WD-40 Alternative: Final Design Report

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Abstract

The main idea of this project was to create a WD-40 alternative that could be used in Africa to help loosen rusted bolts effectively while being cost efficient and possibly help boost the economy of several small villages and populations. In order to create this alternative penetrating oil, several tests were completed on rusted bolts to provide data on the components of alternative materials other than WD-40. Experiments were designed and completed effectively yet more time and information could definitely benefit this pursuit of an alternative. The results after several tests completed indicate that a mixture of vegetable oil and acetone may be better than WD-40 in terms of capabilities discussed in this report. Future work on this project would improve upon already collected data and generate a better overall project. If more rusted bolts could be tested, the parameters for the mixture ratio would be even smaller and tests would also be done more than twice to create more precise data.

Project Overview

It is in the best interest of developing African countries to develop alternative penetrating oil for WD-40 that would be easily accessible as well as cost effective and sustainable. In developing African countries today, penetration oils such as WD-40 are often too expensive and not accessible by many poor communities. These communities are plagued with rusted bolts and fasteners that cannot be replaced without the help of a penetrating option. The longer the bolts are allowed to rust, the more of them that cannot be saved and reused later on because of the extensive damage done to them by continuous oxidation of iron. Penetration oils can help loosen these damaged bolts and act as a temporary rust preventative for replacements. For this reason, inexpensivealternative penetrating oil that is easily accessible to the African people would save homes and structures throughout the continent.

Materials and Methods

Design Constraints

Our design constraints were determined in three tiers:

Primary:

- The alternative penetrating oil must be able to reduce the friction of the fasteners in order to properly remove, adjust, or replace them.
- The penetrating oil must be able to prevent rust corrosion
- The penetrating oil must be able to be safely disposed of

Secondary:

- The penetrating oil must be inexpensive and accessible

Tertiary:

- The penetrating oil must have potential to generate income

Decision Matrix

A decision matrix was used to guide the design process in the first round of conceptual design, so we could focus our efforts.

Factor	**Weighted Importance ***	**Option A**	**Option B**	**Option C**
Lubricating ability	3	3	3	3
Rust prevention	2	2	2	2
CO2 emission	1	1	2	1
Disposability	3	1	3	1
Cost	3	2	2	1
Manufacture ability	2	3	3	1
	TOTAL:	29	36	22

*On a scale of 1 (least important) to 5 (most important)

Option A: Transmission oil (can be used), paraffin wax, acetone
Option B: Vegetable oil, paraffin wax, acetone
Option C: WD-40 (contents secret)

Materials

Raw Materials:

- Acetone
- Paraffin wax
- Vegetable oil
- WD-40
- Automatic transmission fluid (ATF)

Method

The total supplies consisted of coffee filters, four paint brushes, sixteen 3/4inch bolts, one vice grip, one torque wrench (N.M), one pipe wrench, sixteen small solo cups, one measuring cup, and one container of vegetable oil, ATF, acetone, and WD-40 for testing. All paint brushes and measuring cups were cleaned after use to limit the amount of human error involved in testing. Also, Bobby Love would be the primary torque wrench user to limit the human error involved in removing the bolt. Figure 1 shows the bolts in question. These bolts were corroded over the time of one week using salt water and sulfuric acid to help speed the corrosion effect. Due to time constraints, the bolts were corroded quickly to allow a good amount of time for the testing of the applicants.

The main design being considered is the half transmission oil/half acetone + paraffin mix. Since transmission oil and acetone don't mix very well, paraffin is added to the design to make these two reactants mix. Transmission oil in this design acts as a lubricator while acetone is the rust remover. The trick is to find the right mix in order to make the product cost efficient at the same time as being effective. In order to achieve this, a series of trial and error experiments will be performed in order to find the right percentage of acetone and transmission oil. Paraffin is also great at prevent iron and steel from oxidation, which will help the effectiveness of our final product.

Another design being considered is replacing transmission oil with vegetable oil in this case. In order to make this product more accessible the ingredients themselves need to be easy to get. Also, by replacing transmission oil with vegetable oil you get a more "green" product for the environment. This is something being seriously considered since sustainability is important.

The testing of the bolts involved two different tests, a corrosion removal test, followed by a force test for removing the bolt with the applicant. The corrosion test (Figure 2) took place over an assortment of days to be determined. The force test was done over this time period in the kitchen by coating a seized bolt (Figure 3) and then removing the bolt from the nut with a torque wrench (Figure 4). Five different methods were tried. ATF 100%, vegetable oil 100%, acetone 100%, 95% ATF +5% acetone, and 95% vegetable oil +5% acetone. Two trials for each were tested.

Figure 1: Rusted ¾ inch bolt

Figure 2: Acetone corrosion removal test

Figure 3: Coating of 100% ATF onto corroded bolt.

Figure 4: Experimentation

Deliverables

After the conclusion of this project several deliverables will be given. A series of alternative penetrating oils will be tested and ranked by their efficiency, sustainability, and cost. Also data pertaining to penetrating oils tested will be available to help determine which one is the best option to use in a developing country. Information regarding certain mixes which work better in certain situations will also be given to help inform the African society about when certain mixes of penetration oil should be utilized.

Experimental Results

Corrosion Test

The acetone corrosion test was the first corrosion test of the series. As the bolt was dropped into the cup containing the acetone, an immediate effect occurred on the bolt. Debris started to release instantly as the acetone bubbled slightly and the release of gases occurred trough bubbles. The release of bubbles however wasn't very violent.

The vegetable oil corrosion test was the second test attempted. As the bolt was dropped into the cup of vegetable oil, the only immediate effect noticed was the release of gases trapped in the bolt. The gases in this case were concluded to be just pockets of air bubbles on the nut and bolt fastener. Overall, the vegetable oil had no real effect on corrosion, at least not immediately.

The third corrosion test attempted was the WD-40 control test. As soon as the bolt was dropped into the cup of WD-40, gases and an assortment of debris were released from the bolt. The bubbling however did not stop as quickly as did the Acetone. Well passed two minutes, the WD-40 still contained bubbles on the surface. This may however have something to do with the components of WD-40 and not the effect of corrosion removal of the substance. As more time passes more results will be concluded.

The fourth and final test for corrosion removal was the ATF liquid. As the bolt was placed into the cup containing the ATF, bubbles began to rise as the pockets of air were filled with the liquid. As with the vegetable oil, no immediate effect of corrosion removal was noticed.

All four test subjects will be monitored over the course of several days and each day one picture will be taken of each substance to determine the effect. After the conclusion of the test, all the bolts will be removed and a jury of peers will determine which substance helps the most with corrosion removal.

3/4 inch bolts test

The first test for the amount of force required to remove a bolt from the fastener was the ATF 100% liquid formula. Using a paintbrush, ATF was applied to the nut and bolt as shown in Figure 8. Three attempts were made into getting an average amount of force applied to remove the bolt using a torque wrench.

Test #	Force Applied (N.M)
1	11.6
2	11.5
3	11.4
Average	11.5

The average amount of force required to remove the bolt with an application of ATF was 11.5 Newton meters.

As for the other options the following occurred. These were done all in order respectively.

Test # (Result in N.m)	Vegetable Oil 100%	Acetone 100%	95% ATF, 5% Acetone	95% Vegetable oil, 5% Acetone
1	11.6	4.1	4.9	11.3
2	11.5	4.9	11.3	4.2
Average	11.6	4.5	8.1	7.7

The table concludes that acetone is indeed the best lubricate force wise. As for the other testing subjects, as acetone is added to the mixture the force required in removing the bolt was indeed lessened. More tests will be needed to be done. One of the primary reasons in even doing this test was to find out if ATF and vegetable oil can be replaced with one another. For cost reasons and amount of resources in rural environments, vegetable oil would be much easier to get as compared to transmission oil. Also, as for the environmentally friendly vegetable oil is must easier to get rid of compared to ATF. Vegetable oil degrades by itself easily, while ATF has many chemical components involved that can be harmful to the environment. As for acetone itself, it evaporates very quickly allowing very little harm to the environment.

1-1/8 inch bolts test

On May 26, 2012, an additional six tests were completed. These tests were designed after the first tests on May 25th as data from the initial experiments was used to decide which substances would be best to progress in the right direction. These tests used rusted 1-1/8 inch bolts instead of ¾ inch bolts and they were rusted for exactly 1 week prior to testing.

The results are as follows on the table: (VO= Vegetable Oil, A= Acetone)

*All tests are measured in newton meters. (N.M)

Test #	Control (WD-40)	90%VO,10%A	80%VO,20%A	70%VO,30%A	85%VO,15%A	87.5%VO,12.5%A
1	82.7	33.9	33.9	64.2	36.6	23
2	54.2	39.3	50.1	32.5	40.7	51.5
Avg	68.5	36.6	42.0	48.4	38.7	37.3

Cost and Performance

Cost of raw materials per liter:

Material	Cost per liter
Automatic Transmission Fluid (ATF)	$21.16
WD-40	$20.55
Acetone	$12.12
Vegetable Oil (VO)	$2.63

Cost of lubricant mixtures per liter and seized bolt performance:

		Force to remove seized bolt (N.m)	
Lubricant	**Cost per liter**	**1-1/8”**	**¾”**
100% ATF	$21.16	---	11.5
95% ATF 5% Acetone	$20.71	---	8.1
100% WD-40	$20.55	68.5	---
100% Acetone	$12.12	---	4.5
70% VO 30% Acetone	$5.48	48.4	---
80% VO 20% Acetone	$4.52	42.0	---
87.5% VO 12.5% Acetone	$3.82	37.3	---
85% VO 15% Acetone	$4.05	38.7	---
90% VO 10% Acetone	$3.58	36.6	---
95% VO 5% Acetone	$3.11	---	7.7
100% VO	$2.63	---	11.6

According to the calculations and approximate cost of materials, as acetone is increased in the mixture the cost of the solution increases. All solutions involving acetone and vegetable oil are significantly cheaper than the alternatives of WD-40 and ATF. Acetone being used in small percentages keeps the price of the solution down but still adds more effectiveness to the penetrating oil. These calculations are all done with small solutions. During testing to keep supplies up tests were done with 50 mL at a maximum.

Conclusions and Future Work

The finished product was decided to be the 87.5% vegetable oil and 12.5% acetone mixture. According to the results gathered over the span of two weeks of testing, the mixture responded well to removing corrosion and providing lubrication to the assigned task. Acetone being the primary corrosion remover element, mixed very well with vegetable oil without the need of adding paraffin. Vegetable oil as a standalone does not do well in removing corrosion; however the vegetable oil lubricates very well and is a great replacement of ATF (automatic transmission fluid). The final design is an eco-friendly design as well, since vegetable oil is bio-degradable while acetone evaporates very quickly and causes no harm to the environment.

Future Work

If the project had another ten weeks of development there would be more time to carry out more experiments and try different materials and liquids to perfect the design. The final design that came out of this project was done so in the time span of only ten weeks which severely limits the amount of possibilities you can come up with for a solution to a problem. To properly extend the effectiveness of the project, more experiments would need to be done in all different aspects of the project. Corrosion effectiveness, lubrication ability, amount of time an object stays lubricated, amount of force applied to remove fastener, CO2 emission, the list can go on.

One of the main aspects of this project was to design a penetrating oil lubricant that is cheap, easily accessible and assembled, and being environmentally friendly. Although our final project does indeed reach these goals there was still much work to be done. The design constraints given at the beginning of the project limited the amount of options that could have been used in the design. If there was more time however, more options could have been given a chance in experimentation.

For improvements of the design, more specificity would be a good example of something that would be better. Also, more information of the regions specified that would be needing this penetrating oil would allow more insight into the type of material and liquids that specific region has, which would allow more than one design to compliment the recourses in that given region.

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