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Recreation of the Galileo Spacecraft Accident Using Cold Welding

I. Introduction

1. Motivation of Selction

We learned about the Galileo spacecraft accident and its cause, cold welding. Recreating the accident is as important as analyzing its cause. We decided to **reproduce the Galileo spacecraft accident**. Additionally, we planned to **measure the force between cold-welded interfaces**.

2. Experimental

A. Cold welding
Cold welding is a process where two clean, flat surfaces of metal strongly adhere if brought into contact while in a vacuum without fusion or heating at the interface.

B. Galileo spacecraft accident
It is an accident in which the Galileo spacecraft's antenna, HGA, got broken because of cold welding.

II. Materials and Methods

Reproduced cold welding phenomenon with titanium and indium, and measured the force of the welding.

1. Materials and Equipment

a vacuum chamber, a vibrating table, indium plates titanium plates, sand paper, weights, Pasco force sensor

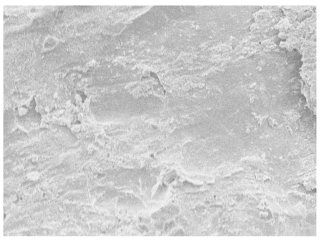
2. Experiment

Experiment A.
1. Cold-weld the indium plates using the vacuum chamber
2. Observe the metal surfaces using SEM
3. Incude galling on the indium plates
4. Observe the metal surfaces using SEM

Experiment B.
Repeat procedure 1~2 of the Experiment A with titanium plates, instead of indium ones

III. Results

Experient A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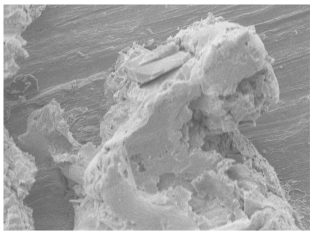
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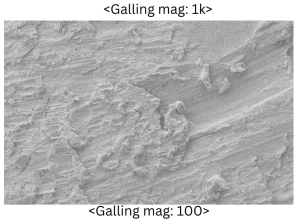
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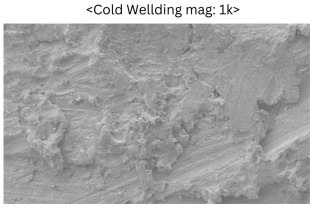
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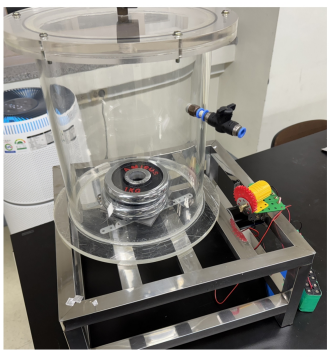
Cross section of cold welding is Clean
However, the cross section of Galling is Lumpy

#1	#2	#3	#4	#5
0.99	0.94	1	1.05	0.97
#6	#7	#8	#9	#10
1.07	1.02	1.11	1.07	1.11
average	1.03	standard deviation		0.05533

We have to get an average in the table.
The average of force is 1.03N

Experiment B

Cold welding using titanium was attempted, but low enough air pressure was not provided as the oxide film was not formed.



IV. Conclusion

1. We can be able to infer that the cause of Galileo Spacecraft accident is coldwelding

2. The force of Indium coldweling is 1.03N

3. We have to do Ti cold wellding by high presure

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Optimizing Microwave Power Transmission Efficiency Based on Humidity Changes

1. Introduction

(1) Research motivation

Space technology is developing, and **minimizing energy loss** in the process of energy transfer to space is an important topic. We will find the relationship between the weather environment and energy propagation on such topics.

(2) Purpose of research

We will analyze the cause by finding the humidity and temperature conditions that **maximize the energy propagation efficiency.**

2. Theoretical Background

(1) MPT

MPT, which is short for **microwave power transmission**, enables wireless energy transfer using microwave frequencies. Electrical energy is converted into microwaves and transmitted using directional antennas. Rectenna receives and converts the microwave back into electricity. It is mostly used at space-based solar power.

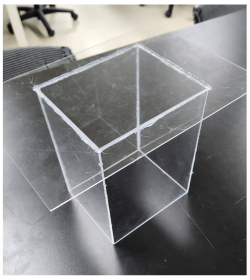
(2) Radio frequency

Radio frequency refers to electromagnetic waves from 3kHz to 300GHz. In MPT, radio frequency waves, particularly in the microwave band, are used to transmit energy efficiently.

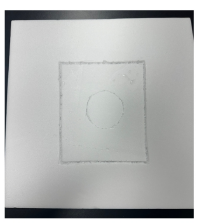
3. Research Process

(1) Make acrylic Box and Styrofoam Board

Cut two acrylic sheets so that the horizontal sides measure 136mm and 161mm, creating four acrylic walls.
After that, use a glue gun to assemble the acrylic box.



[Fig. 2] Processed acrylic box

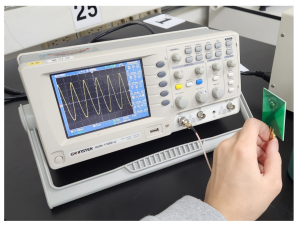


[Fig. 1] Processed Styrofoam board

Using a knife, cut the styrofoam to match the dimensions of the acrylic box.

(2) Connect antenna to oscilloscope

Use an SMA probe connector to connect the SMA female-to-female connector to the oscilloscope. Then, connect the antenna to the SMA female connector.

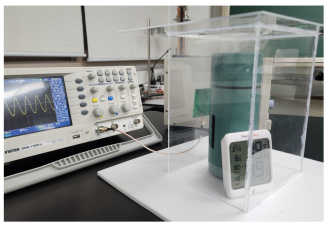


[Fig. 3] Antenna, Oscilloscope

(3) Collect Data

Attach the antenna to the acrylic box at the 13 cm position using tape.

Turn on the humidifier and record the peak values of the voltage graph displayed on the oscilloscope as the humidity increases from 50% to 95%.

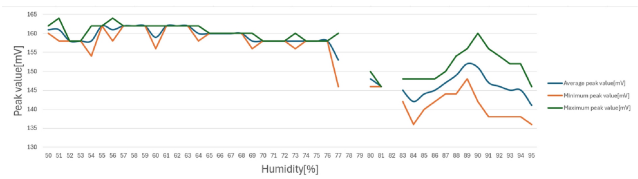


[Fig. 4] Data Collection

Organize the measured data in Excel and create a graph based on the recorded values.

4. Results

While running the humidifier continuously, radio waves through the humidifier were measured using an antenna. And the peak value of the radio wave graph appearing at each humidity was recorded. Using the recorded values, we were able to obtain [Fig. 5] showing the peak value for humidity.



[Fig. 5] Relationship between **humidity** and **peak value**

5. Discussion

Due to a malfunction of the microwave transmitting device, radio waves generated by the humidifier were used, and as a result [Fig. 5] shows the relationship between humidity and received radio wave intensity. In the humidity ranges of 50-55%, 76-84%, and 90-95%, it was observed that the **intensity of radio waves weakened as humidity increased,** which appears to be due to electromagnetic wave scattering by water vapor molecules. The reason the graph is cut off in the 75-84% range is because of the humidifier's intermittent **turn-off function.** The increase in radio wave intensity in the 84-89% range is believed to be because radio waves of certain frequencies are better absorbed depending on the water vapor concentration. Since radio waves were used, the peak value range will be different in experiments using microwaves.

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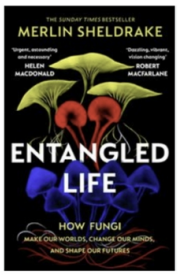
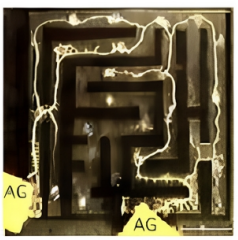
Research on the phenomenon of fungi spreading through the shortest path

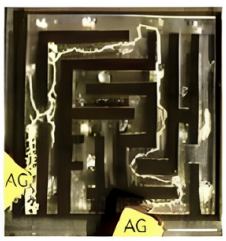
1. Research Motivation and Purpose

We read the book below and learned that the path becomes the shortest path when the hyphae are repeatedly grown.

So we wanted to see if the bacteria were growing in the medium to see if they were closer and closer to the shortest path by repeatedly culturing them several times.







[Fig. 1] a book read [Fig. 2] the path of progression of hyphae

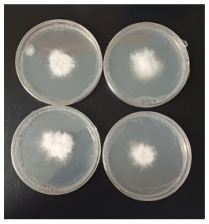
2. Theoretical Background

Mycelium, the thread-like vegetative part of fungi made of filaments called hyphae, absorbs nutrients by breaking down organic matter. Mycelium of the oyster mushroom (Pleurotus ostreatus) grows rapidly in moist, nutrient-rich environments like wood or agricultural waste, thriving at 20-23°C. Known for its strong decomposition abilities, it is widely used in mushroom cultivation, bioremediation, and as a sustainable material for eco-friendly products like biodegradable packaging and leather substitutes. Mycelium also forms a "Wood Wide Web," exchanging chemical signals and nutrients with plants and other fungi to share information about stress, pathogens, and resources, enabling a cooperative communication system.

3. Experiment Procedure

1) Cultivating oyster mushrooms

The oyster mushroom mycelium will be obtained from KCTC.



[Fig. 3] Cultured Oyster mushroom

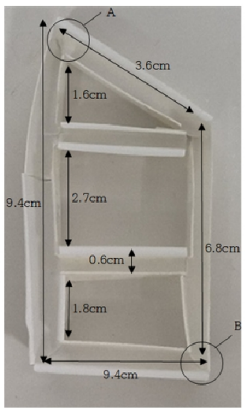
[Fig. 4] Oyster mushroom

The oyster mushroom strain will be transferred and cultured onto multiple media using an inoculating loop.

2) Maze construction

Construct the maze by using () like [Fig. 5].

The MEA culture medium is poured onto the maze paths inside the biological safety cabinet (BSC) and allowed to solidify.

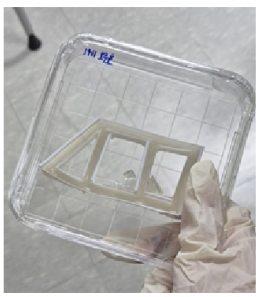


[Fig. 5] The maze 1

3) Strain inoculation

The oyster mushroom strain is inoculated at position A, and a pine wood fragment collected from outside is placed at position B.

The growth of the mycelium is observed at regular time intervals, and the above experimental process is repeated approximately three times.

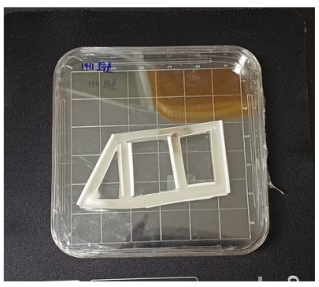


[Fig. 6] The maze 2

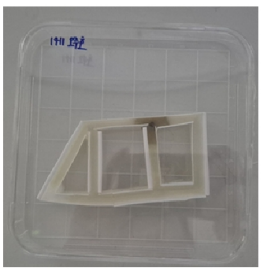
4. Experiment Results and Conclusion

The fungi grew 3 cm at a rate of 0.4 cm per day along two paths, aiming to confirm the shortest route to a wooden block. The next step involved testing fungal behavior in a 3D truncated icosahedron structure. However, the experiment was inconclusive due to time constraints and delayed delivery of fungal strains. Pre-activated strains and backup media were prepared, but growth remained insufficient. Inadequate sterilization or microorganisms in the wood, caused contamination which was observed on the wooden block.

To prevent this in future studies, the wooden block will be thoroughly sterilized and coated with a solidified culture medium for more reliable results.



[Fig. 7] Result 1



[Fig. 8] Result 2