Impulse-driven Capsule by Coil-induced Magnetic Field Implementation

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Outline

- Background
- Theoretical Analysis
- Experiments and Results

Background

Human body ….Composed of soft tube

Traveling capsule

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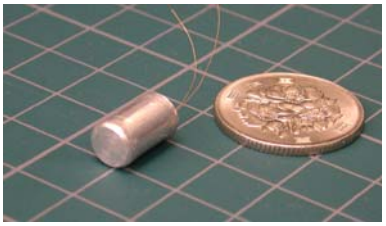
Useful for medical treatment

Traveling on a Elastic Material

Our Three Main Goals

- Make it smaller
- Heat evaluation
- Speed up

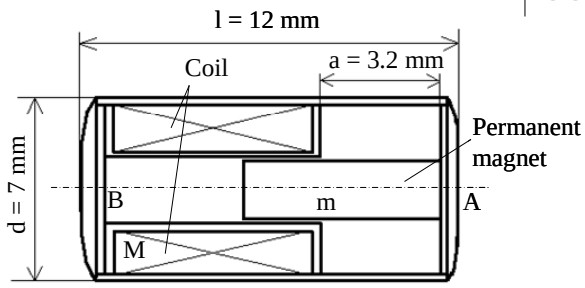
Traveling Capsule



Size : 12 (mm) × ϕ 7 (mm)
Weight:1.12 (g)

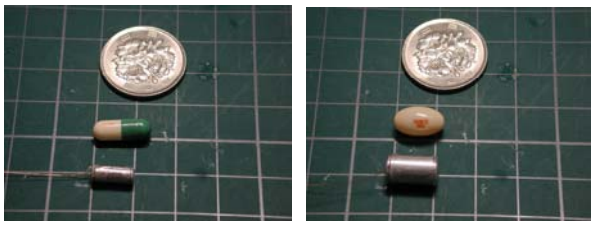
Coil :0.05(mm)
:200 turns

Inside of our Capsule



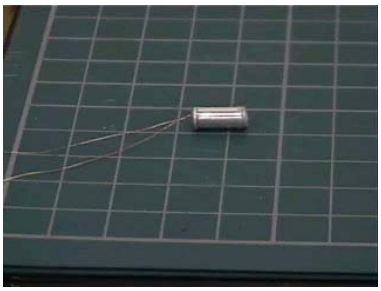
Traveling Capsule

- Similar size of medicine capsule



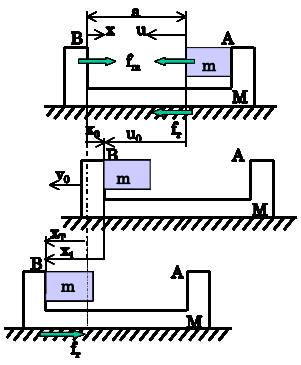
Traveling Small Capsule

- diameter: 4mm



Theoretical Analysis

Traveling Mechanism of the Capsule

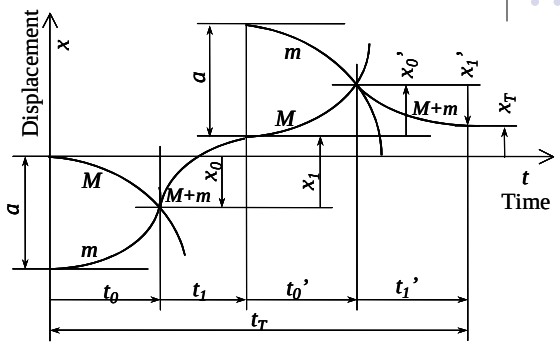


(i) M and m are accelerated by magnetic force f_m

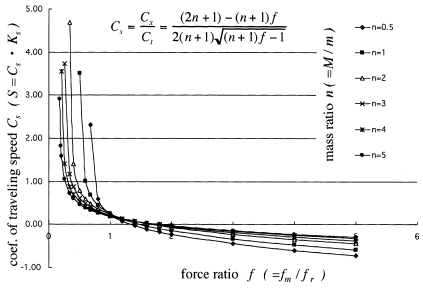
(ii) After collision, M and m move together with v_0

(iii) M and m are decelerated by friction force f_r until they stop

Result of Analyzed Motion

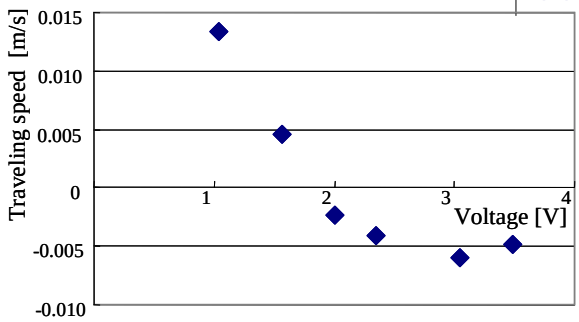


Speed-force characteristics



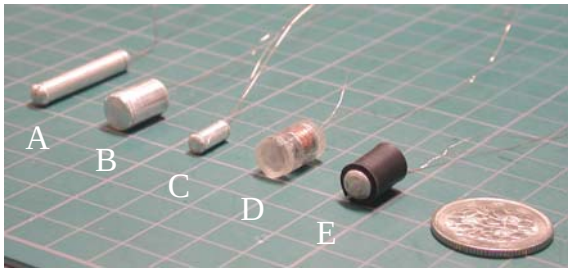
Experiments and Results

Speed Characteristics Measured in the Experiments



capsule: aluminum, d=7mm, on dry plastic plate

Capsules Made for Comparison of Heat



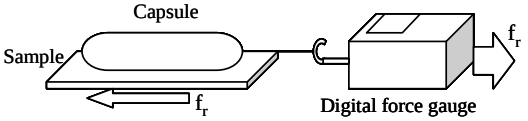
A:Big, B:Thick, C:Small, D:Acryl, E:Rubber,

Capsule Surface Temperature

（capsule speed: 10mm/s, room temperature: 18°C）

Capsule	1 minute	2 minutes	3 minutes	Current	Voltage
A (l = 30 mm)	25.5 °C	25.8 °C	28.8 °C	0.55A	4.19V
B (d = 8 mm)	22.5 °C	22.5 °C	22.5 °C	0.12 A	1.22V
C (d = 4 mm)	22.0 °C	23.0 °C	23.3 °C	0.24 A	1.13V
D (acryl)	24.6 °C	25.1 °C	26.2 °C	0.09 A	0.91V
E (rubber)	27.3 °C	30.0 °C	35.5 °C	0.25 A	2.13V

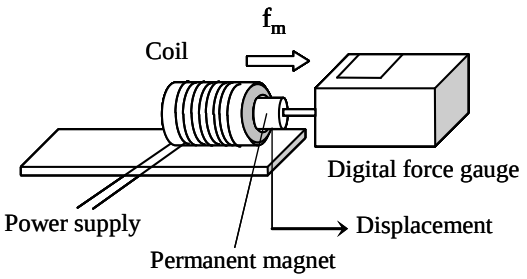
Setup for Measuring Friction Force



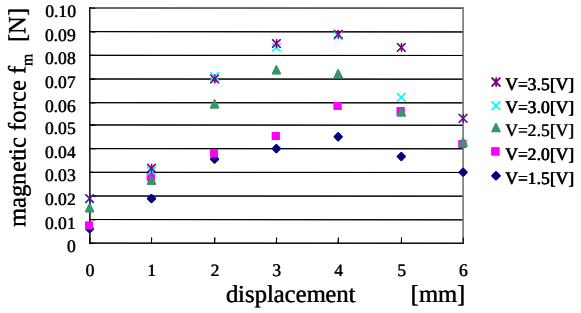
Summary of Friction Force Measurements

Capsule	Aluminum			
Sample	Rubber plate	Phantom		Plastic plate
Sample condition	Dry	Dry	Wet	Dry
Friction force f_r[N] (Average of 10 measured values)	0.020	0.015	0.018	0.005
Standard deviation	0.0034	0.0021	0.0016	0.0004

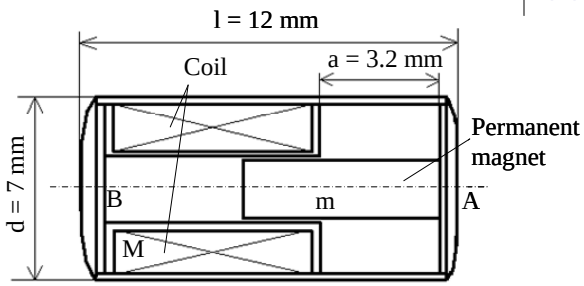
Magnetic Force Measurement



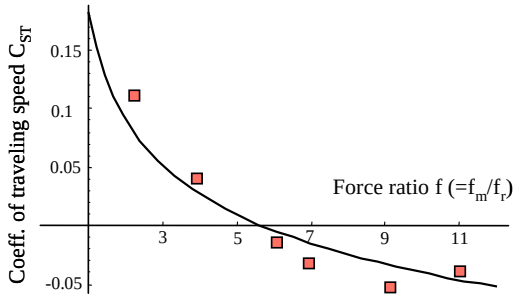
Displacement-force characteristics



Inside of our Capsule

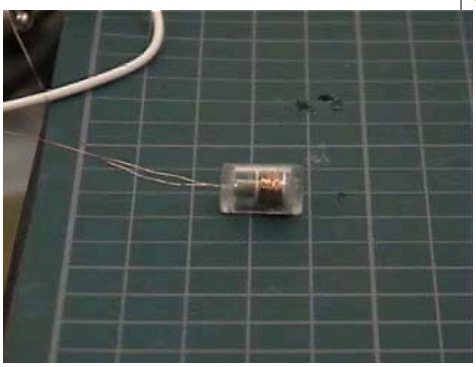


Capsule Speed Characteristics (Calculation) and Experimental Results (■), on Dry Plastic Plate



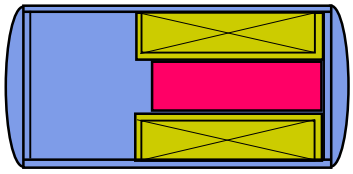
Traveling Capsule

- Acryl



How it works

- Outer shell moves by inner magnet motion



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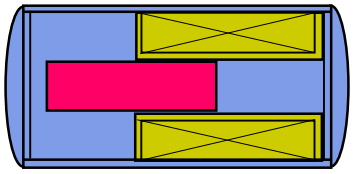
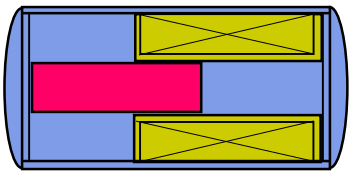


How it works

- Outer shell moves back a little by inner collision



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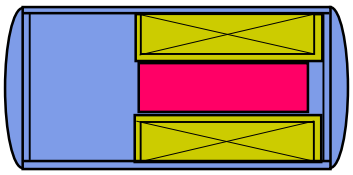
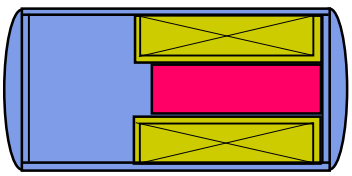


How it works

- Outer shell proceeds by inner collision



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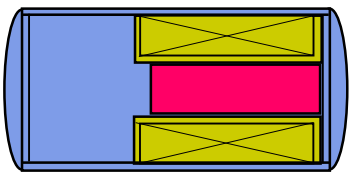

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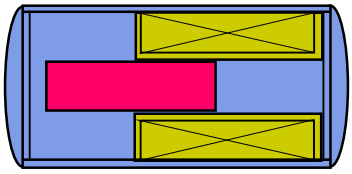

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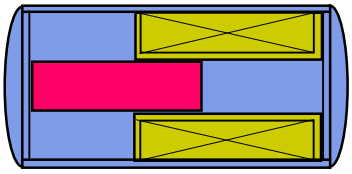

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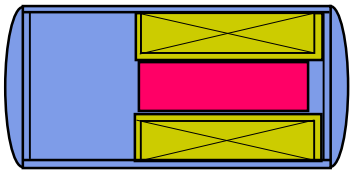

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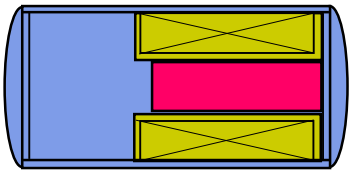
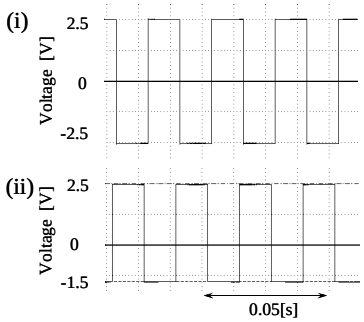


Improvement of Input Voltage Waveform



(i) conventional (ii) proposed

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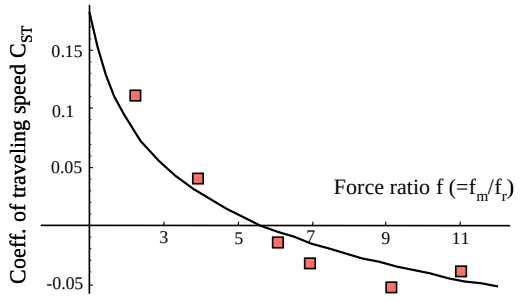

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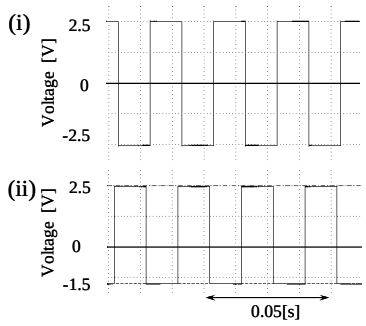
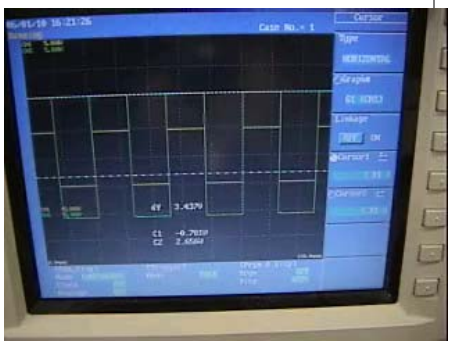


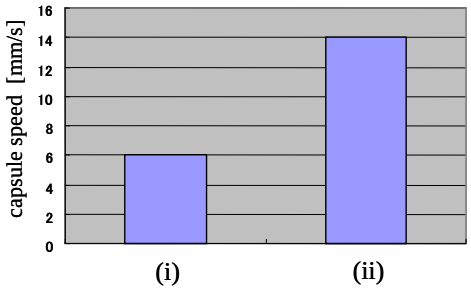
(i) conventional (ii) proposed

Effect of input signal improvement

- experiment(video)



Capsule Speed Improvement



(i) with conventional input wave form

(ii) with proposed wave form

Summary

- Smaller capsule (length 30mm→12mm)
- Thick capsule is advantageous for less heat
- Speed up achieved by new input wave form

Acknowledgement

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