FECAL SLUDGE TREATMENT BY VISCOUS HEATING

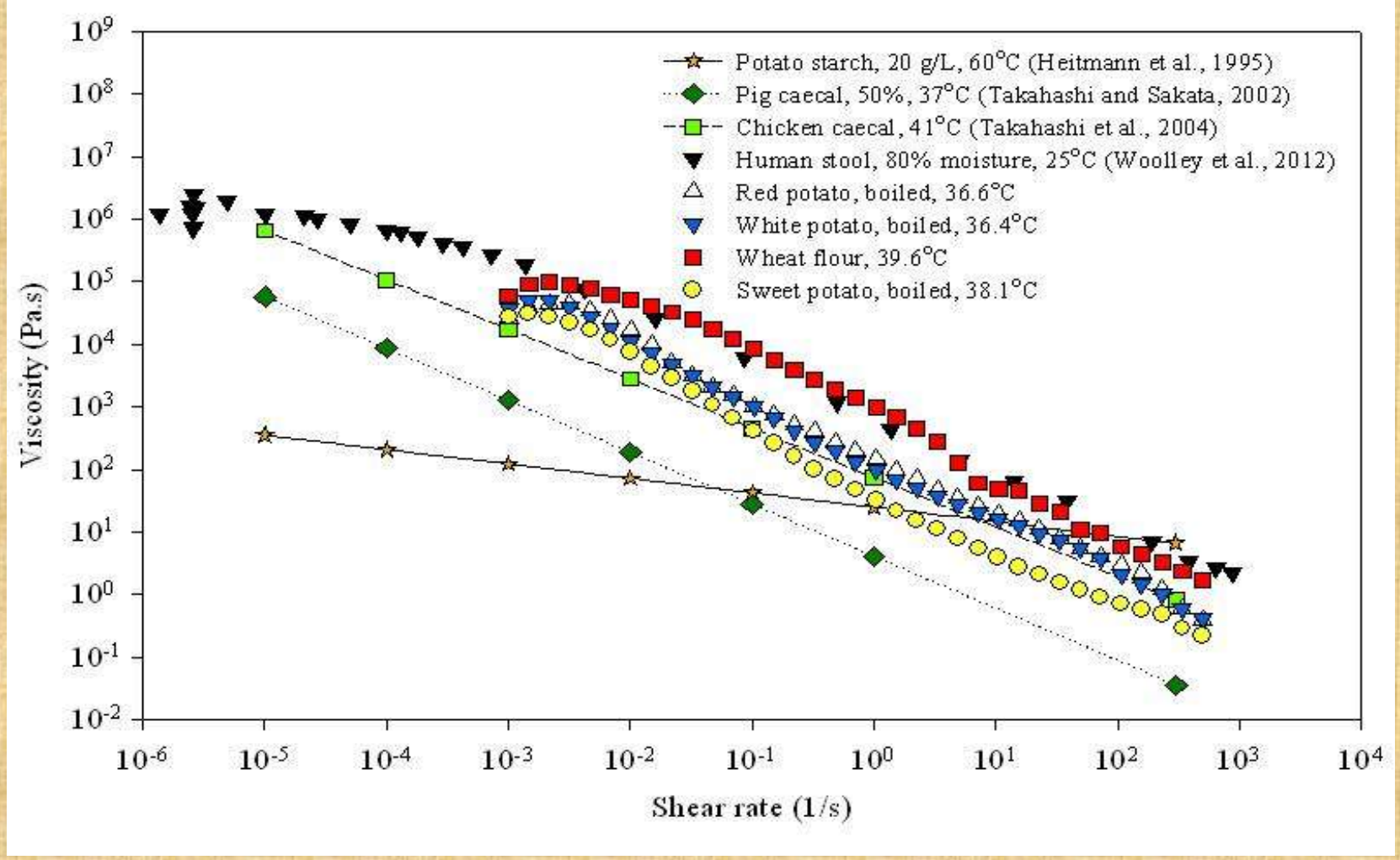
Presented by
Gary L. Foutch
Oklahoma State University
USA

Research Group
A.H. Johannes
Md. Waliul Islam
Jagdeep T. Podichetty
David Van
Mason Reichard

Initial Thoughts

- Feces is viscous
- Viscous substances produce heat under layer deformation
- An existing technology – e.g. polymer melting for extrusion molding

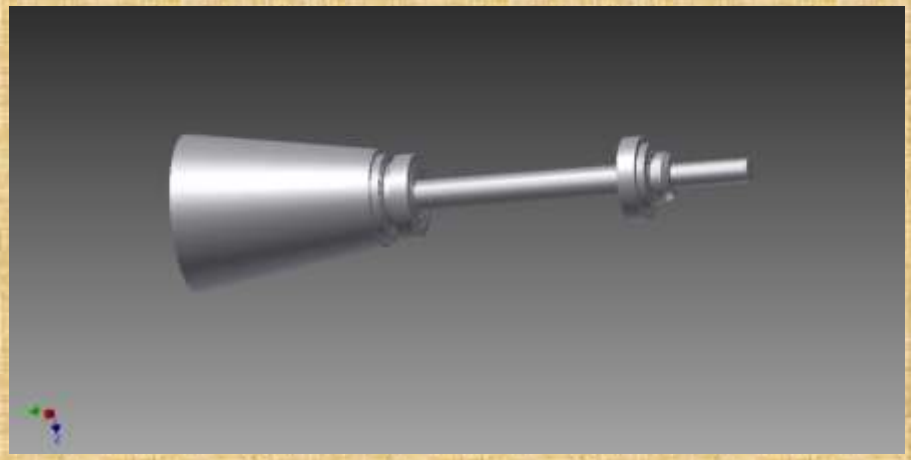
How Viscous is Human Feces???



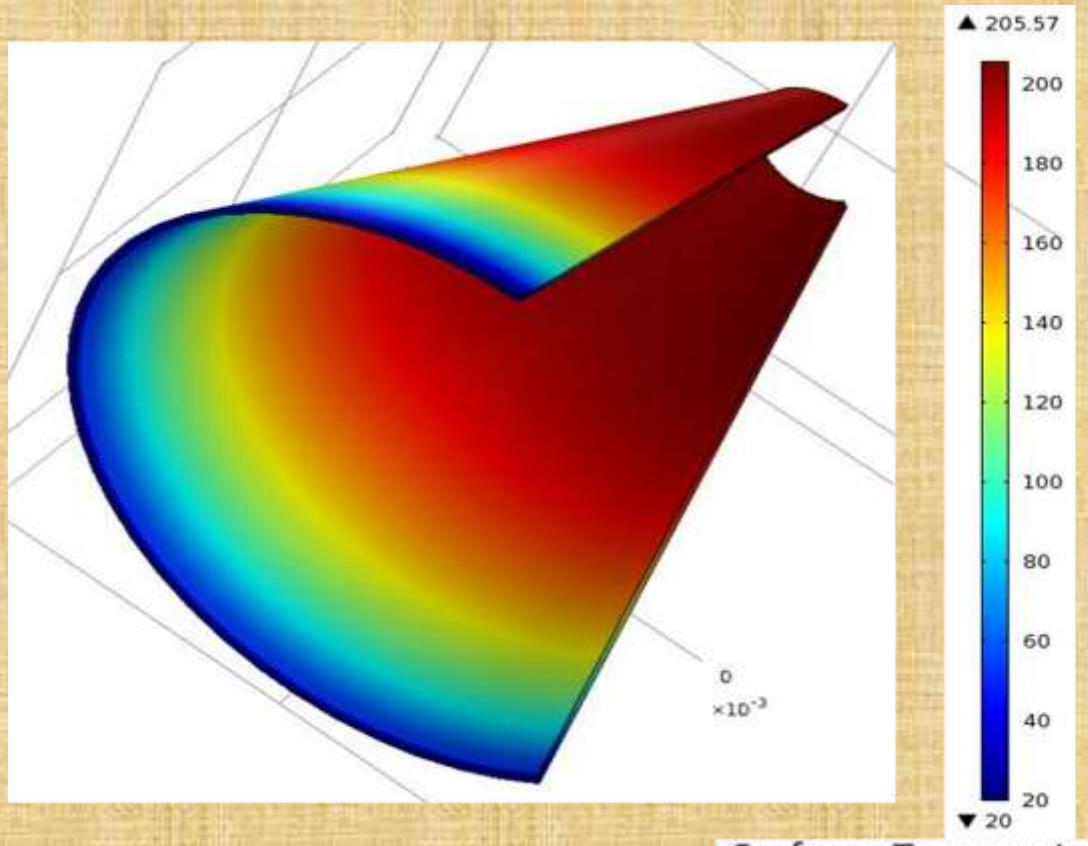
Shear rate decrease with viscosity for various feces and simulants

System Geometry

- The cone will rotate inside a shell
- Layer deformation of Feces will occur in between the gap of shell and cone
- High temperature as a result of viscous heating will kill all microorganisms



Feasibility simulation in COMSOL Multiphysics

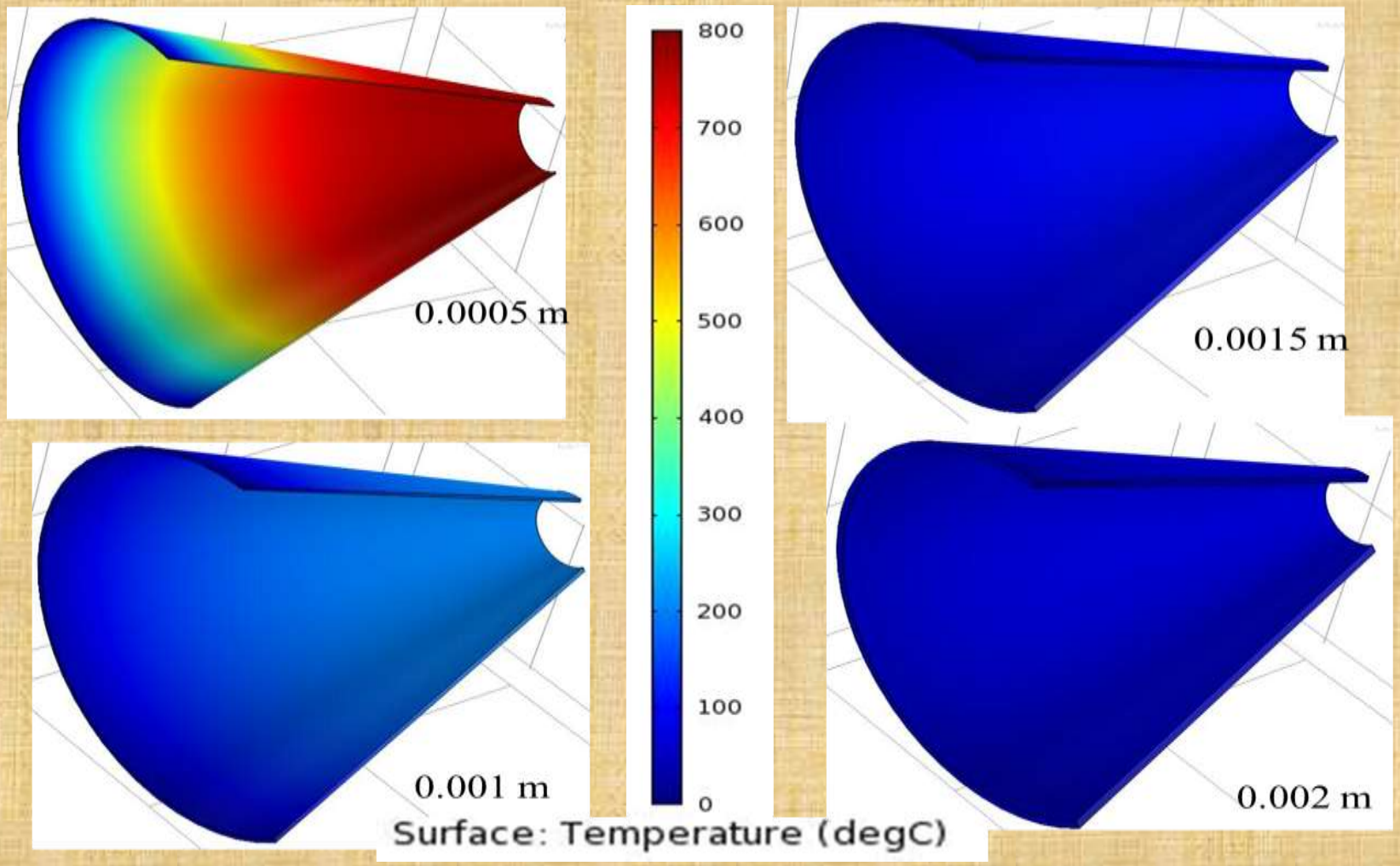


Assumptions

Density	**1000 kg/m³**
Viscosity	**5 Pa.s**
Thermal conductivity	**0.03 W/(m.K)**
Heat capacity	**4186 J/(kg.k)**

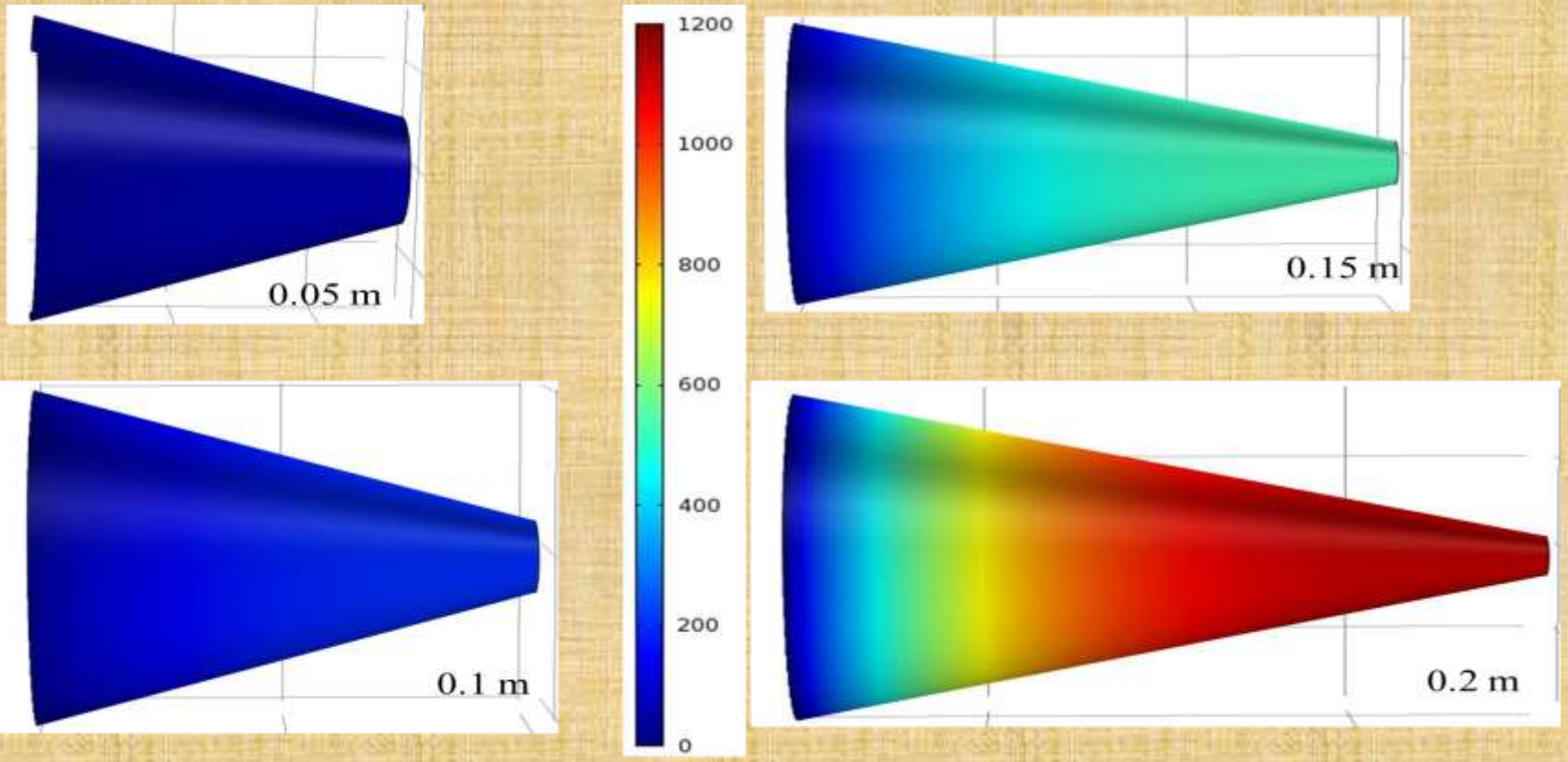
Temperature gradient @ inlet velocity 0.002 m/s @ 500 rpm

Effect of Clearance



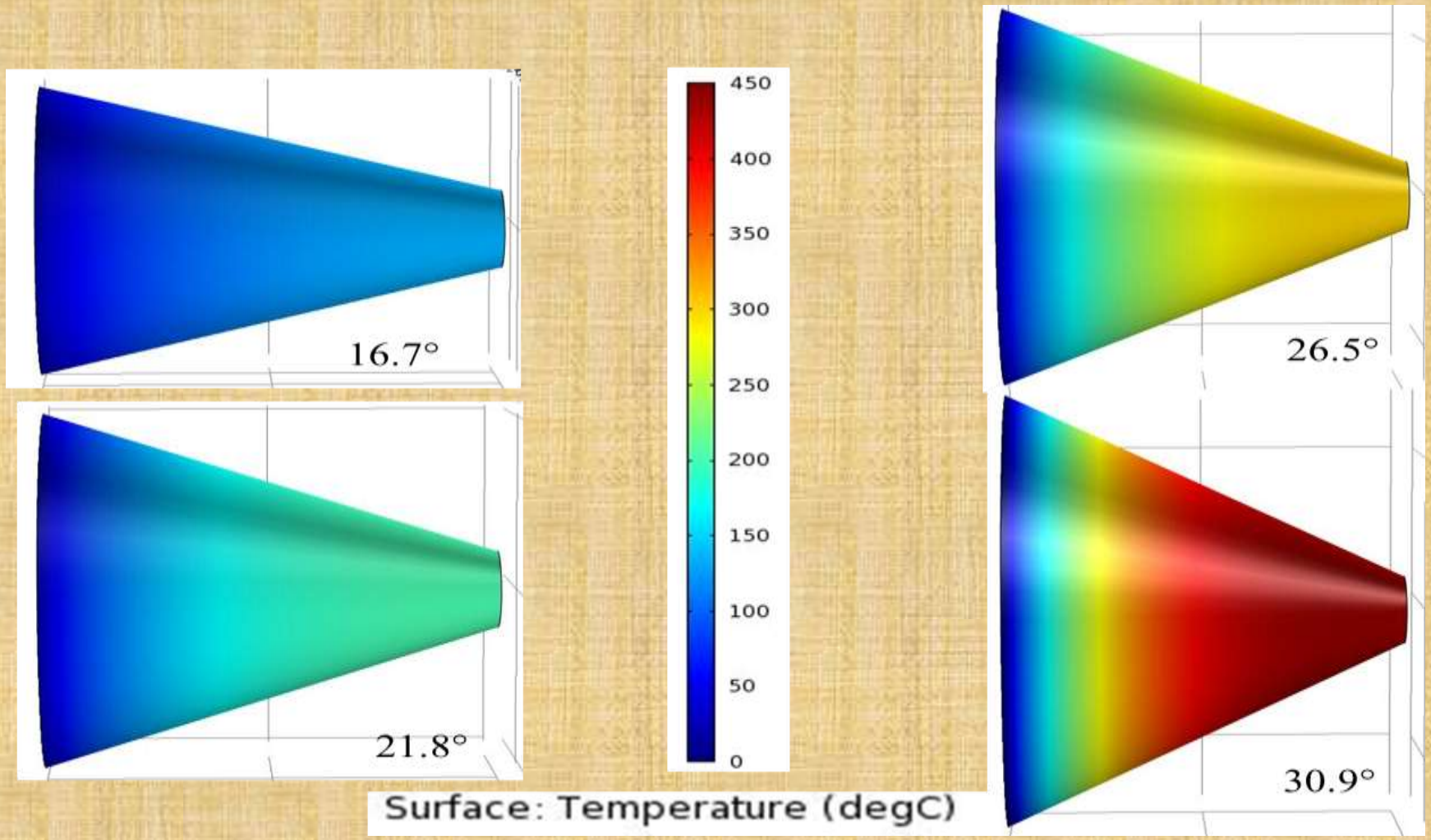
Temperature with clearance @ 0.1 m, angle = 21.8°

Effect of path length



Temperature with reactor length @ 21.8 and clearance = 0.001m

Effect of angle



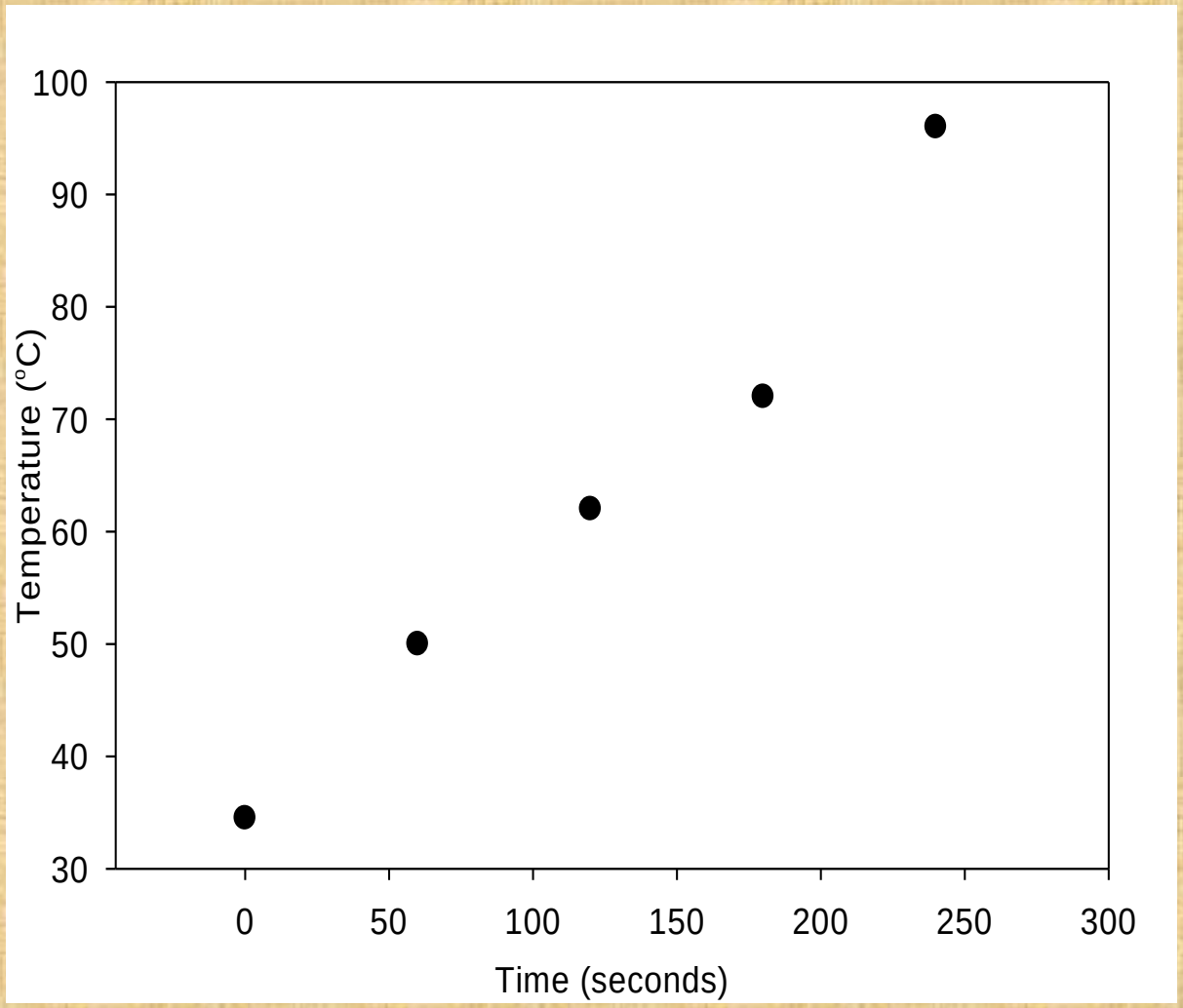
Temperature with angle @ length = 1 m, clearance = 0.001 m

Fully Instrumented Reactor

Reactor Core

Reactor Core Installed

Effect of Hold-up Time on Temperature



- constant feed pressure
- Constant rpm
- Constant gap spacing

gives a near linear plot.

Temperature with time. 100 psig, 1150 rpm and 0.75mm gap spacing

Summary of Simulant Experimental Results

- Temperature rises as rpm increases
- Temperature increases as hold-up time increases
- Temperature increases as gap space decreases
- The highest observed temperature is 200°C

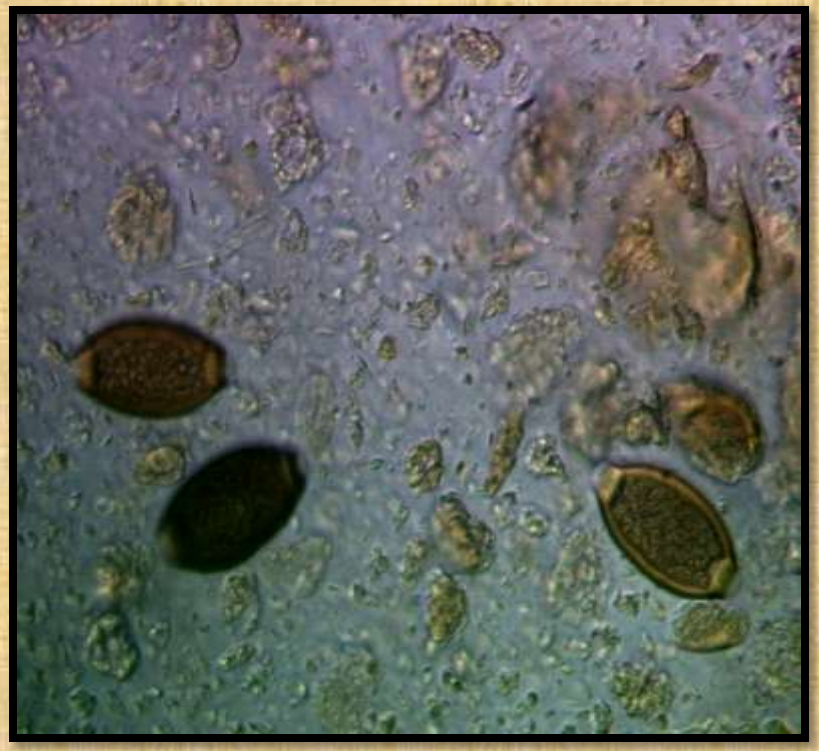
Parasite Destruction

- A satisfactory destruction approaching 99% was achieved for *Thrchuris trichuira* eggs
- Max temperature achieved for smallest spacing (0.75 mm) and highest rpm setting 1700
- Kill rate at lower temperature indicates destruction using shear stress alone
- Speed may be lower because of the presence of a considerable amount of baboon hair in the samples

Trichuris trichiura egg destruction in Baboon feces

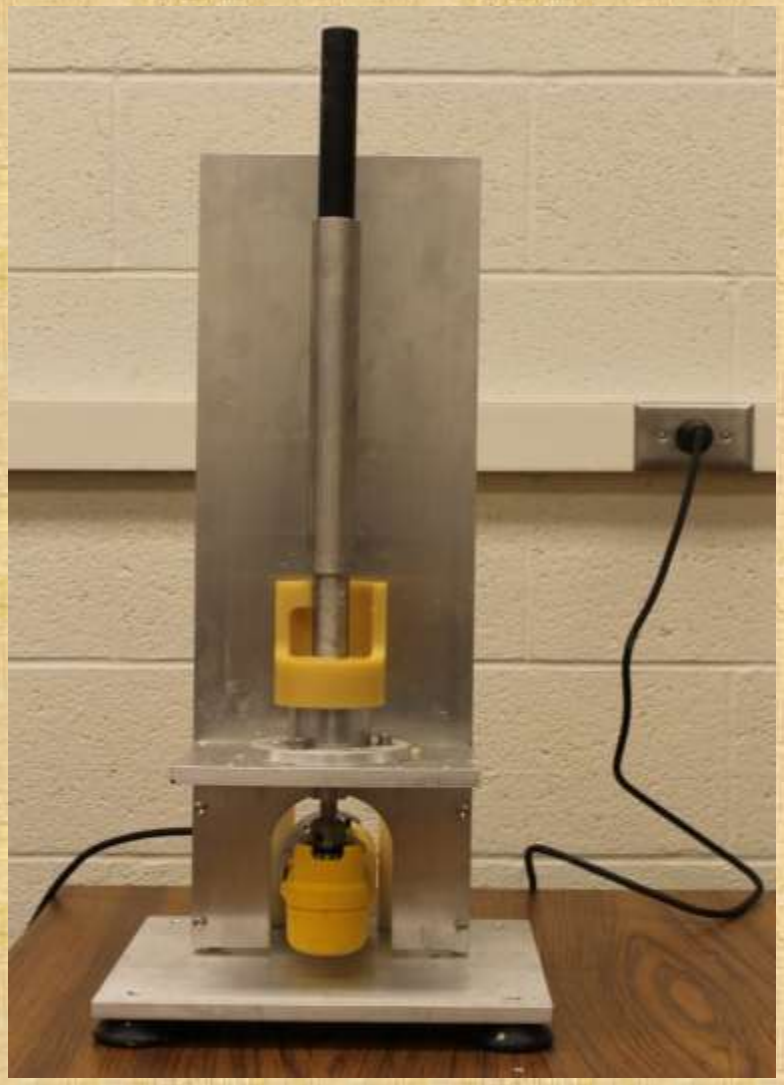
rpm	Spacing	Temperature	Egg Kill
	mm	°C	%
875	1.20	42	93
1700	0.75	51	99
1700	0.75	86	95

Photomicrographs of *Trichuris trichiura* eggs from helium being processed through the extruder 400 x magnifications



Second Prototype

- Spacing = 0.7 mm
- rpm can be varied as necessity
- Portable



Concluding thoughts

- Shear stress and temperature controlled by rpm and spacing
- Recycle of "dryer" feces would increase viscous; as could solid wastes (paper, grass, saw dust)
- Possible to combine with other technologies as a sanitation step.
- A small motor connected to a battery using solar power is sufficient for small-scale use