assembly is made from cast aluminum and is the second half of the ratcheting system. The latch pawl assembly engages the ratchet helping to secure the hose every 15 inches.

14. Tie Rods: The tie rods are made of stainless steel. The tie rods cannot be seen in the picture but are connecting the 2 heads and provide structural support to the reel assembly.

15. Swivel Assembly: The swivel assembly is made of carbon steel. The swivel is what the inlet hose connects to and swivels to prevent binding or twisting in the inlet hose. The swivel has 1 inch female NPT threading on both sides.
16. The hardware used to put the reel together. All the hardware is made from stainless steel.
Results

How to use:
1. Install inlet hose onto swivel.
2. Connect the desired dispensing valve onto the end of the hose.
3. Grab hose in front of bumper and extract hose to desired length.
4. Ensure ratchet is engaged to lock spool.
5. Complete dispensing medium.
6. Extract hose until ratchet is disengaged (this can be heard and felt through hose).
7. Walk hose back until the bumper contacts the rollers while ensuring even distribution of hose onto the drum.

General Maintenance:
1. Lubricate bearings and swivel via grease fittings as needed.
2. Routinely inspect hose for cracks and leaks, replace when necessary.
3. Use silicon-covered cloth to clean and lubricate hose as needed.

Photos

Figure 25

Figure 26

Figure 27

Figure 28
Example Applications:

NOTE: These photos represent how the reel could be utilized in the field.

The hose reel can be used in a variety of different situations in industry. Frequently customers order the hose reels to be mounted near the pumps and are used to get the fluid further than a normal dispensing hose would be capable.

Another common scenario for the application of these hose reels is the mounting the reels on the fire trucks. The longer hose gives the firefighters the ability to keep the truck further from danger.

The final scenario pictured above is the use of the hose reel in a mobile service truck. These trucks often need long hose’s to reach disabled vehicles. This reel would accommodate the needs of these service trucks.
Testing

Cycle Test
The cycle test is performed to test the fatigue life of the arbor spring. This is done by connecting the hose reel assembly to the cycle tester using a high pressure hose. The hose reel assembly is first securely bolted to the cycle tester base. The cycle test timer is then set so that the total number of turns needed to completely unwrap the hose on the drum is pulled out. Pulling out the hose will cause the spring to tension. Once the arbor spring is fully tensioned, the tester drum clutch disengages allowing the hose to retract back onto the hose reel drum. This will be repeated until the spring has reached its fatigued life of 7300 cycles or has reached spring failure.

Cycle Test Results
Our test results showed that the spring was able to withstand 7,300 cycles without failing. The frame also showed no visual signs of weakening or failure after the cycle test.
Pressure Test
The pressure test will also be used to check the characteristics of how the 1-inch I.D. hose will react when it is fully pressurized and has the heaviest medium (water). The first step was to connect the pressure tester to the hose reel assembly. After all of the fittings were securely fastened, a valve was connected to the end of the hose so that the flow out of the medium at the end of the hose could be regulated. Next the water pump was engaged using compressed air and controlled with a pressure regulator. With the hose pressurized, we could check for leaks in the connections and fluid path of the reel.

The next portion of this pressure test is used to see if a person would be able to unwrap the 100 feet of hose from the reel, and conversely see if the spring outputs enough torque to fully retract the hose with minimal assistance from the operator. This part of the testing is important because when pressurized, the hose becomes more rigid and thus makes the hose more difficult to unwrap and retract. The hose was pressurized to 200 PSI. The complete length of hose was then removed from the drum. After fully extending the hose, the latch pawl was disengaged and the hose was allowed to retract back onto the drum.

Pressure Test Results
At this point the proof of the mechanical concept is validated, however we found that the original spring used to assist in the retraction of the hose does not output enough torque to entirely retract a fully pressurized hose at ground level nor the average elevation application height of 4.5 ft. Our second spring choice which was .010” thicker. It was able to fully retract the hose with no assistance at ground level, but unable to do so at the average elevation application level of 4.5 ft. There was 15 ft. of hose left that needed to be retracted onto the drum. The second spring did increase the output torque needed to retract the hose, however it did not seem to affect the input torque, which is the torque applied when the operator is pulling out the hose.
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Cost Note:
The cost of the reel so far has come in under our original forecast; this is mainly due to the fact that we were able to utilized standard parts in our final design. Doing so keeps the cost of manufacturing down.
Conclusion

We have determined the frame we designed for this type of application is more than adequate. This frame will be used in developing other large capacity hose reels in the future. Although the current design utilizes the larger spring 600426 it is still insufficient for retracting the hose when fully pressurized. This has lead the company to investigate in developing new sizes of springs and spring cases to accommodate the extra torque required for large capacity hose reels. The findings of this paper has led the company to explore a way of determining the stiffness of hoses based on the pressures and include these calculations in the initial design phases of new projects.

Standard fabrication will be utilized on all standard parts used in the new hose reel design. Until the development of the new spring design and spring case is finalized we cannot conclude what modifications will be needed in the manufacturing process of the new hose reel design.

We have determined from our pressure test that the fluid path will be able to withstand the max pressure of 250 psi without leaks. From our truck mounted pressure test we concluded that the hose will be easily extracted from the reel when pressurized, but due to the pressurization of the hose the spring was unable to fully retract the hose without assistance from the operator. From the cycle test we were able to confirm that our spring would be able to withstand 7300 cycles of the hose. This would be the number of cycles of a person extracting the hose completely ten times in a day for two years. The two years was determined because of the length of Reelcraft’s warranty is 2 years.