Fire Spread Simulation of Small Plastics using FDS Ver. 6.0.0

Kazuhiro Mori

0. Real Stream (鳩ノ巣渓谷)

Fujifilm GSW690 & Velvia 50

1. Abstruct

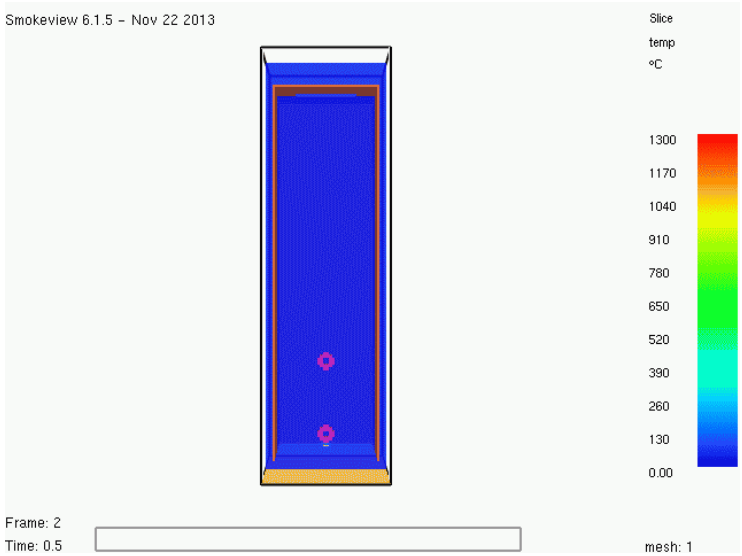
FDS(Fire Dynamics Simulator) is open-source software developed by NIST of USA. Pyrolysis is considerd by solving the one-dimensional heat conductivity equation in three directions respectively. FDS is widely applied for building fires, tunnel fires and so on. We have executed fire spread simulations of small plastic gears with a diameter of 30 mm and 10 mm in thickness in a closed duct to evaluate the capability of FDS as a development tool. We have investigated the combustion characteristics of an upper gear for the distance between two gears and aperture ratio of upper surface of the duct. We make an analytical model with 2.5 mm mesh size to compare time variation of temperature with experimental results. Our numerical calculations correlate well with our experimental results. In addition, time variation of concentration of a fuel gas shows a physically reasonable behavior. For the small distance between gears, the fuel gas generated from an under gear mainly plays an important role in ignition of the upper gear. We understand the effect of temperature and fuel concentration generaterd by the under gear. As we described above, we conclude that FDS Ver. 6.0.0 is applicable to solid combustion phenomena for 10 mm size plastics.

2. Introduction

■ FDS is widely applied for building fires, tunnel fires and so on.

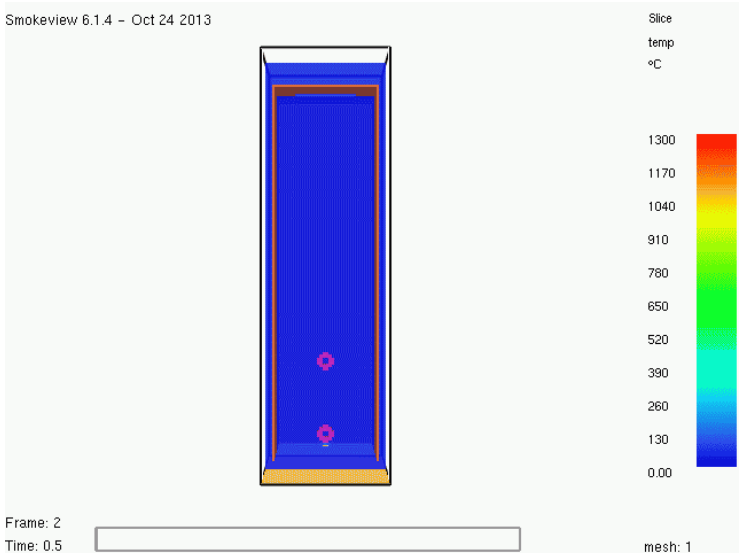
■ FDS Ver. 5.5. is not used to solid combustion phenomena for 10 mm size solid.

■ We will show fire spread simulations of small plastic gears with a diameter of 30 mm and 10 mm in thickness in a closed duct to evaluate the capability of FDS as a development tool.



Ver. 5.5.3 LES

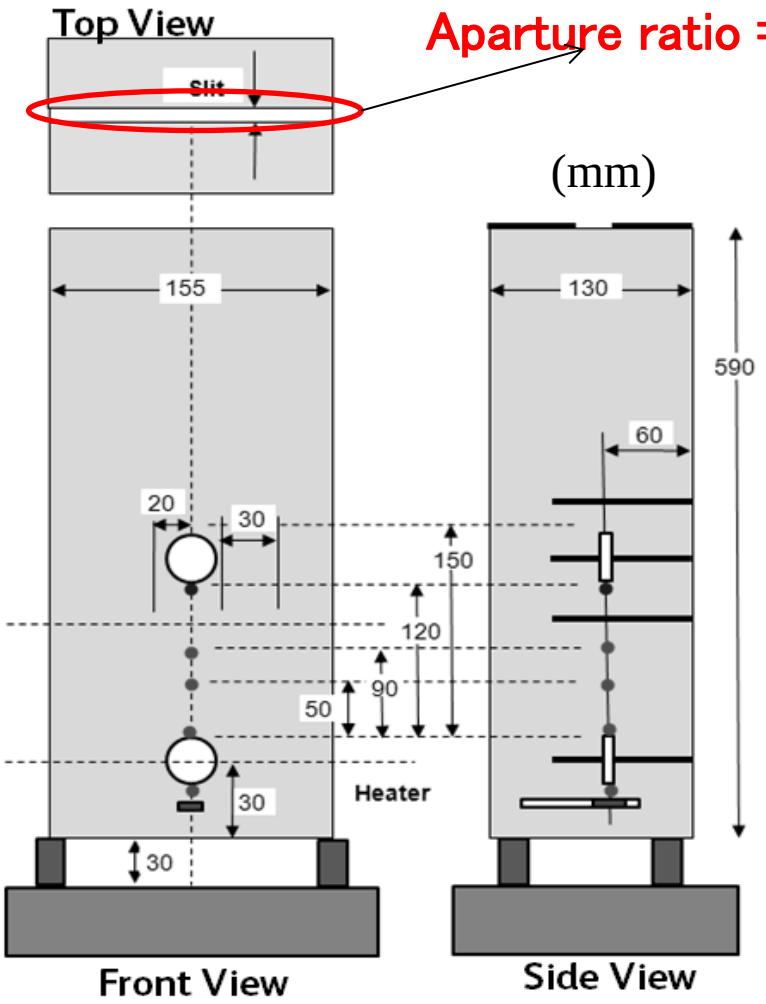
■ Log law is not applicable for energy equation.



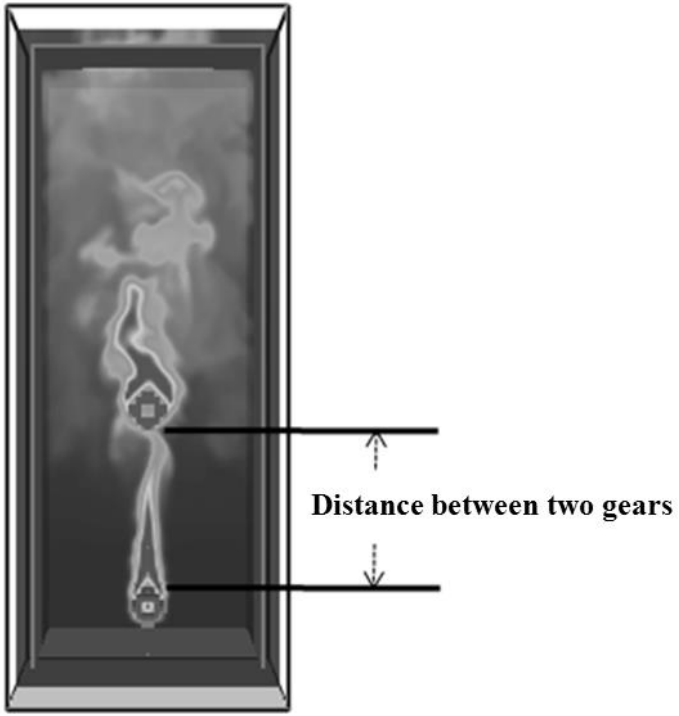
Ver. 6.0.0 LES

■ Log law is applicable for energy equation.

3.1. Geometry and Analysis Model



Geometry.



Analysis model.

Heater

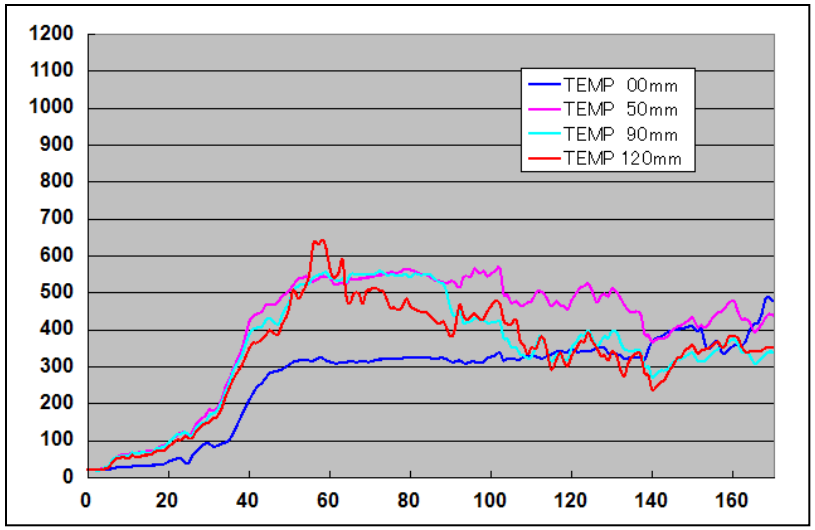
0 ～ 30s, 800 ℃

3.2. Material Properties and Input Parameters

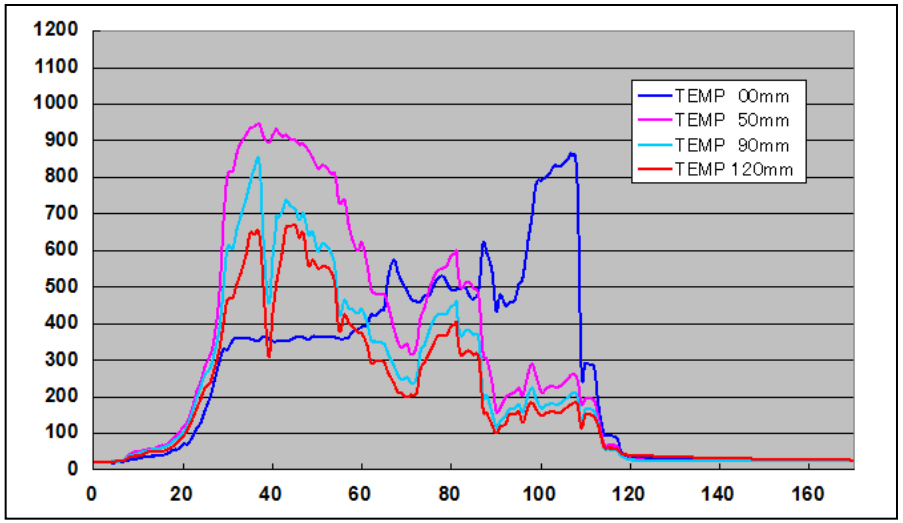
	Input
&REAC ID	POM
Number 0f atoms	C=1.0 H=2.0 O=1.0 N=0.0
SOOT_YIELD(kg/kg)	0.0
&MATL ID	POM
SPECIFIC_HEAT	1.47
CONDUCTIVITY(W/m/K)	0.25
DENSITY(kg/m^3)	310.2 (Dropping)
Pre-exponential factors A(1/s)	1.957E+11
Activation energies E(kJ/kmol)	118000
HEAT_OF_COMBUSTION(kJ/kg)	10200.0
HEAT_OF_REACTION(kJ/kg)	1720
RADIATIVE FRACTION	0.35

■ RADIATIVE FRACTION = 0.45[2] is probably better.

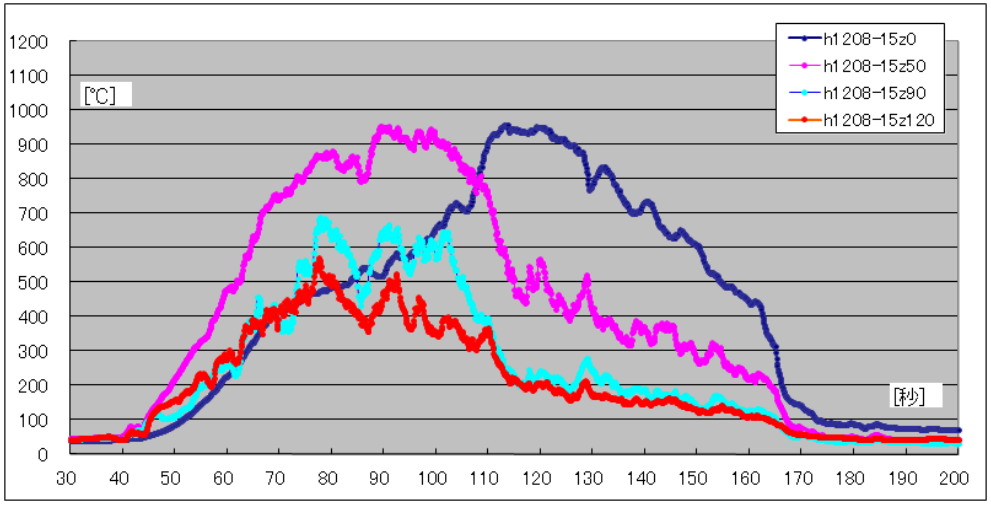
4. Time Variation of Temperature (Distance=120mm)



Ver. 5.5.3 Laminar
RADIATIVE_FRACTION=0.35

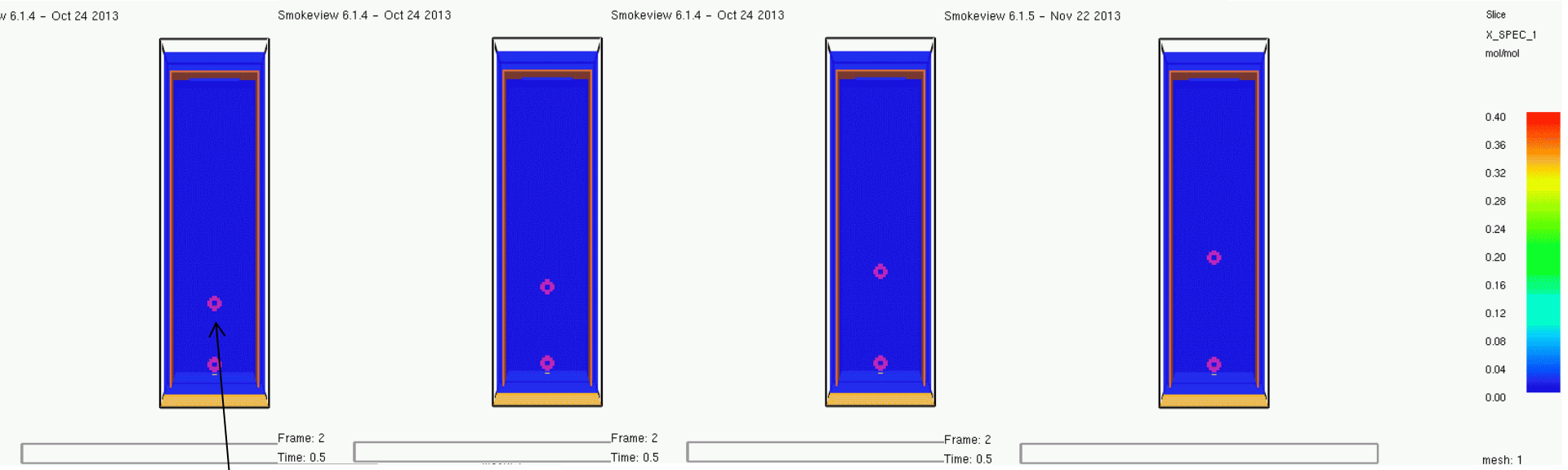


Ver. 6.0.0 LES
RADIATIVE_FRACTION=0.35



Experimaental[2)]

5.1. Concentration of Fuel Gas

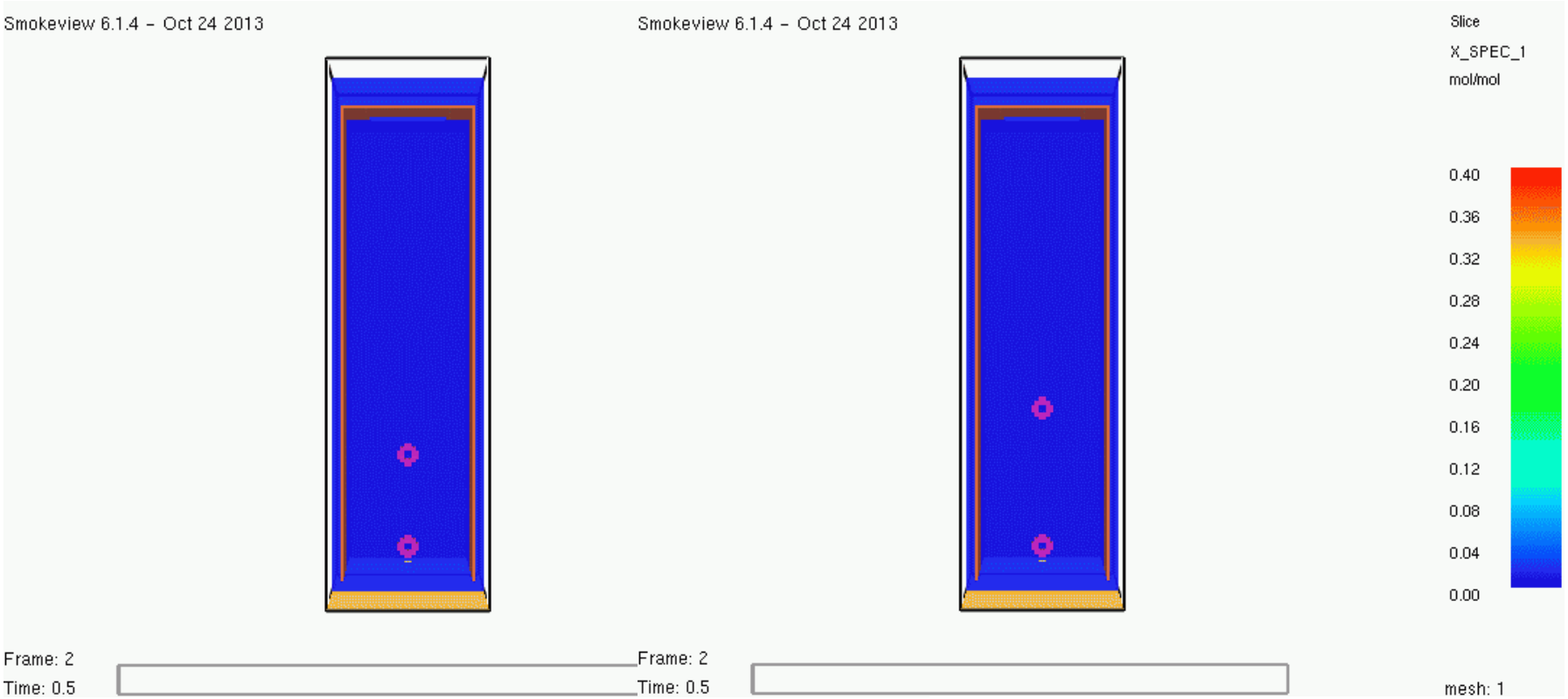


90 mm　120 mm　150 mm　180 mm

■ The fuel gas generated from the under gear does not reach to the upper gear.

■ The fuel gas generated from the under gear reaches to the upper gear.

5.2. Concentration of Fuel Gas



90 mm

150 mm

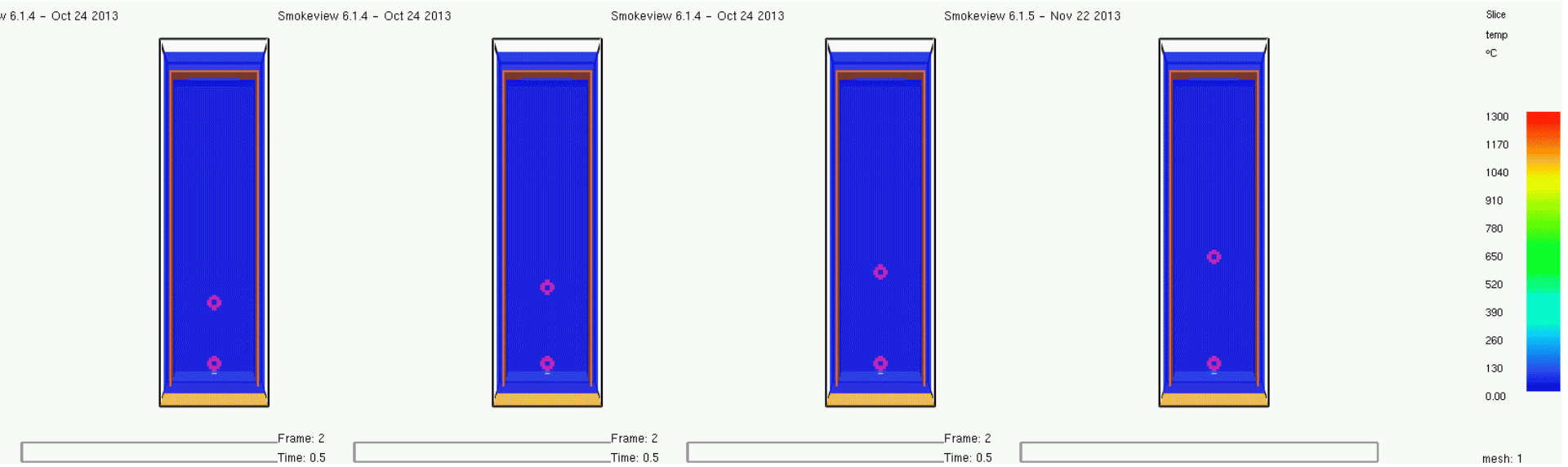
■ The fuel gas generated from the under gear reaches to an upper gear.

■ The fuel gas generated from the **under** gear mainly plays an important role in ignition of the upper gear.

■ The fuel gas generated from the under gear does not reach to an upper gear.

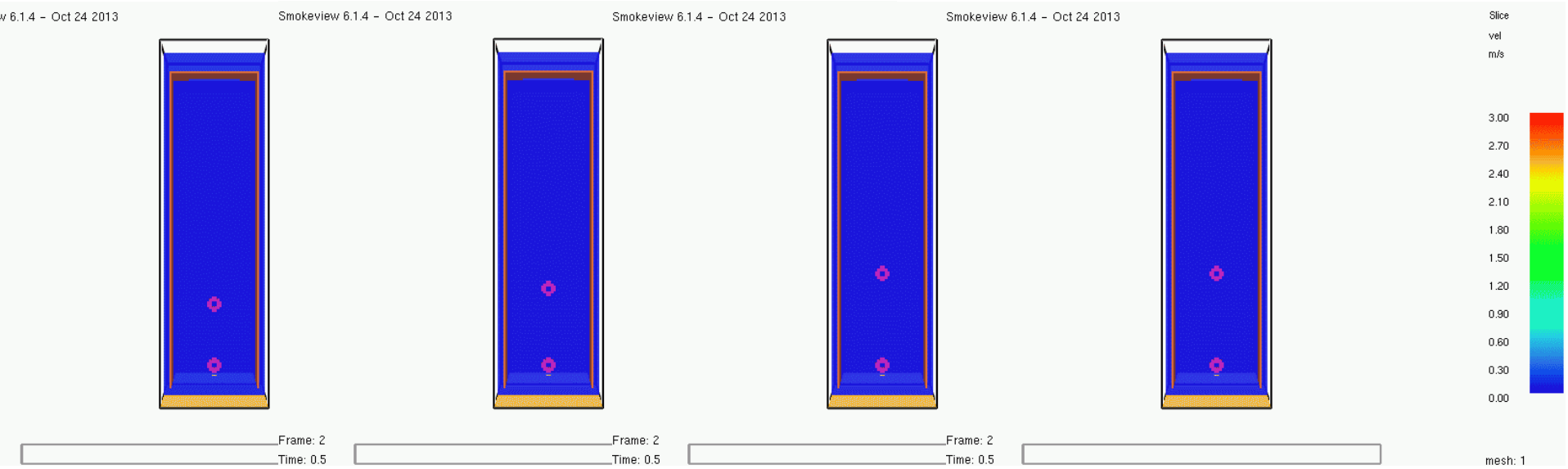
■ The fuel gas generated from the **upper** gear mainly plays an important role in ignition of the upper gear.

5.3. Temperature



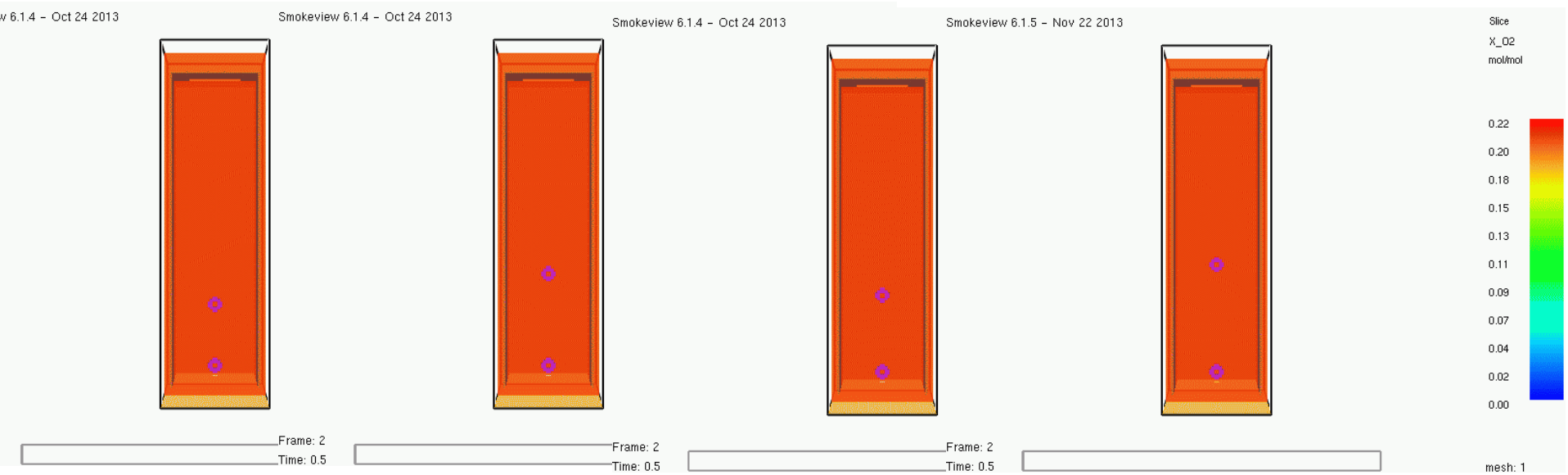
90 mm 120 mm 150 mm 180 mm

5.4. Velocity



90 mm 120 mm 150 mm 180 mm

5.5. Concentration of Oxegen



90 mm 120 mm 150 mm 180 mm

6. Summary

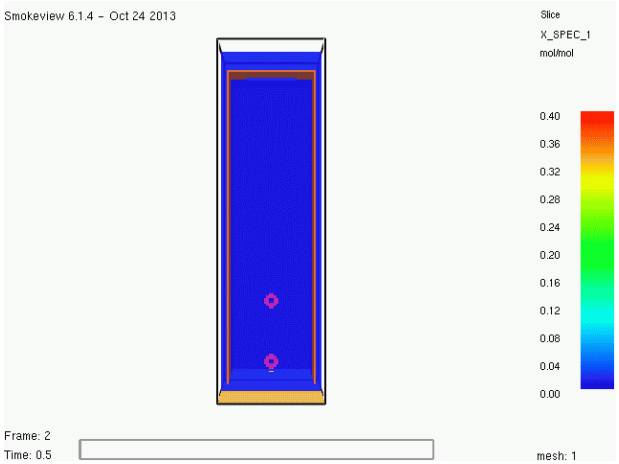
■ We have shown fire spread simulations of small plastic gears with a diameter of 30 mm and 10 mm in thickness in a closed duct to evaluate the capability of FDS as a development tool.

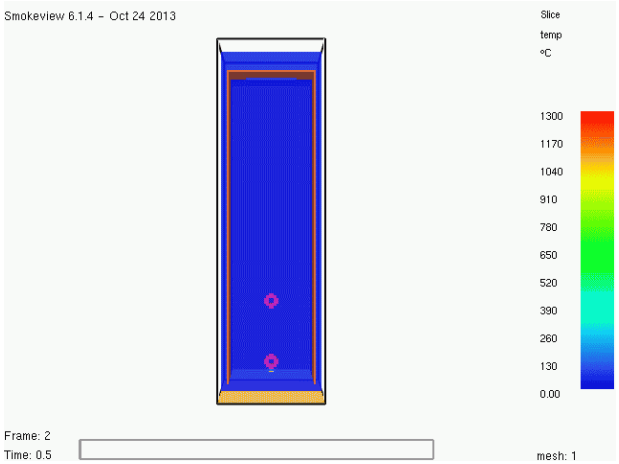
■ Time variation of concentration of a fuel gas shows a physically reasonable behavior. For the small distance between gears, the fuel gas generated from an under gear mainly plays an important role in ignition of the upper gear.

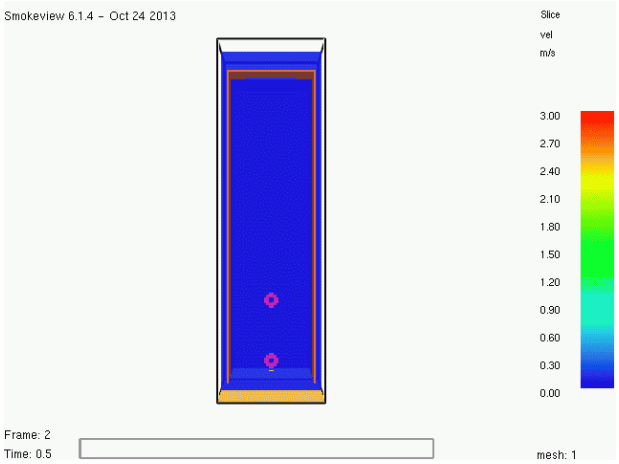
■ We understand the effect of temperature and fuel concentration generaterd by the under gear.

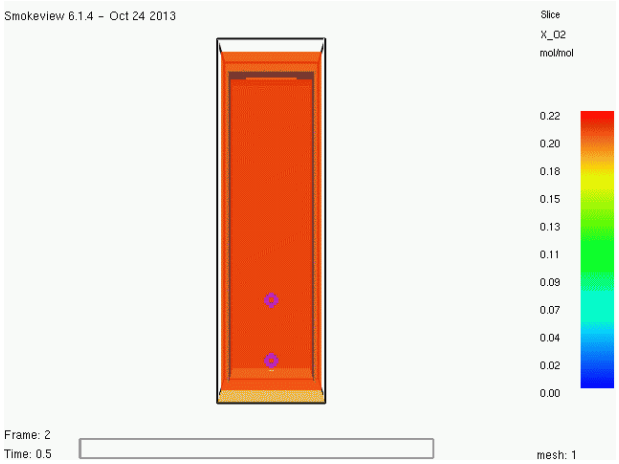
■ We conclude that FDS Ver. 6.0.0 is applicable to solid combustion phenomena for 10 mm size plastics.

Appendix 1.1. Distance = 90 mm

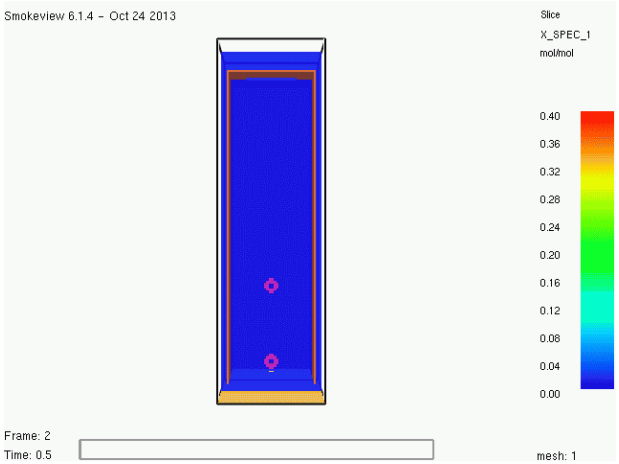


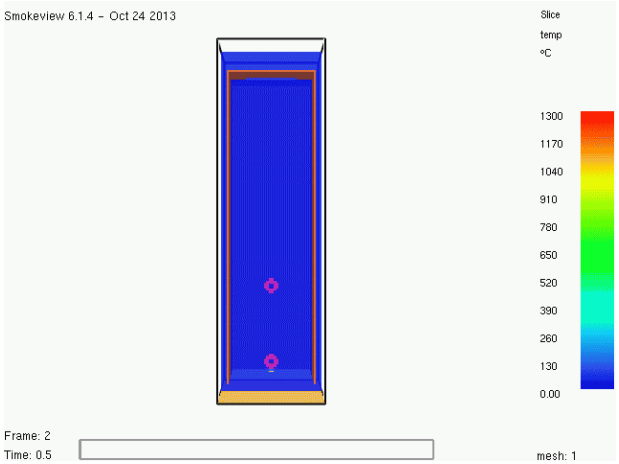


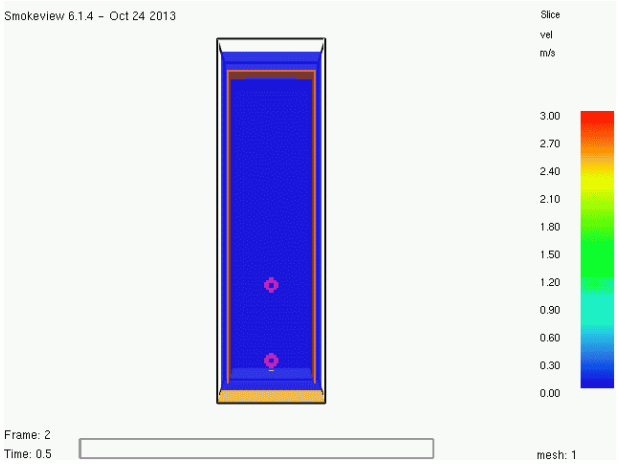


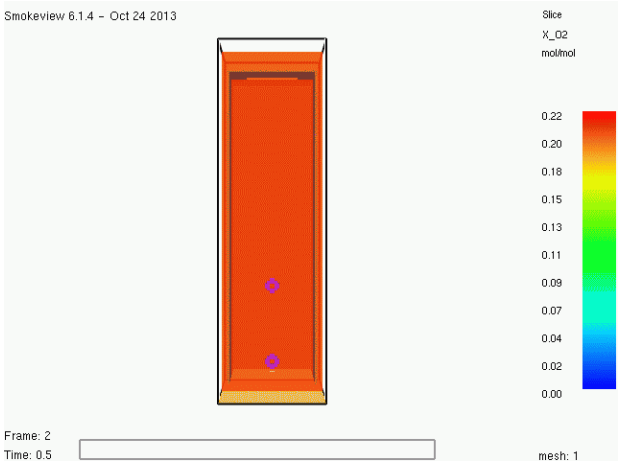


Appendix 1.2. Distance = 120 mm

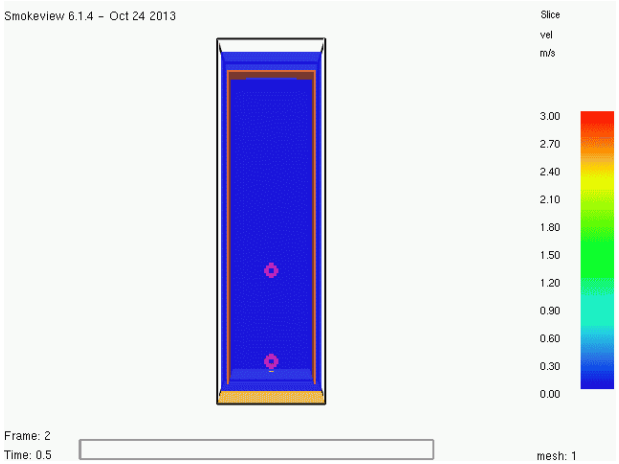


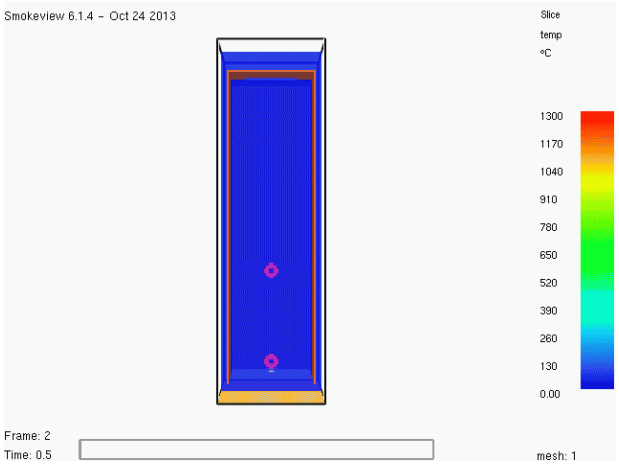


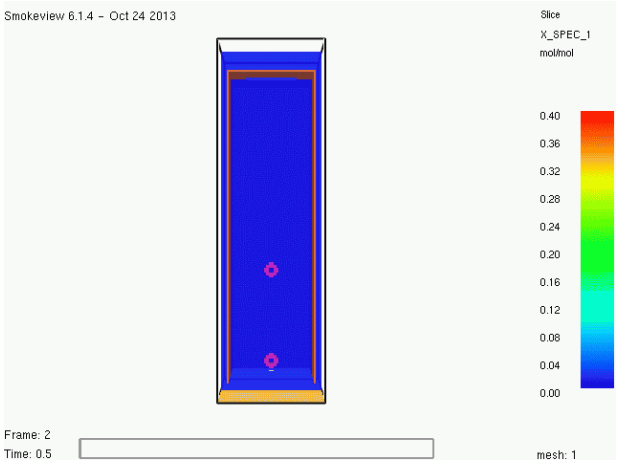


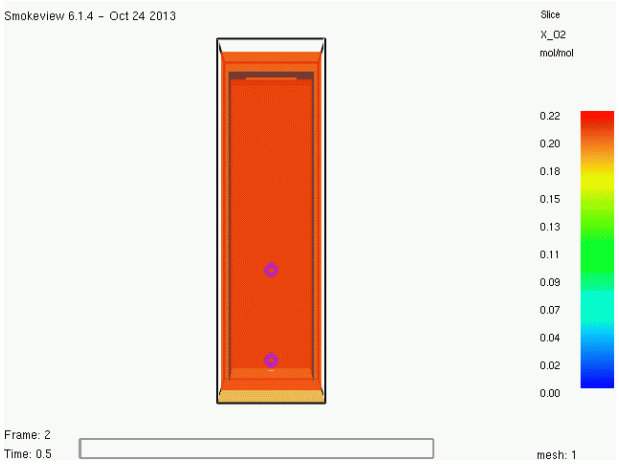


Appendix 1.3. Distance = 150 mm

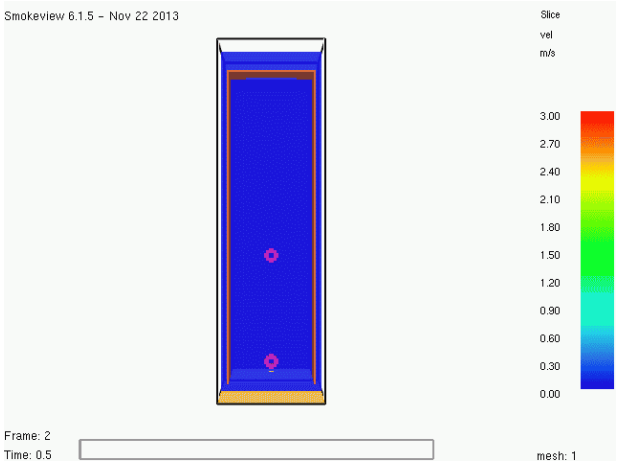


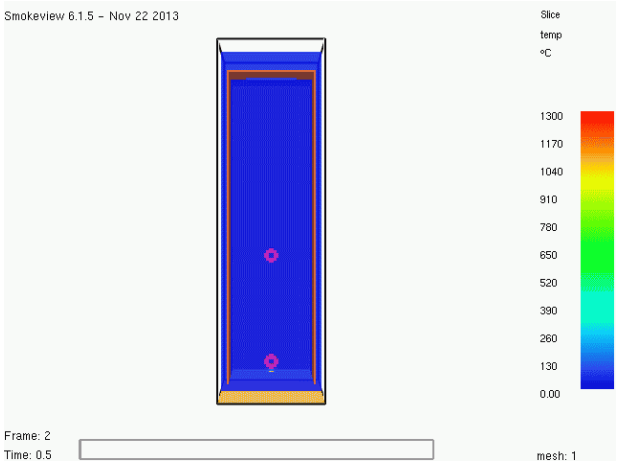


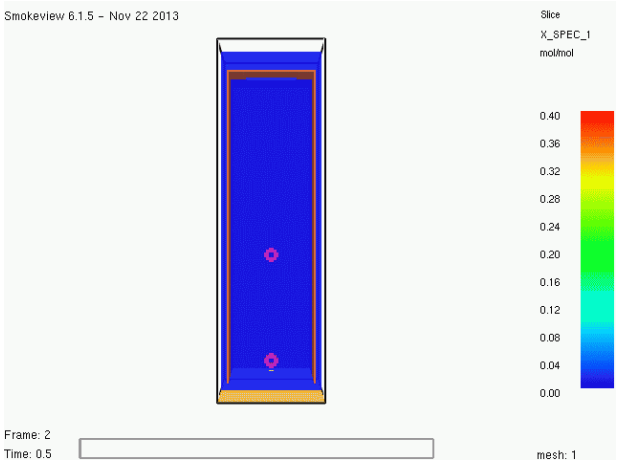


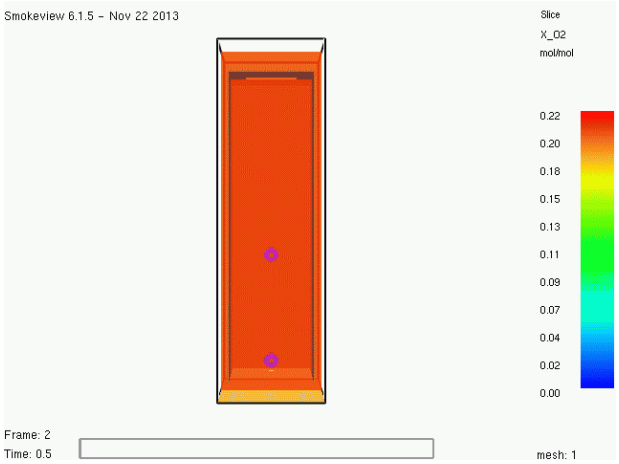


Appendix 1.4. Distance = 180 mm



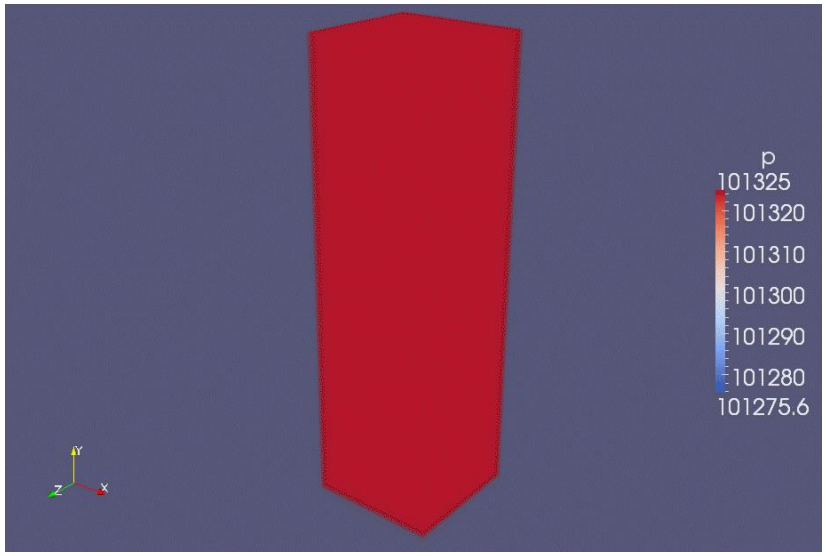






Appendix 2. Modified Tutorial of fireFoam

- OpenFOAM Ver. 2. 2. 2.
- Extend area of tutorial of fireFoam.
- Two thin plates are expressed by 0 thickness panel.
- Panels are not probably burn away.



References

1）錦 慎之助, 秀浦 勉, 森 一浩, 柴田 義麿, 藤本 良一, 岡本 直樹:オープンソースコードFDSによる固体燃焼シミュレーション．, OpenCAE Workshop 2013, http://www.opencae.jp/wiki/, 2013.

2）森 一浩, 秀浦 勉, 柴田 義麿, 岡本 直樹, 錦 慎之助: オープンソースコード FDS Ver. 6 による小型樹脂部品の延焼シミュレーション．, OpenCAE Symposium 2013, http://www.opencae.jp/wiki/, 2013.

3） K. Mori, T. Hideura, Y. Shibata, N. Okamoto and S. Nishiki :”Fire Spread Simulation of small Plastics using FDS Ver. 6”. , Japanese Journal of Forensic Science and Technology., To be accepted., 2014 (In Japanese).