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Research on Concentration Conditions at which the Deceleration Efficiency according to the Temperature of a Non-Newtonian Fluid Is Maximized

1. The Necessity of Our Research

1) The seriousness of traffic accidents caused by speeding

More than 200, 000 traffic accidents occur in Korea every year.

-traffic accident analysis system

9 out of 10 pedestrians die when colliding with a vehicle traveling at 60 km/h, but 5 out of 10 people die when colliding at 50 km/h and 1 out of 10 when colliding at 30 km/h.

-pedestrian collision test, Korea Transportation Safety Authority, 2018

2) The application and problem of the speed bump

- arc-shaped
- road pavement materials & rubber, plastic

- excessive impact
- discomfort
- destruction of vehicle

3) Development of smart speed bump using non-Newtonian fluid

Smart speed bump using non-Newtonian fluid is developed to improve the discomfort caused by speed bumps while still serving their primary purpose of speed control. To contribute to the development, we did a research on concentration conditions at which the deceleration efficiency according to the temperature of a non-Newtonian fluid is maximized.

2. Theoretical background

Newtonian fluid: a type of liquid that has a constant relationship between shear rate and shear stress when temperature and pressure remain constant

Non-Newtonian fluid: a type of liquid that doesn't have a consistent relationship between shear rate and shear stress when temperature and pressure are constant

Shear-banding: a type of phenomenon when a fluid separates into layers with different shear speeds while flowing

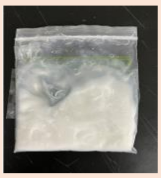
Shear-thickening: a type of phenomenon where the viscosity of the fluid significantly increases as shear stress or processing speed goes up

Pipe-flow(Press fluctuation): a type of phenomenon where highly concentrated suspensions exhibit flow instability not only where shear-thickening occurs but also throughout the overall flow velocity

Oobleck: a non-Newtonian fluid made from a mixture of starch and water

3. Research Method

1) Oobleck Production Process



(1) To make Oobleck 1, measure 14g of potato starch in a 100 mL beaker using an electronic scale.
(2) Use an electronic scale to measure 56 g of water into another 100 mL beaker.
(3) Put the measured potato starch into the PE zipper bag first, then slowly add the measured water while mixing with a glass rod.
(4) After removing as much air as possible from the PE zipper bag, seal it.
(5) Use Scotch tape to reseal the opening of the PE zipper bag.
(6) Label the PE zipper bag with Oobleck using a name pen.
(7) Create Oobleck 2 and Oobleck 3 using the same method.

	Oobleck 1	Oobleck 2	Oobleck 3
potato starch(g)	14	40	56
water(g)	56	30	14

2) Setting up Experimental Equipment

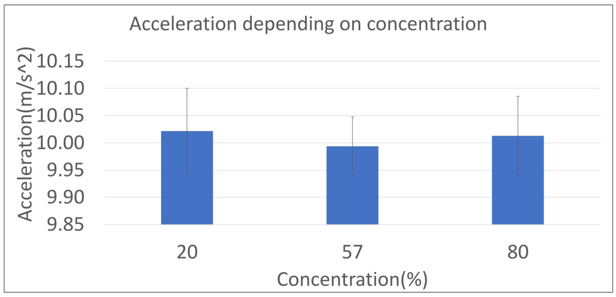
(1) Secure one spring clamp to each of the two laboratory stands using clamp holders.
(2) Ensure that the spring clamps are aligned horizontally and secure the G-clamp between them.
(3) Adjust the height of the G-clamp to be 11 cm above the horizontal surface.
(4) Place one end of the rail on top of the G-clamp to support it and install the remaining two rails on the horizontal surface in a way that they meet the inclined rail. Position the rails so that the 120 cm mark is aligned with the end closer to the G-clamp.
(5) Place steel plates on both sides of the two rails to fix them and prevent any shaking.
(6) Fix the Oobleck contained in the zipper bag between the two flat rails using tape.

3) Acceleration Measurement Process

(1) Place a 250g weight on the PASCO Wireless Smart Cart and position the rear of the cart at the 80 cm mark on the inclined rail.
(2) Release the cart and use the built-in acceleration sensor to measure acceleration in the x, y, and z axes.
(3) Repeat the measurements five times for each type of Oobleck.
(4) While the smart cart passes over the speed bump made of Oobleck, record the data by averaging the x, y, and z-axis accelerations.

4. Research result

1) Acceleration depending on concentration



As a result, the post-collision acceleration was minimal, with values of approximately 50%, 80%, and 20% in sequence. Consequently, it can be concluded that the ride comfort is good in this order.

5. Conclusion

Oobleck, known for its momentary rigidity and ability to withstand strong impacts, can be utilized in creating smart speed bumps. These bumps vary in strength based on vehicle speed, maintaining fluid properties for low-speed vehicles to enhance ride comfort and reduce vibration. However, for high-speed vehicles, Oobleck stiffens, providing deceleration effects similar to conventional speed bumps. Optimizing the 4:3 starch-to-water ratio in Oobleck experiments enhances ride comfort.

Despite its benefits, Oobleck may not be suitable for regions with high asphalt temperatures, such as Korea in the summer due to transformation. Overall, these advantages may contribute significantly to traffic safety.

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RESEARCH ON THE IMPLEMENTATION OF CLOAKING TECHNOLOGY THROUGH THE FORMATION OF THREE-DIMENSIONAL BLIND SPOTS USING OPTICAL COMPONENTS

The Necessity of Our Research

Many researches about cloaking are going on these days. Just like an invisible cloak, cloaking technology can make things not be seen. This is widely used in the military field in order to deceive the enemy or protect our allies, and researched a lot too.

In order to understand how this is possible, and find out how we can make 3D objects invisible in all three coordinate axes, we decided to implement this technology ourselves.

Understanding the principles and finding out a easier way to actualize this technology will help many follow-up researches using cloaking effect.

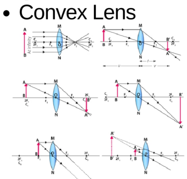
Theoretical Background

A. What is 'Cloaking Effect?'

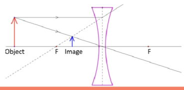
- It refers to the technology of making an object invisible of undetectable.
- The principle of the cloaking is to manipulate the path of waves around an object so that they won't interact it.
- After passing the object, these waves should resume their original state, so that they could be seen like they weren't disturbed at all.

B. Optical Lenses

- Convex Lens



- Concave Lens



C. Implementing 'Cloaking Effect' with Lens

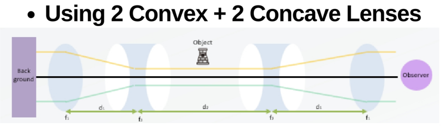
('f' represents the focal distance of each lens, and 'd' represents the distance between 2 lenses.)

- **Using 4 Convex Lenses**

$f_1 > f_2$
$d_1 = f_1 + f_2$
$d_2 =$ doesn't matter

Any object placed here, it can't be seen at the position of the observer as it doesn't block any ray from the background. However, the background image is upside down

- **Using 2 Convex + 2 Concave Lenses**



$f_1 > f_2$
$d_1 = f_1 + f_2$
$d_2 =$ doesn't matter

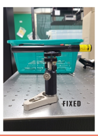
The background image remains unchanged. and the object isn't seen because the ray doesn't go through the object.

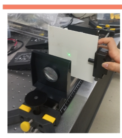
Research Progress

A.Checking the Possibilites in 1 Dimension

1. Fix two lasers

We made a laser stand with a mount and fixed the two laser pointers on the stand. We used small screws on the mount to fix the height and tilt.





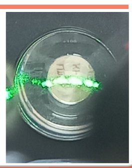
2. Check the focal length of the lenses

On our first experiment, we placed two convex lenses. Distance between them was set to 20cm as the focal length of the lens was 10cm and we need two focals to be placed at one point.

We used two convex and concave lenses for the next experiment. Convex lenses located between concave lenses. In order to place focal points on right points, the distances between each lenses were 5, 10, and 5cm.

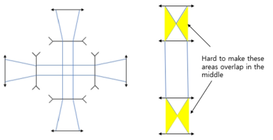
3. Check the existance of cloaking area

A wrench we put between two convex lenses was not visible through the lenses. However, the background image was upside down. When we used 2 convex and 2 concave lenses, the wrench between two convex lenses was still not visible and the background image was upright.

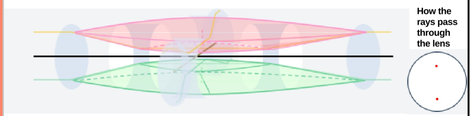


B. 2 Dimensional Cloaking

- Our Expectations



Since the 4 convex lenses idea is much harder to overlap the 1 dimension cloaking areas together, we chose using the 2 convex & 2 concave lenses idea to actualize 2 dimensional cloaking.



This is the 3D picture about our 2 dimensional cloaking expectation. Since the cloaking area isn't made in every direction, we can't call this as 3 dimensional cloaking.

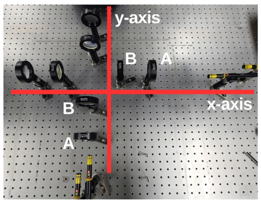
When the sets of 4 lenses are placed in a circle, the cloaking lens area will look like 2 truncated cones, one on the top and one on the bottom part. We'll saw whether this was possible.

- Actual Experiment & Result

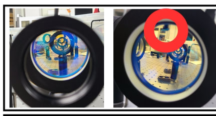
Experiment Process

1. Lain 2 lasers parallel, and set the height same as the lenses.
2. Based on the lasers, fix the position of the lenses considering the focal distance, type, and order.
3. Check whether the cloaking zone is formed in 1 dimension.
4. Repeat 1~3 for the axis perpendicular to the first sequence of lenses.
5. Check whether the cloaking zone is formed like our expectation.

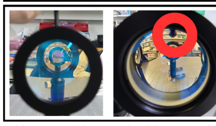
Making the 1 dimensional cloaking area



Making 2 dimensional cloaking area



Checking cloaking effect of the x-axis -> It works!



Checking cloaking effect of the y-axis -> It works!

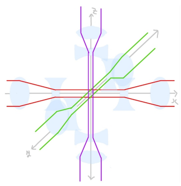
Checking at position A Checking at position B

We checked the lowest height that the object can become invisible in front of the concave lens, and maintained the height in order to check the cloaking area of the middle.
-> **truncated cones**
By this progress, we could **find out the cloaking area in 2 dimensions corresponds with our expectations.**

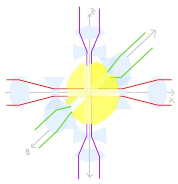
C. 3 Dimensional Cloaking

Our original goal was to build a 3-dimensional cloaking device. However, we didn't have the exact equipment that could make lenses float on the z-axis.
Instead, we decided to do make a simulation of the 3 dimensional cloaking, and expect the shape of the area based on what we have learned and found out from the previous experiments.

We replaced the experiment with an actual device with thought experiment. Rays that enter the device will go through them as shown on the drawing.



How the direction of the rays look like



How the cloaking area looks like

The cloaking area is formed as if the truncated cones from the 2 dimensional cloaking has rotated 360 degrees. It looks like a **sphere with small tunnels breaking through**, since the rays have to pass by.

Conclusion and Reflections

A. Conclusion

We visually verified that cloaking areas are created by the sets of lenses through these experiments. Then we made **2-dimentional cloaking device and designed 3-dimentional one with multiple two-concave-and-two-convex-lenses devices**, which don't have any crossing point on rays' way. 2-dimentional device experiment was succesful, and we might try building 3-dimentional one later, too.

B. Reflections

It was a hard job to fix the lasers on proper positions. **To achieve tight lock, We tried various types of pedestals, and finally found a modest one.** The background was bent, the light coming from the laser was too blurry. The reason of this is **'Aberration'**, which is caused by the imperfection of the lens. Aberrations can be divided into chromatic aberrations and monochromatic aberrations