New Method of Evaluating the Flow Properties of Thickening Agents

2013.09.06

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1) Introduction

In recent years, the number of places where viscosity has started to be evaluated has increased.

- Viscosity measurement of blood or bile

- Viscosity measurement to decide the drinking sensation in the throat from soft drinks

- Viscosity measurement relating to eating or swallowing ⇒ possibly triggering pneumonia in the elderly
  - Viscosity of food products is an influence
  - Viscosity management at care facilities or the performance of commercially available thickening agents are problems that have arisen recently

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2) Aim of new product development

Thickening agents: Xanthane gum
CMC (carboxymethyl cellulose)
HPC (hydroxypropylcellulose)
Lecithin

A rheometer is proposed as a new tool for evaluating these and other agents

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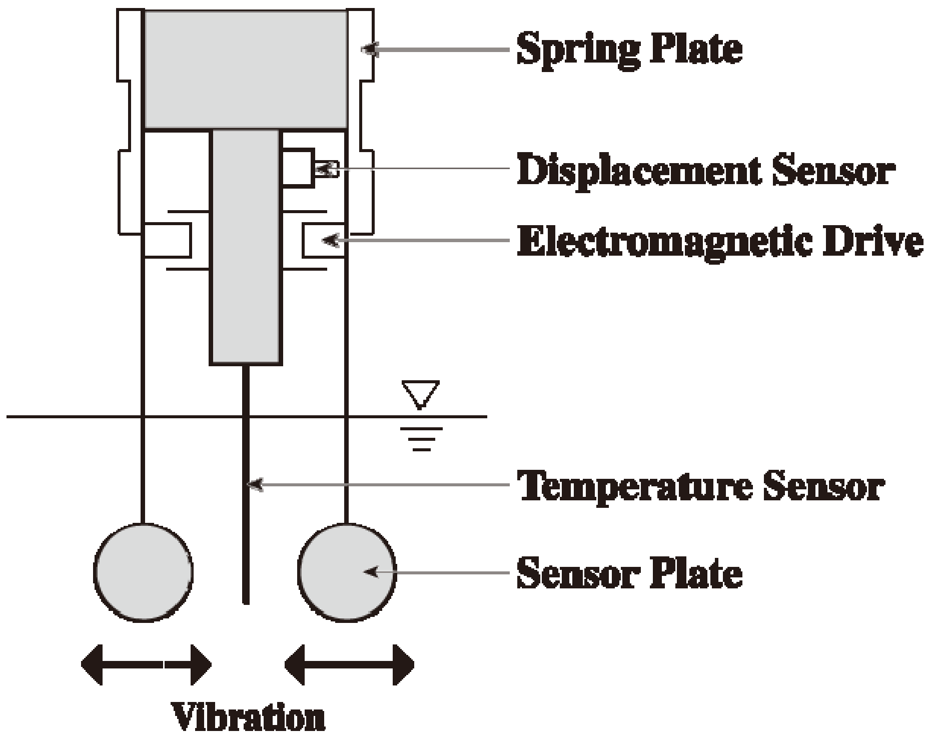
3) Measurement principles



Theoretical model

Rz is the mechanical impedance the sensor plates receive from the liquid

$$R_z = A\sqrt{\pi f \eta \rho}$$

f: vibration frequency (Hz), A: surface area of both sides of the sensor plates,
η : viscosity of liquid, ρ : density of liquid

If the force by which the electromagnetic driver gives the fixed vibration velocity $Ve^{i\omega t}$ to the sensor plates is stated as F:

$$R_z = \frac{F}{Ve^{i\omega t}} = A\sqrt{\pi f \eta \rho}$$

The force generated by the electromagnetic driver is proportional to the product of viscosity η and density ρ.
F generated by the electromagnetic driver is found with the following formula:

$$F = I \times B \times l$$

I: drive current (A), B: density of magnetic flux (T), l: coil length (m)

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4) Product appearance and sensor specifics

RV-10000

Constant heat water tank

Anti-vibration table

Enlargement of sensor unit

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5) Static viscosity

① Capillary viscometers:
Kinetic viscosity = Viscosity / Density

② Rotational viscometers:
Viscosity

③ Vibro viscometers
Static viscosity = Viscosity × Density

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6) Product Specifications

Measurement method	Tuning fork vibro method/natural frequency 30Hz	
Amplitude range	0.07mm to 1.2mm (at tip of fork)	
Viscosity measurement range	Amplitude (at tip)	Viscosity range
	0.07mm	2,000 to 25,000 mPa・s
	0.1mm	20 to 25,000 mPa・s
	0.2mm	0.3 to 25,000 mPa・s
	0.4mm	0.3 to 12,000mPa・s
	0.6mm 0.8mm	0.3 to 5,000 mPa・s
	1.0mm 1.2mm	0.3 to 3,000 mPa・s
Temperature measurement range	0 to 160°C	
Temperature measurement accuracy	0 to 20°C：±1°C 20 to 30°C：±0.5°C 30 to 100°C：±2°C 100 to 160°C：±4°C	

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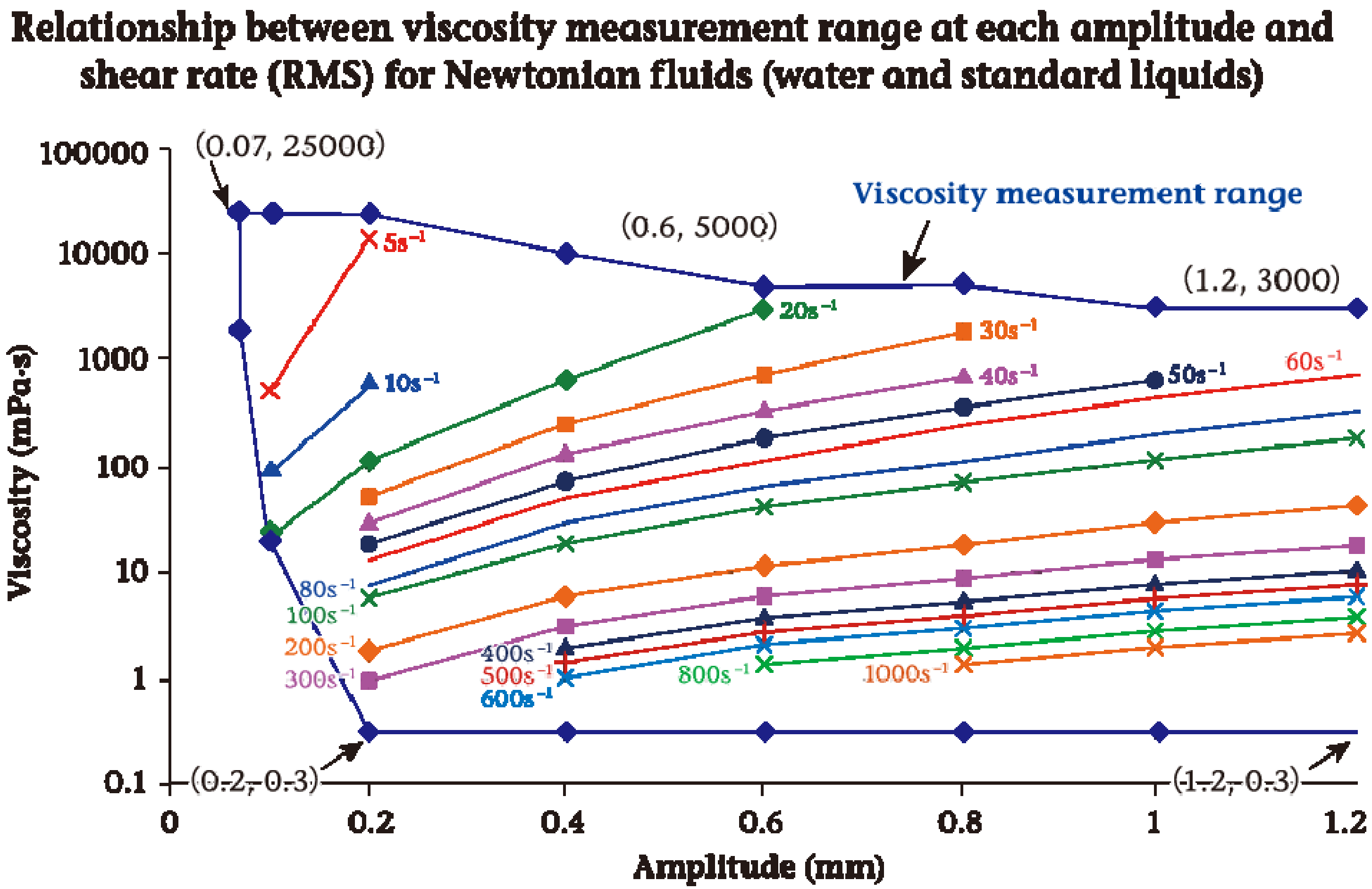
7) RV10000: Relationship between viscosity measurement range and shear rate



Repetitive vibration in a sine wave is induced on the oscillators (sensor plates).

The shear rate for vibro visocometers is calculated and notated as an effective (RMS) value.

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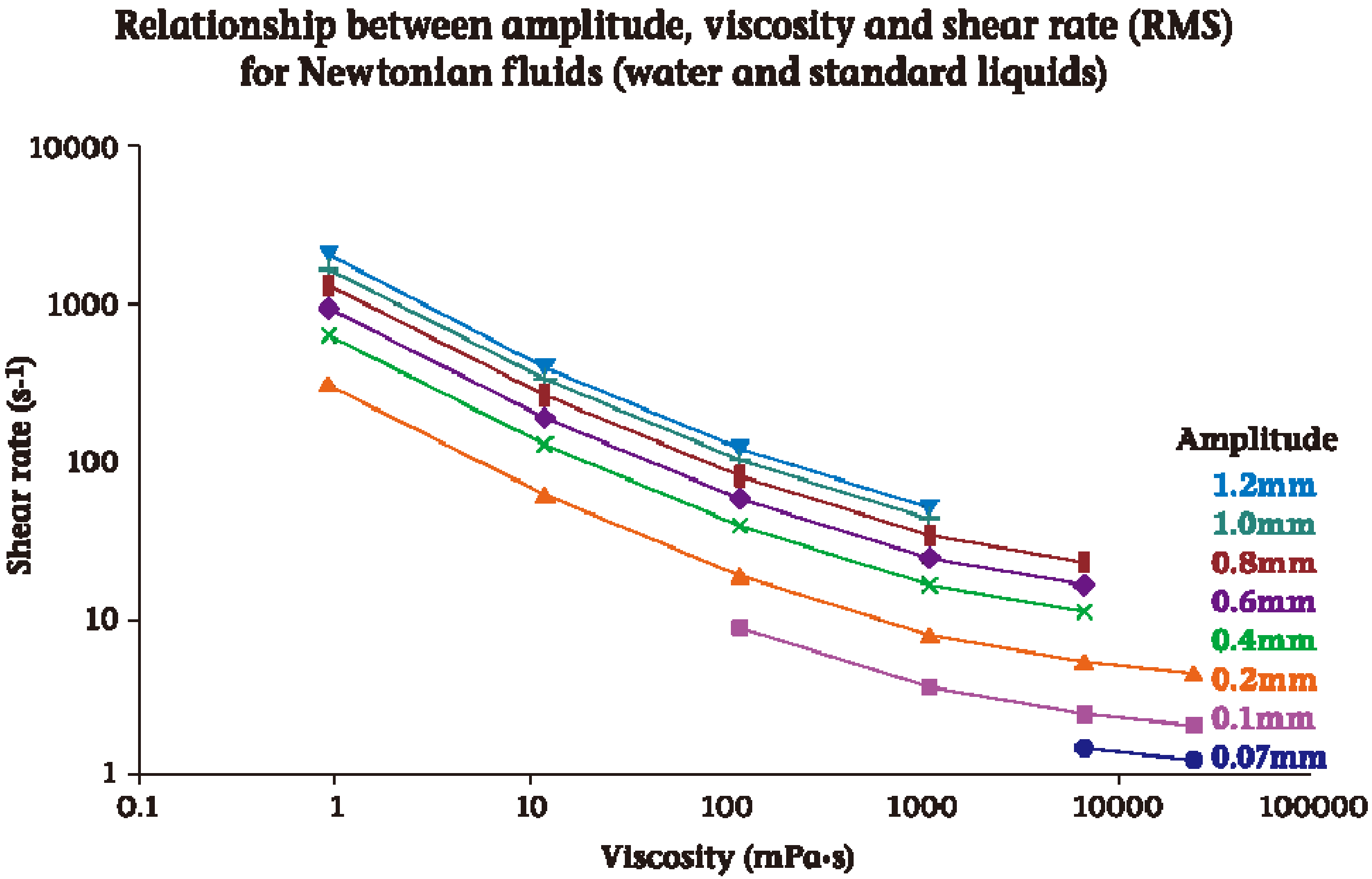
8) RV10000: Relationship between viscosity value and shear rate



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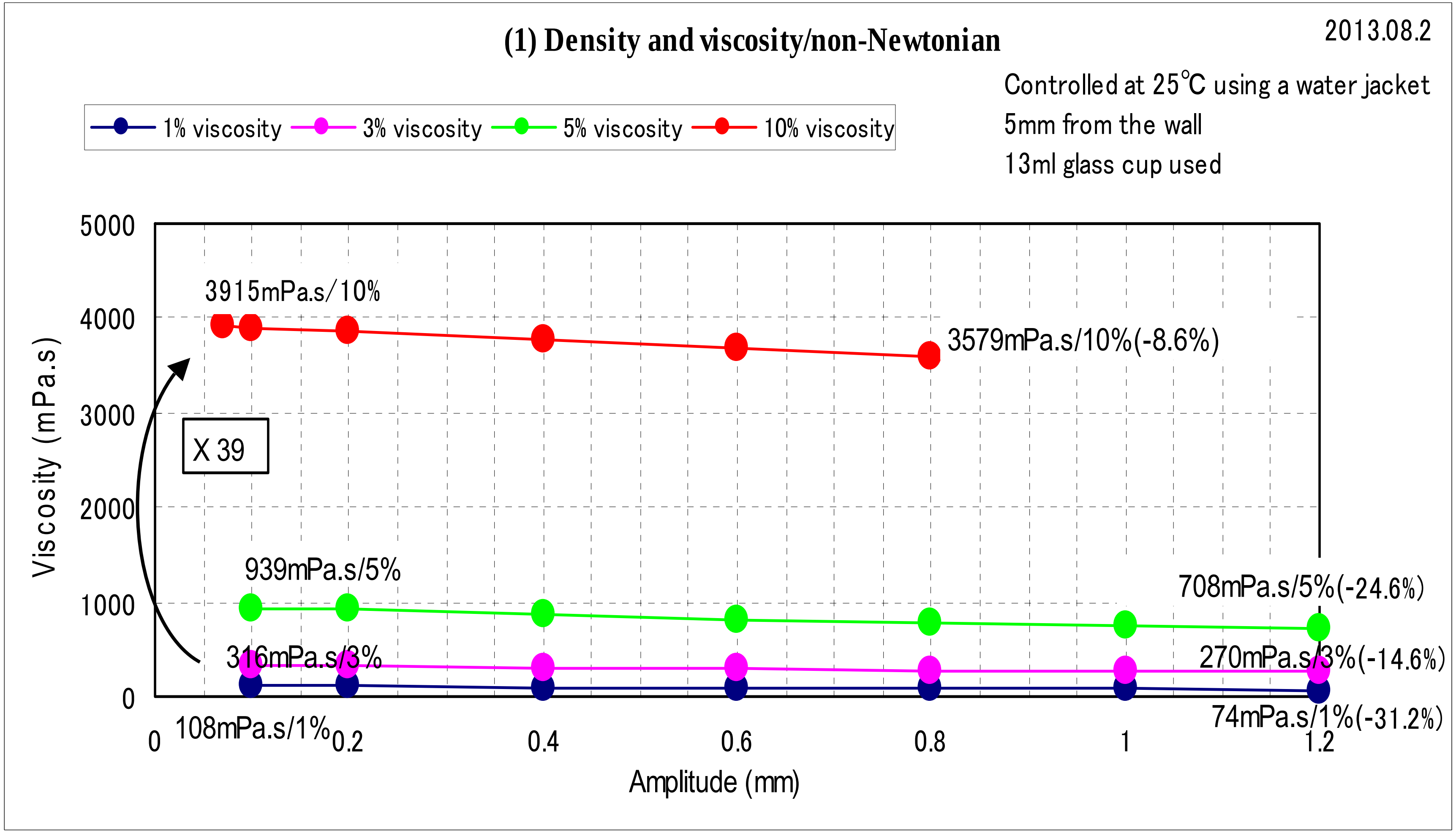
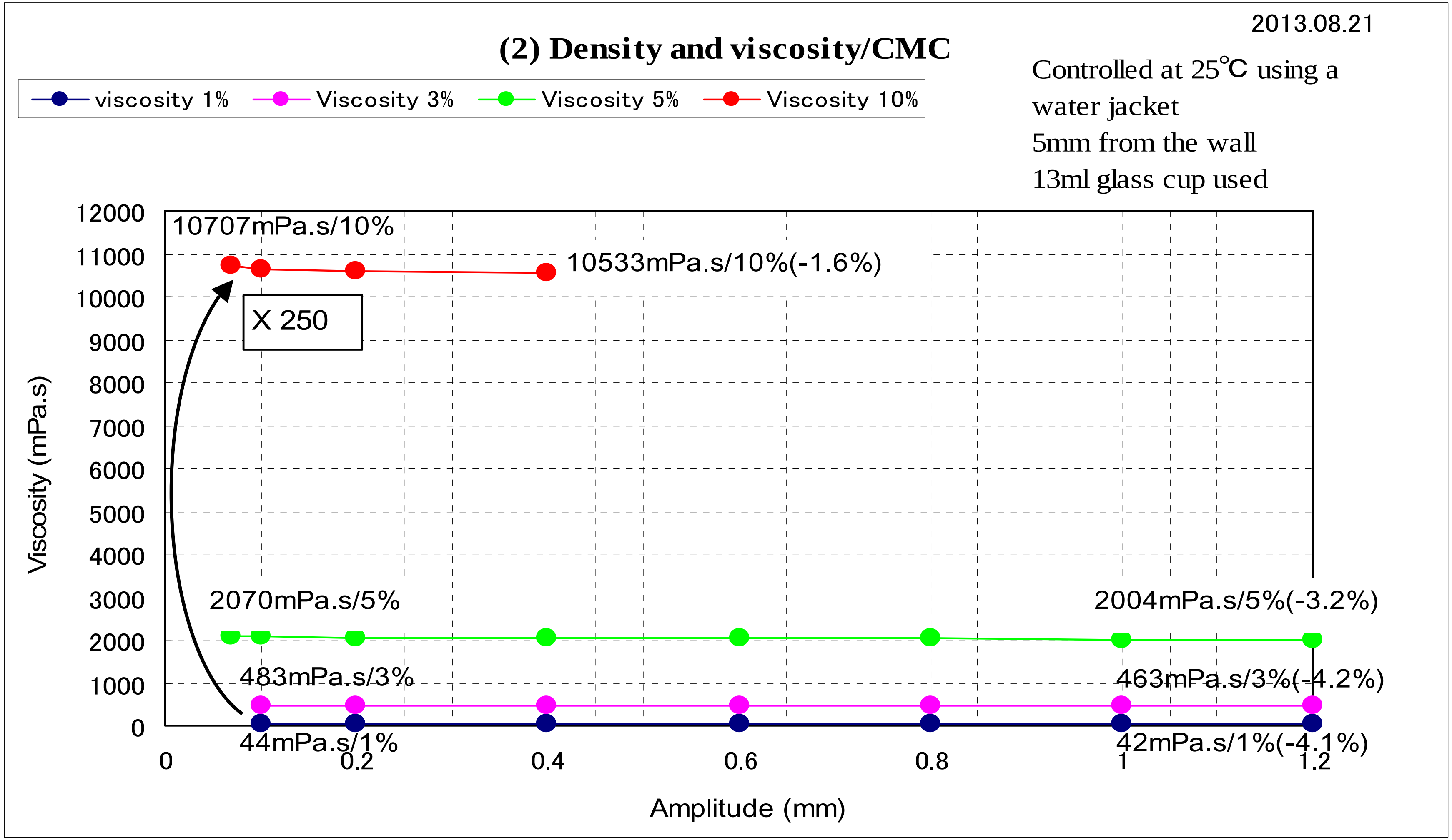
9) Test results　1. Xanthane gum



9) Test results 2. CMC (Carboxymethyl cellulose)



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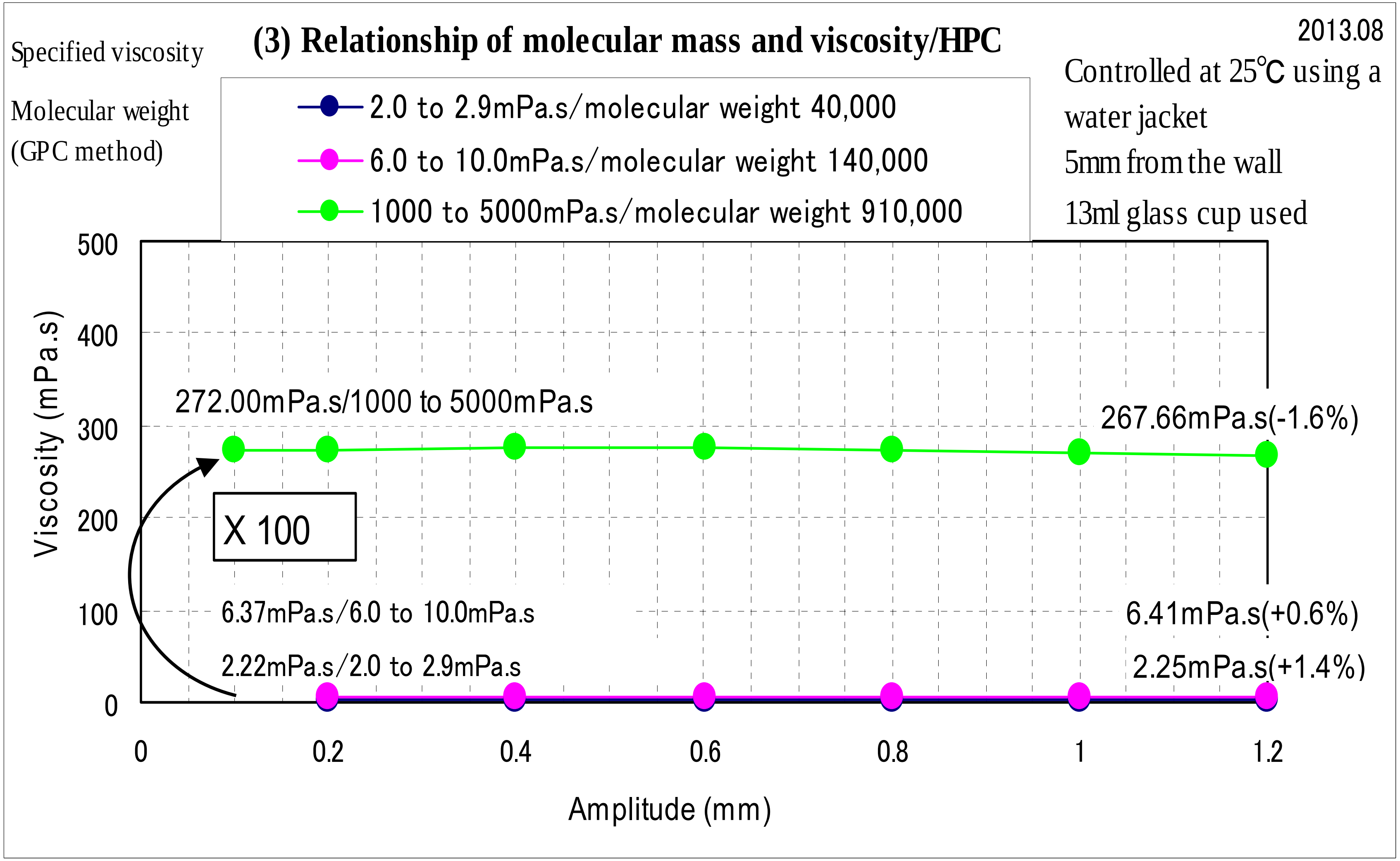
9) Test results   3. HPC (Hydroxypropyl cellulose)



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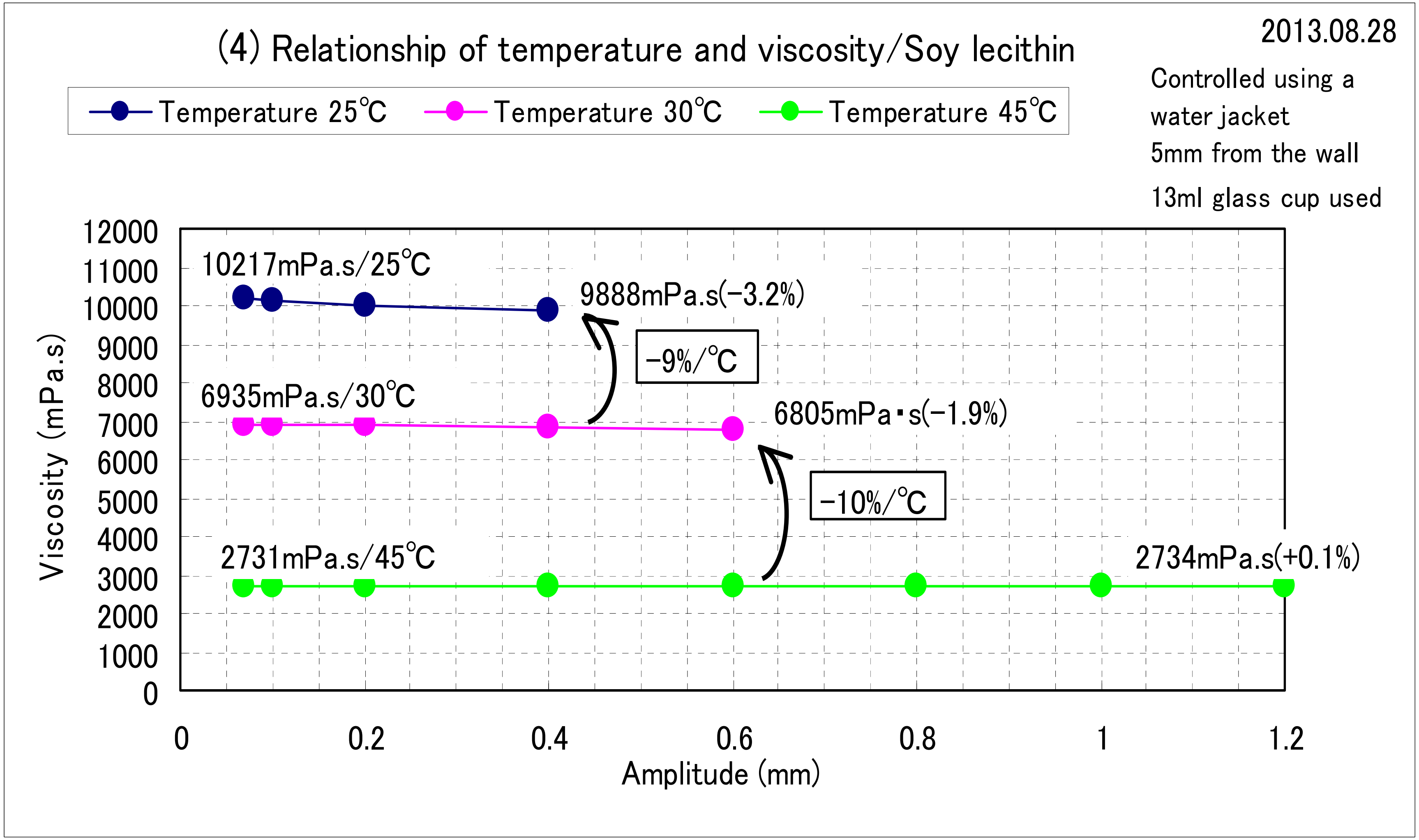
9) Test results 4. Lecithin



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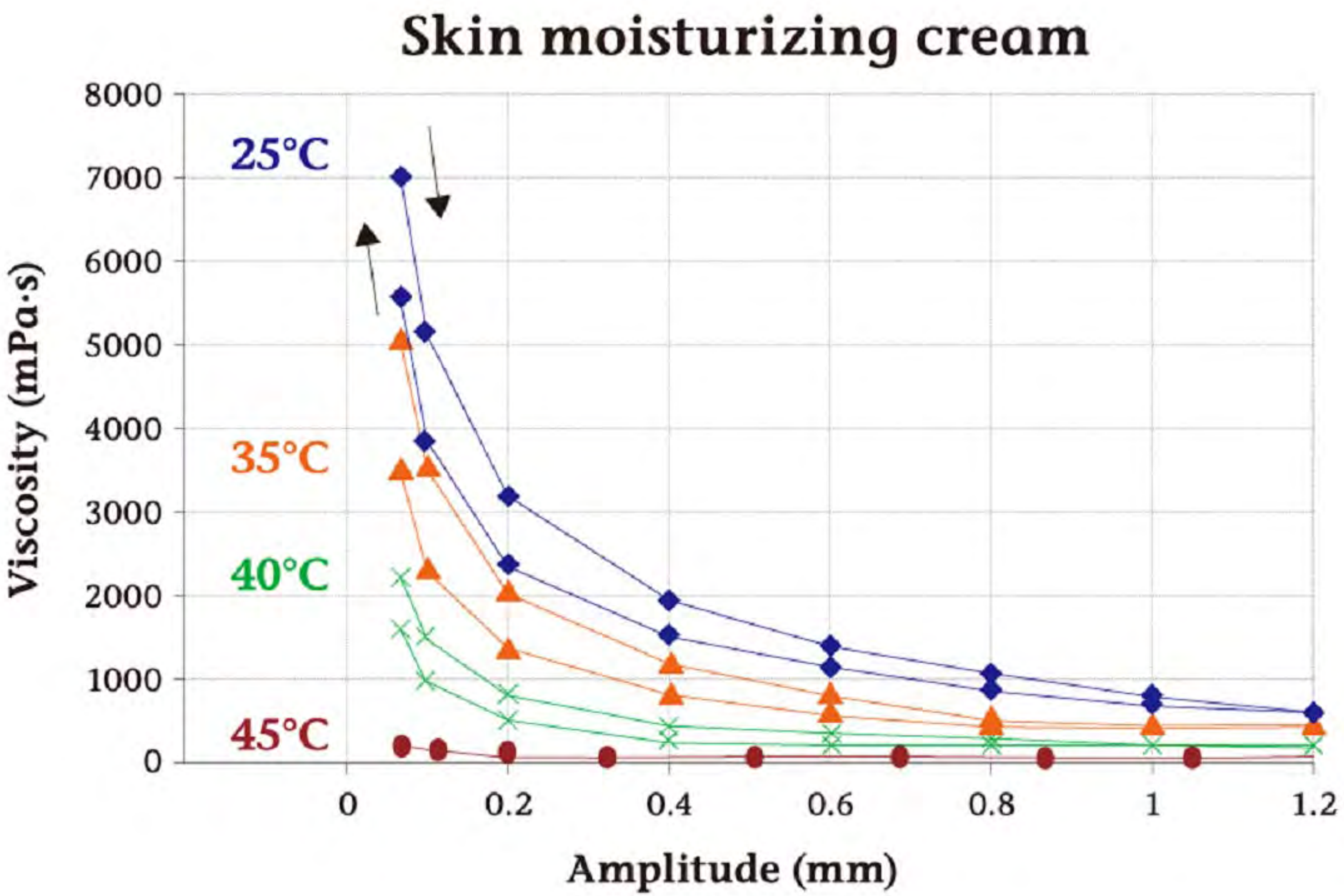
9) Test results　5. Moisturizing skincare cream



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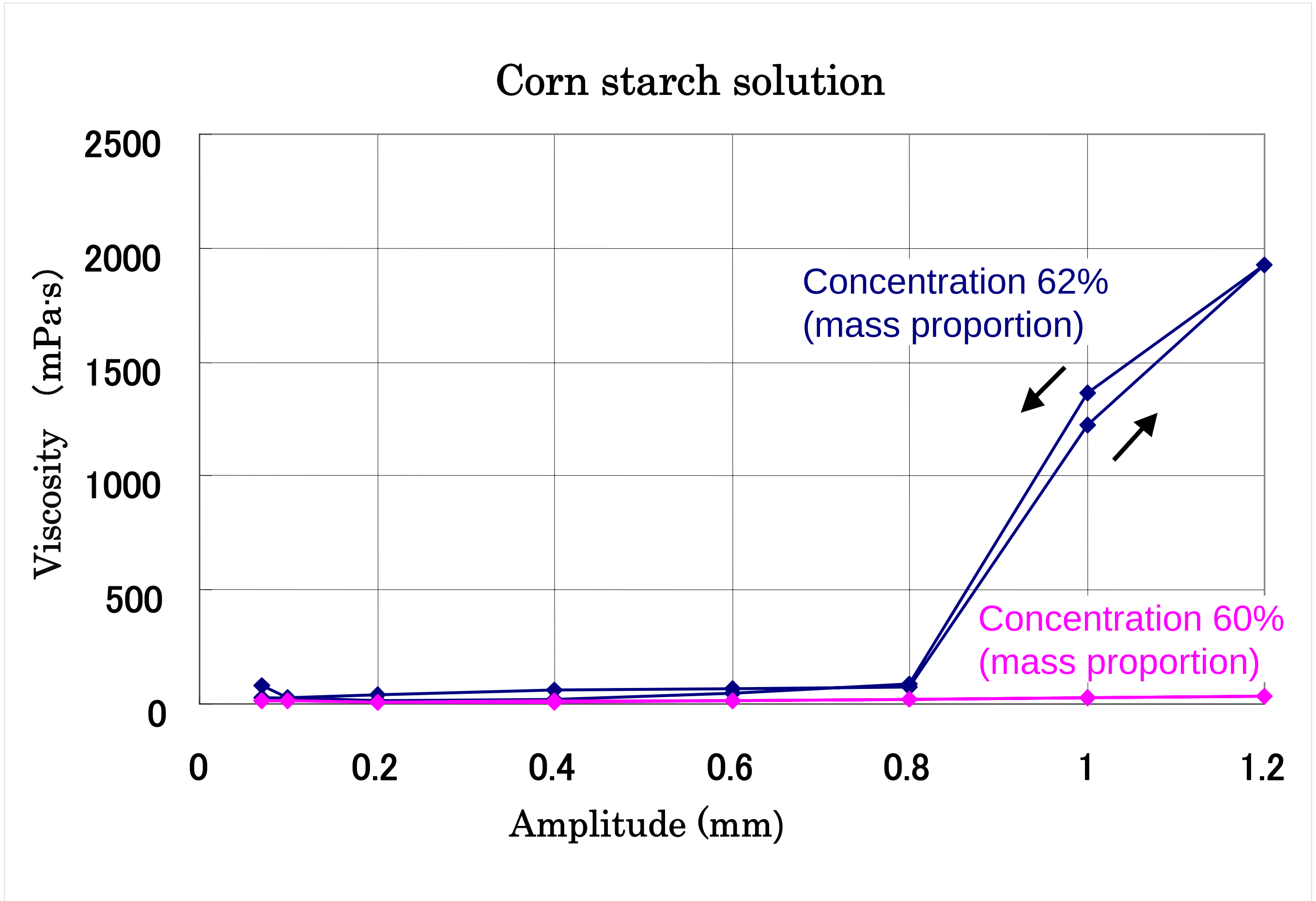
9) Test results 6. Cornstarch

(5) Measurement example of a Dilatant fluid - 1



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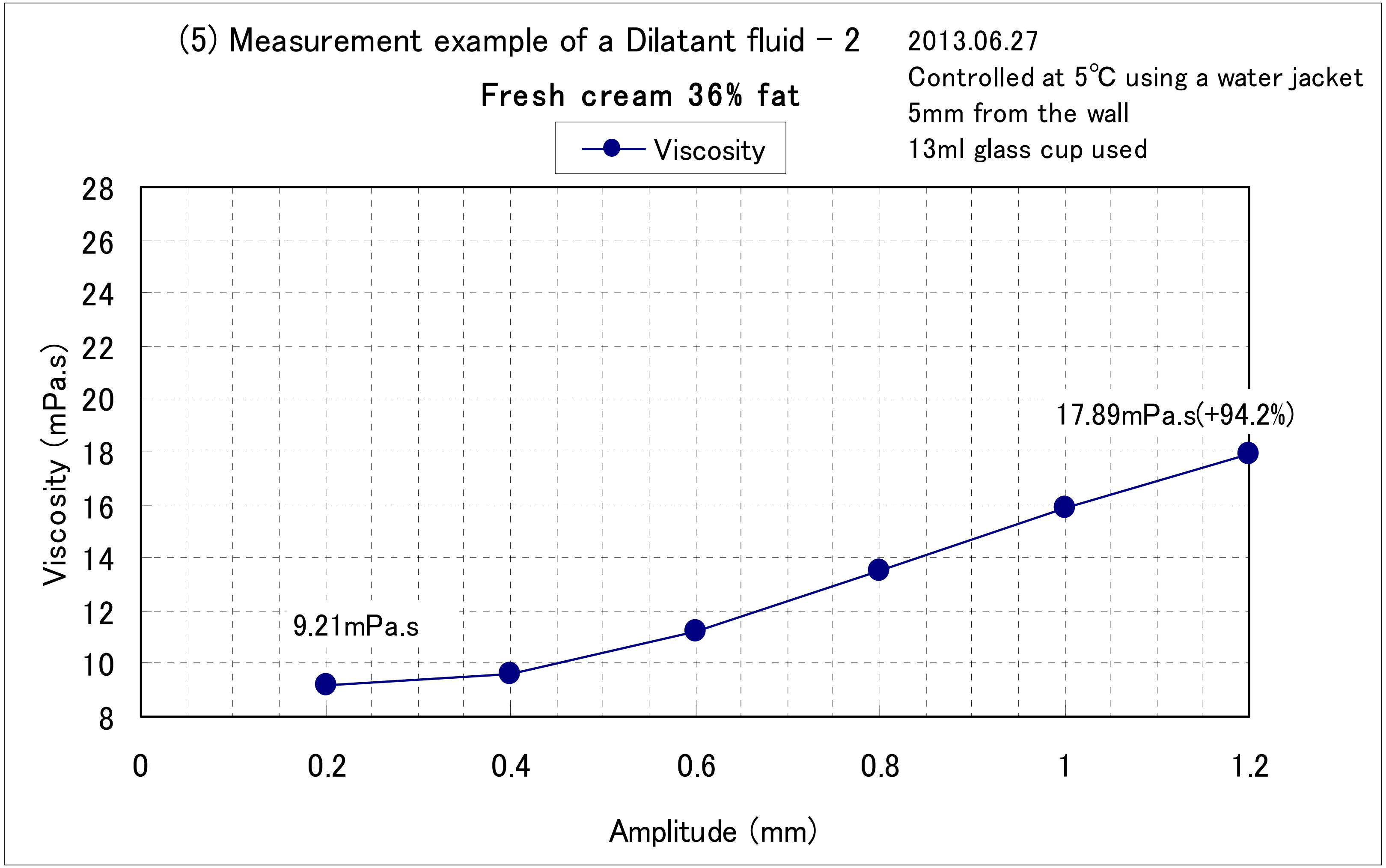
9) Test results 7. Fresh cream



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10) Conclusion

Measurement results for each thickening agent

- The difference in viscosity value attributable to the difference in density was confirmed in a short amount of time. In particular, the increase in viscosity for CMC when the density rose was striking.

- A drop in viscosity could be seen in typical thickeners with a rise in shear rate, though they had weak non-Newtonian properties.

- It became clear that HPC was a Newtonian fluid. The results of the testing also revealed that the viscosity value of the high viscosity sample given by tuning fork method was incongruent with the nominal value.

- It was revealed that the viscosity of lecithin dropped approx. 10% with every 1°C rise in temperature. Non-Newtonian properties could also be seen with higher shear rate x lower temperature.

- An increase in the viscosity value by raising the shear rate was confirmed in the cornstarch solution and fresh cream.

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