Quicksand:

How to Get Out of It

Alexander Hane

6th grade

Abstract

Quicksand is a non-Newtonian fluid made of fine-grained materials like sand, clay and water. It looks like stable sand at first sight, but becomes unstable when added stress is applied. The goal of this experiment is to find out how to get out of quicksand with minimal resistance. The speeds at which the washer was pulled were 1 second per 5 inches, 3 seconds per 5 inches, 5 seconds per 5 inches, 7 seconds per 5 inches, and 10 seconds per 5 inches. It was hypothesized that pulling the washer out in 10 seconds would have the least resistance and that pulling out the washer in 1 seconds would have the most resistance. If the washer is pulled out slowly, there will be less resistance because the quicksand will not be disturbed and will have less of a viscosity change. It is the opposite for pulling the washer out quickly since more stress is applied which means a substantial change in viscosity. The weight measurement on a fish scale would show how much resistance there was. The quicksand would be 600 ml. of corn starch and 400 ml. of water. Put the washer on a string attached to the fish scale and pull in the different speeds mentioned. The results of the experiment showed, as hypothesized, that pulling the washer slowly had less resistance and pulling the washer quickly would have more resistance.

Table of contents

Question

What is the change in force needed to move a washer through a non-Newtonian fluid at speeds of 5 inches per 1 second, 5 inches per 7 seconds, 5 inches per 5 seconds, and 5 inches per 3 seconds versus the control of 5 inches per 10 seconds?

Research

A non-Newtonian fluid is a fluid substance that does not follow Newton's law of viscosity. There are many non-Newtonian fluids like ketchup, honey, and quicksand. They have a liquid-like form when moved around and change shape to fit a container like a liquid. They can change viscosity quickly when additional force is applied.

Viscosity is a property to most non-Newtonian fluids. It is a measure of a fluid or liquid's resistance to flowing. It is sometimes told as the resistance to flowing (RheoSense. N.d.). The viscosity in many non-Newtonian fluids affects how they move around, and the effect of viscosity gives the fluids their non-Newtonian title.

Non-Newtonian fluids have many industrial uses. Oil is a non-Newtonian fluid. People use it to lubricate their cars, generators, and other high friction engines. Non-Newtonian fluids are also used for art or decoration. When you move into a new house, you usually paint the walls a new color that suits your tastes. Paint is a non-Newtonian fluid since it does not follow Newton's law of viscosity. If it did not have resistance to flowing, it would just slip off of the walls and not get anything done. This is a large use of non-Newtonian fluids' characteristics and there are many more.

To see how the speed of force application affects the viscosity of non-Newtonian fluid, 5 different speeds were tested. The resistance was recorded by a fish scale to see an amount in lbs. The fluid was a quicksand like mixture of corn starch and water, both of which are non-Newtonian fluids. This would give an accurate representation of how quicksand would react to the pulling of washers. The experiment would use the same distance and power for each pull, only varying the time with each different test.

Hypothesis

It is predicted that if you pull the washer out in 10 seconds, you will receive the least amount of resistance from the quicksand (resistance is measured in lbs. on the fish scale).

Scientific Principles and Reasoning

If force is applied quickly, then the quicksand will apply lots of resistance, but if force is applied slowly, the quicksand will apply less resistance. The viscosity will not change much, and things can move in the quicksand.

Materials

- 1 Large metal washer 5 cm. in diameter, a collection of 5-10 smaller washers to hold the large washer in place

- 1 Fish scale

- 400 ml. Water

- 600 ml. corn starch

- 1 container/cup with a volume of 1000 ml.

- 8 in. of Wire/string

- Enough Duct tape/adhesive glue to attach the container to the wooden board [optional]

- 1 Wooden board [optional]

Methods

1a. Find a table in a flat area to do the experiment, mix the 600 ml. corn starch and 400 ml. water together and pour it in a container.

1b. To reduce mess, attach the container to the wooden board with duct tape or adhesive glue.

2. Attach the metal washers to the wire or string, and then attach the wire or string to the fish scale.

3. Dip the washers into the corn starch combination. Lower until the washers are on the bottom of the container.

4. Pull the fish scale at different speeds of 10 seconds (control), 7 seconds, 5 seconds, 3 seconds, and 1 second and measure the weight on the scale. [Another person might be needed to help]

5. Experiment for 5 different trials for each different speed.

6. The weight shown on the fish scale is how many lbs. of resistance there is. Record the weight for each of the trials and see which speed had the least resistance.

Variables and groups:

Independent Variable

The speeds at which you introduce pressure to the non-Newtonian fluid, pulling the fish scale at 10 seconds, 7 seconds, 5 seconds, 3 seconds, and 1 second.

Experimental groups:

When force is being applied at 5 different speeds of pulling the fish scale at 7 seconds, 5 seconds, 3 seconds, and 1 second. When you pull on the washers at the different speeds, that is the condition for the experimental group.

Control group:

When you pull the washer at a speed of 5 inches per 10 seconds.

Dependent variables:

The measurement of the resistance against you in lbs. is the dependent variable. A human hand is not perfect, so the results will vary slightly.

Constants:

- Combination of corn starch and water
- Fish scale
- Washers
- Wire/string
- Tupperware/cup

- distance for pulling the washer

Challenges overcome

One challenge met was that the materials were not correct. Using the original materials listed got too thin of a substance that would not support the experiment well. The materials had to keep being changes before the final experiment so that it would be thick enough to simulate quicksand. Eventually a good amount of corn starch and water was found, and the experiment was continued.

Results

As hypothesized, pulling the washers out in 10 seconds showed the least resistance on the fish scale. Pulling the washers in 10 seconds on average showed about 0.02 lbs. resistance (not counting the weight of the washers). Pulling out the washers in 7 sec. showed about 0.07 lbs. resistance as the second least. Pulling it in 1 second showed the most resistance at 1.85 lbs. on average.

The 10 second pull and the 7 seconds pull were almost identical in the resistance shown on the fish scale. During the trials for the 10 second pull, many of the trials' resistance were lower than the weight of the joint washers (0.11 lbs.) which was unusual but was most likely a malfunction by the fish scale. The same occurred with the 7 second pull's trials, but with less of the tests. The 1 second pulls had resistance differing from all the other trials by over 1 lbs. in resistance. The difference in percentage between the 1 second trials' average and the control's average was about 15416%.

Conclusion

The goal of this experiment was to find the change in force needed to move a washer through a non-Newtonian fluid. The hypothesis was that pulling the washer out at a speed of 10 seconds per 5 inches would produce the least resistance against the experimenter. The hypothesis was supported. When the resistance applied against the pulls were averaged, the 10 second pulls had close to no resistance against them. Compare that to the 1 second pulls with over 1 and a half pounds, the difference is about 15416%. This was likely due to the slow application of force. Quicksand is a fluid is stable until additional force is applied. The low rate of force application means less force applied per second. This causes it to be more stable than a sudden application.

All of the pulls had some resistance against them, but the faster speed pulls had more resistance than the slower ones. The 10 and 7 second pulls had close to zero resistance against them, with some of the pulls coming as low as 0.02 lbs. The 5 second was in between, sometimes having pulls with close to zero resistance, and others with over half a pound. The 3 second and 1 second pulls had the greatest resistance in lbs. with over 1.5 lbs. for some pulls.

Something that could have affected the results is vibrations. Since the experiment was conducted on a plane that was not perfectly stable, it would send the force applied and turn it into vibrations. Since quicksand becomes unstable when extra force is applied, these vibrations could have made the fluid react differently than with just the force of pulling applied.

The results of the experiment show that the slower force is applied to a non-Newtonian fluid, the less resistance will be applied. Quicksand is the same, for if force is applied slowly, less resistance will be applied. If somebody gets stuck in quicksand, instead of thrashing around,

move around slowly so that less resistance will be applied against you making it easier for other to help them get out.

Improvements and Further Research

One improvement is using a machine to pull the washers. A human hand is not perfect and cannot pull out washers in exactly a certain time. It will always vary slightly to the time used. A machine could be programmed to pull the washers in a perfect amount of time so that it replicates the exact same conditions. A more sensitive scale than a fish scale could be used to give a more exact measurement for clarity.

Further research could include testing the same experiment for other non-Newtonian fluids such as toothpaste, honey, and tomato sauce to get further insight on how different non-Newtonian fluids react to stress.

Acknowledgments

I want to thank my science teacher for providing guidance on my experiment. I want to thank my father for helping me get the materials, checking over my project, and helping me with the experiment.

References

Faridi. (March 11, 2011). *Quicksand, a non-Newtonian fluid.* Retrieved November 20, 2020 from https://rashidfaridi.com/2011/03/01/quicksand-a-non-newtonian-fluid/

RheoSense.inc. (n.d). *What is Viscosity? Why is it important for fluids characterization?* Retrieved November 20, 2020 from https://www.rheosense.com/what-is-viscosity

RheoSense.inc (n.d). *Viscosity of Newtonian and Non-Newtonian fluids.* Retrieved November 20, 2020 from https://www.rheosense.com/applications/viscosity/newtonian-non-newtonian