High repetition rate induction cavity

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Design strategy for high rep-rate cavity

-estimation, design, experiment

(1)Heat load and mechanical design

(2)Electromagnetic Property

Heat load and mechanical design of induction unit

Many layers With Notch

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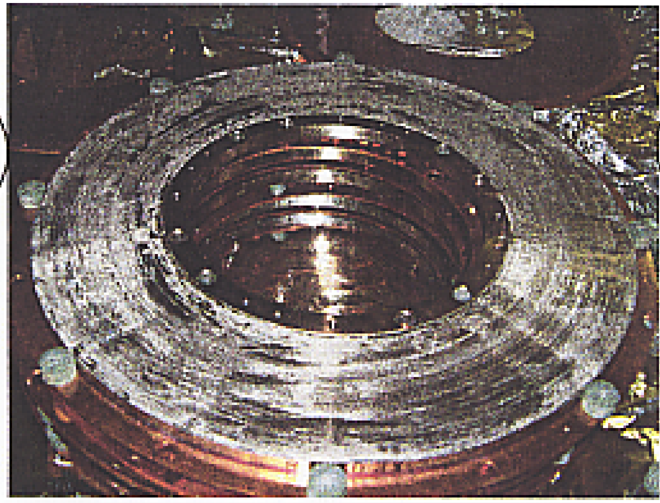
Apply direct cooling



Thin film material =brittle

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Low flow-rate

High heat density 1.2 [MW/m³] 3kW(total)

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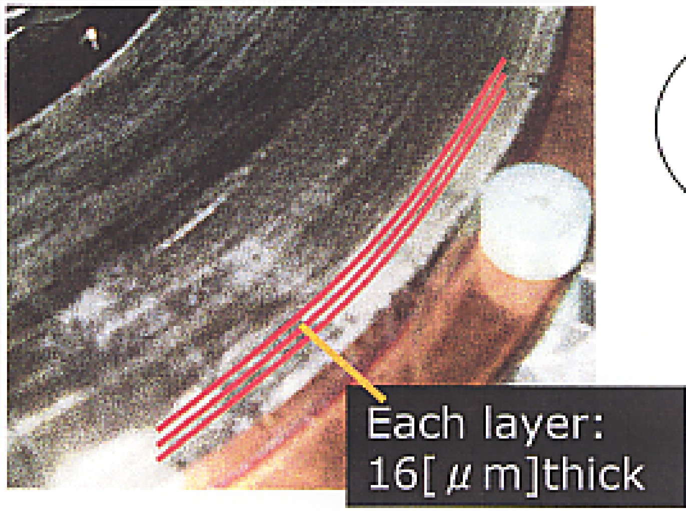
Good cooling efficiency



Pure Fe-based material

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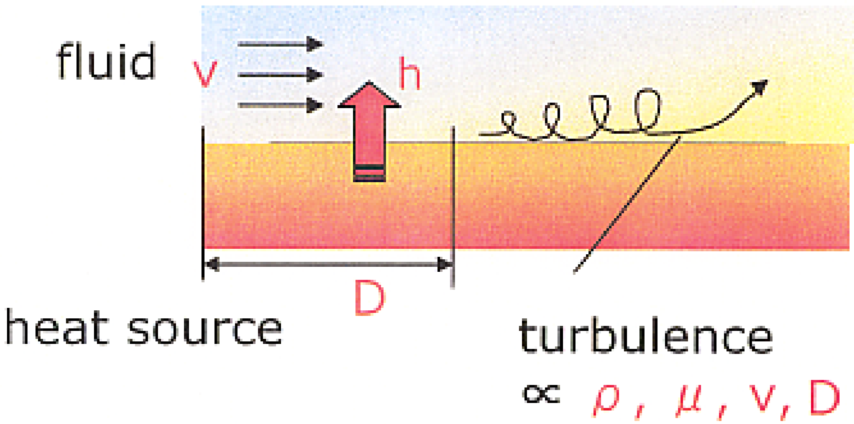
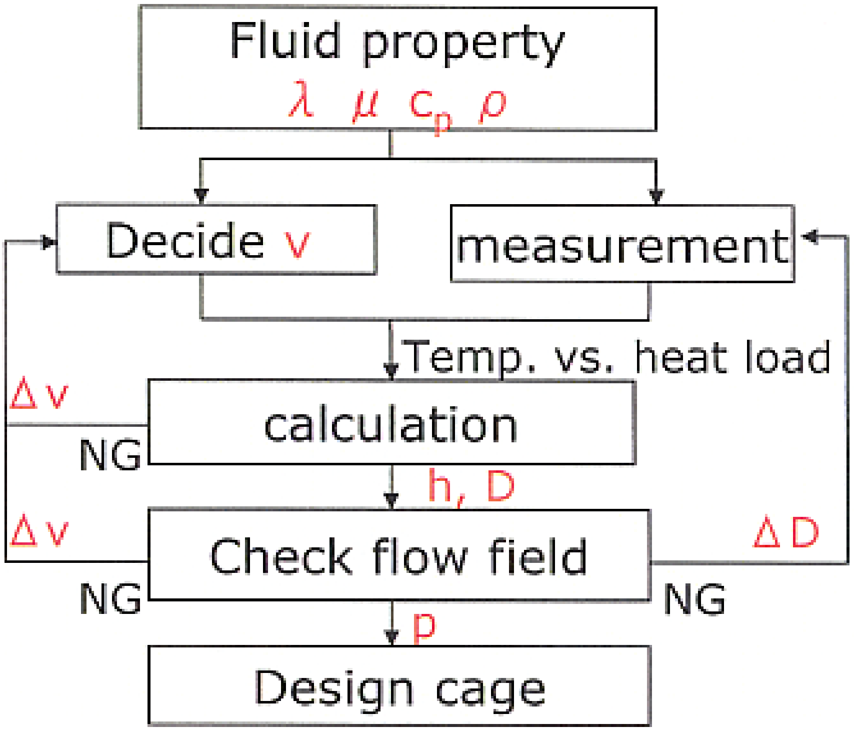
No water

Flow estimation for heat transmission

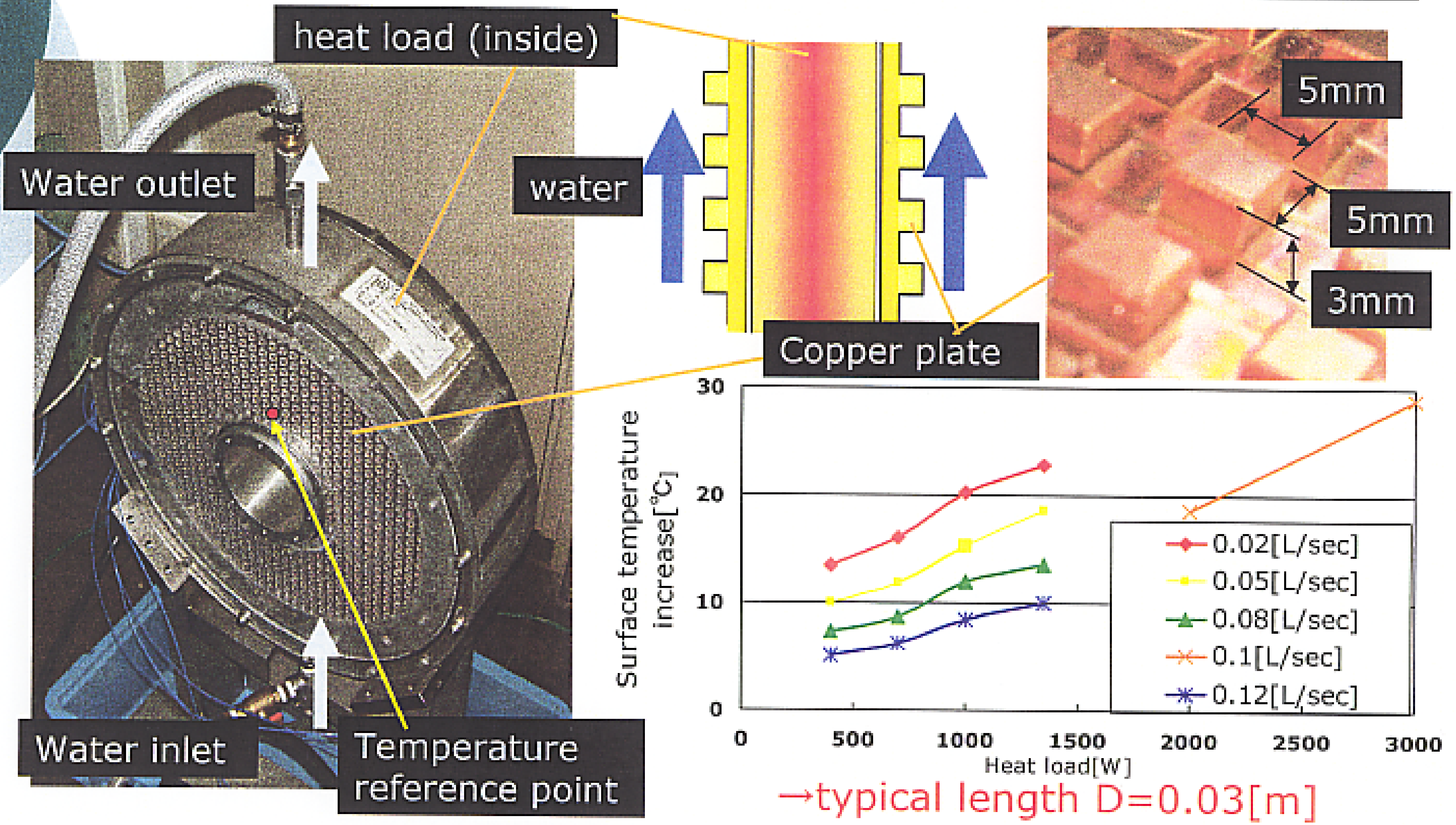
- λ : **heat conduction**
- μ : **viscosity**
- c_p: **specific heat**
- ρ : **density**
- v: **fluid velocity**
- D: **typical length**
- p: **fluid pressure**
- h: **heat transfer rate**

$$h \propto (\lambda)^{\frac{2}{3}} \left(\frac{\rho v}{D}\right)^{\frac{1}{2}} (c_p)^{\frac{1}{3}} \left(\frac{1}{\mu}\right)^{\frac{1}{6}}$$



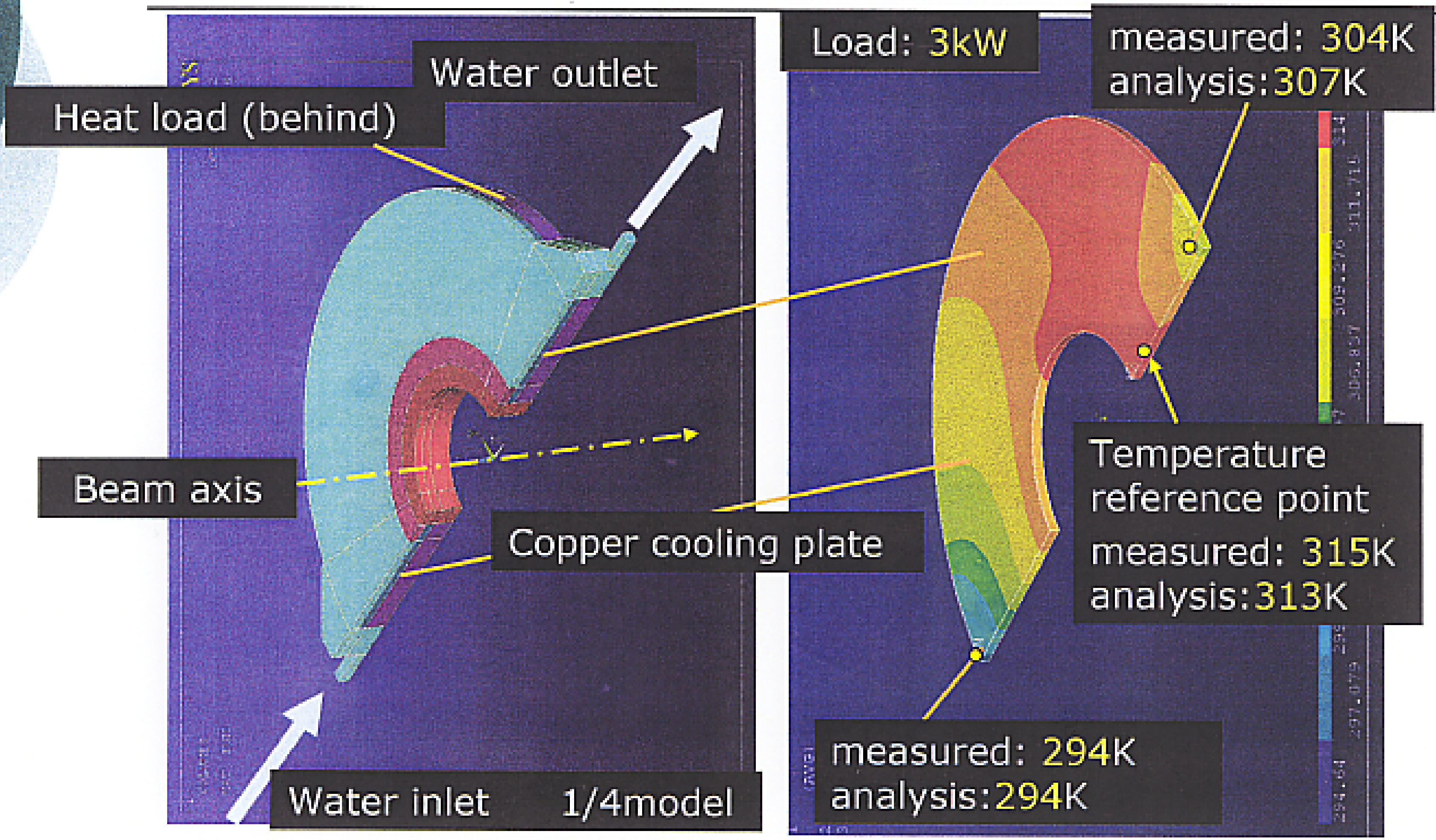


heat load measurement for typical length D



→typical length D=0.03[m]

Temperature distribution analysis by ANSYS



Choice of non-corrosive fluids

design:

ΔT [surface temperature] =30[°C],
S [cross sectional area]=0.976[m^2]
W [design load]=hΔTS=3[kW]

candidates of fluid:

HFE(from 3M)→ low viscosity, high cost

insulation oil → low cost, high viscosity

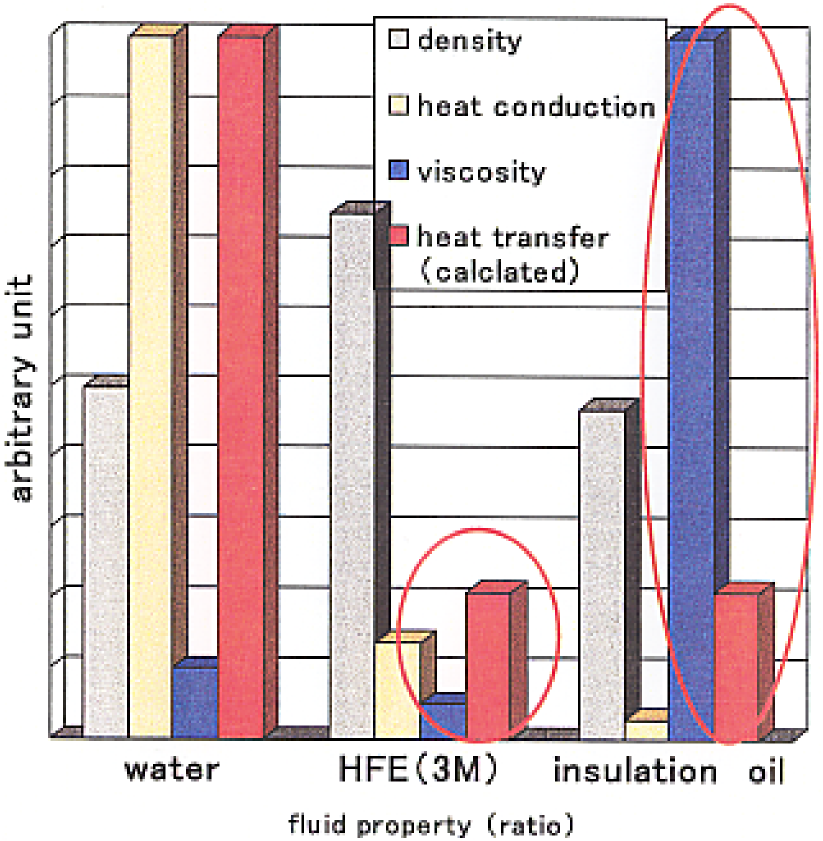
$$h \propto (\lambda)^{\frac{2}{3}} \left(\frac{\rho v}{D}\right)^{\frac{1}{2}} \left(c_p\right)^{\frac{1}{3}} \left(\frac{1}{\mu}\right)^{\frac{1}{6}}$$

→both have similar cooling efficiency

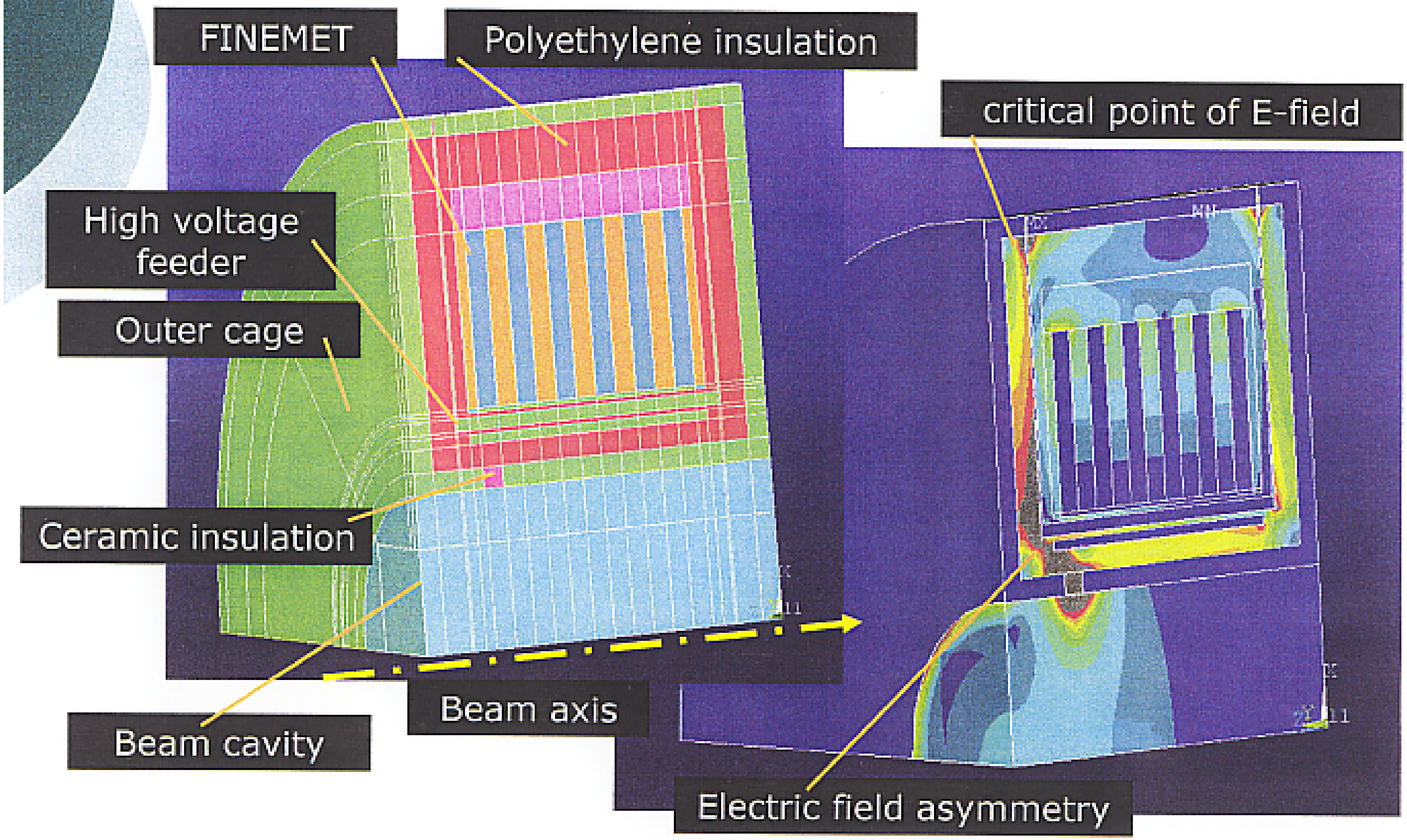
($h \sim 0.21 h_{water}$, $v_{fluid} \sim 0.2$[m/s])

only viscosity is considered

($\mu_{oil} \sim 20 \times \mu_{HFE}$)



Induced E-field distribution by ANSYS



Electromagnetic issue of induction cavity

Short rise-time

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Low capacitance

Good insulation

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E-Field distribution

Avoid resonance

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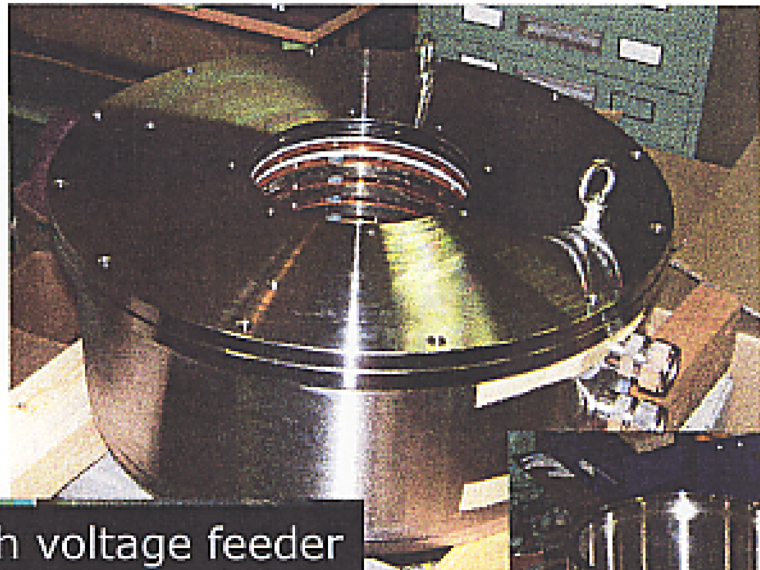
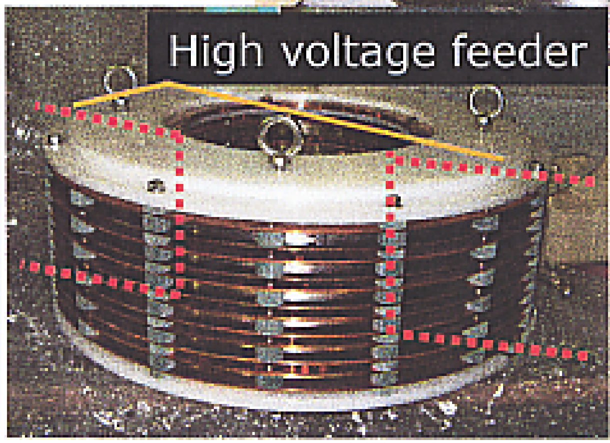
Impedance measurement

cage

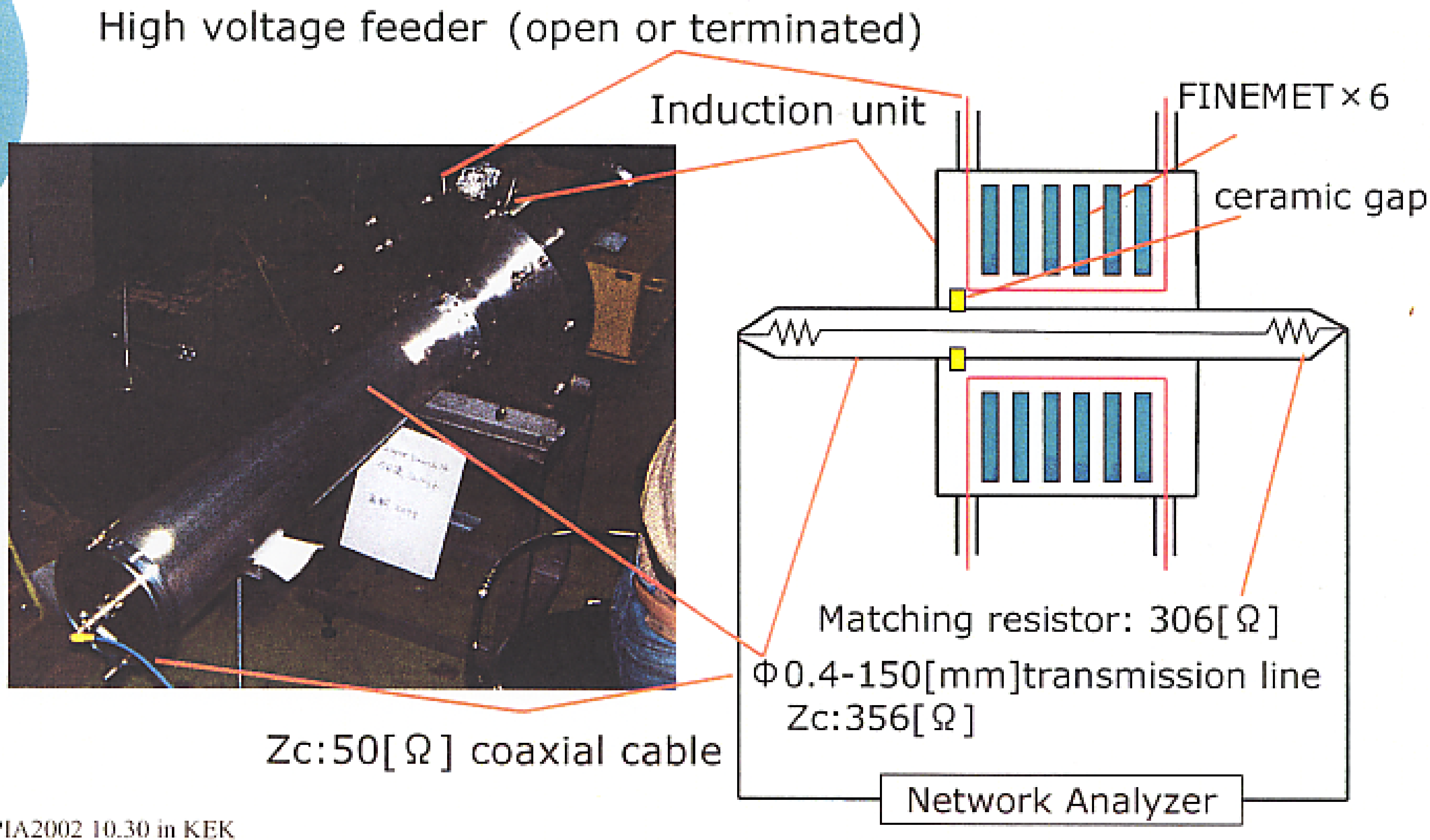




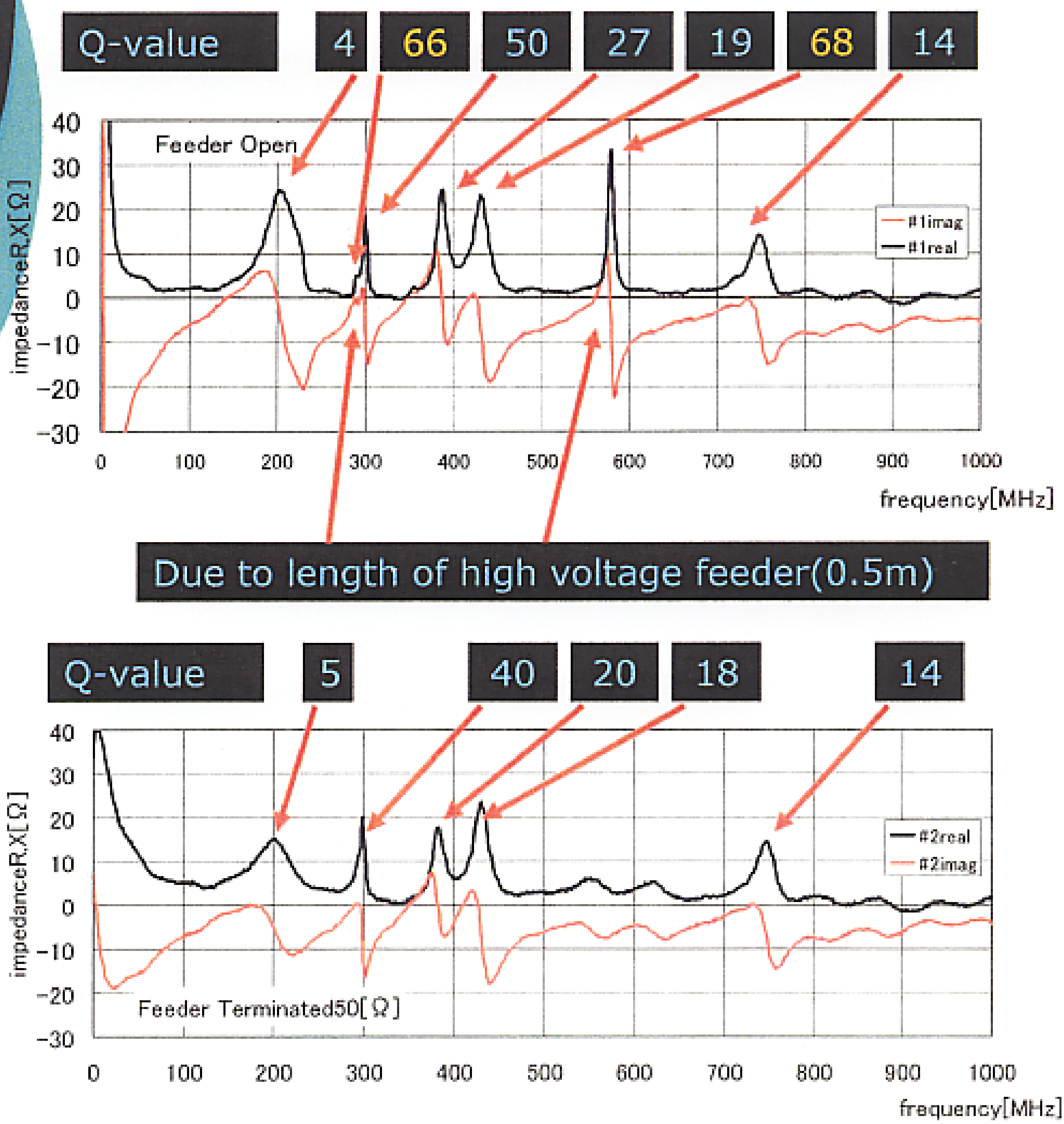
stacked core

ceramic gap

Longitudinal coupling impedance measurement



Longitudinal impedance Z of induction unit



Summary and next step

Summary

- Induction cavity has been assembled.
- Insulation oil as coolant has been chosen from test-bench measurement.
- Electric field distribution is calculated to observe critical point for breakdown.
- Longitudinal coupling impedance is measured, low-Q resonances are observed.

Next step

- Identification of high-frequency resonances.
- Transverse coupling impedance measurement.
- Actual driving by the modulator under optimized setting.