scSTREAM

Cradle
MSC Software Company

Analyses of Spray Air Nozzle and Spray Combustion

Phenomena are analyzed with consideration on evaporation and volatilization using Particle Tracking Method in scSTREAM

Analysis of a Spray Air Nozzle

Using Particle Tracking Method, a spray air nozzle for cooling high-temperature gas with water droplets is analyzed.
Two spray conditions are compared.

Evaporation Model of Water Droplet

Analysis Settings

Inflow high-temperature gas	500 [°C]
Spray air	27 [°C]
Shape	2D axisymmetric (chamber, nozzle)
High-temperature gas velocity	25 [m/s]
Spray air velocity	40 [m/s]
Wall	No-slip, adiabatic

Analysis Results

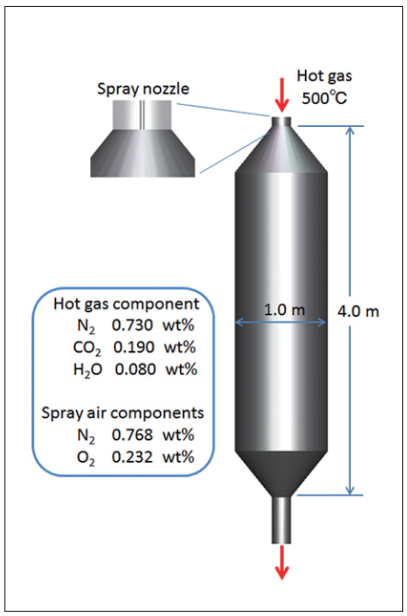


Figure 1: Spray air nozzle

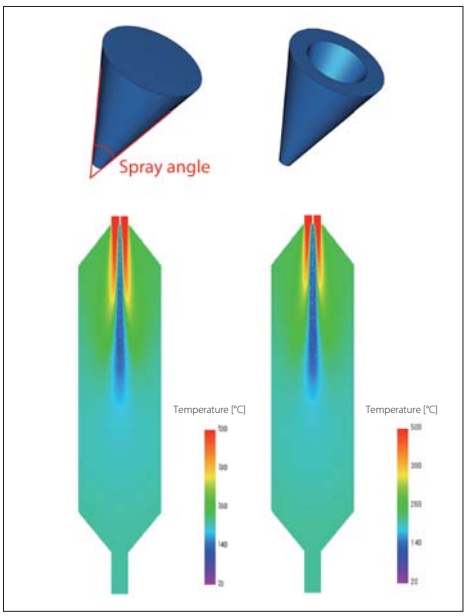
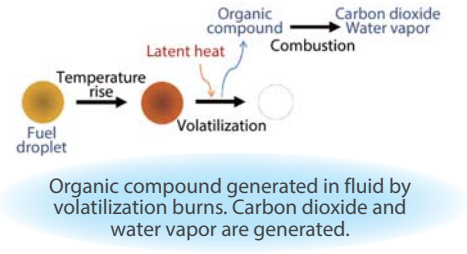


Figure 2: Temperature distribution (7 sec.)
Full-cone (left), hollow-cone (right)

Analysis of Spray Combustion of Fuel Droplets

Spray combustion of fuel droplets is analyzed with Particle Tracking Method.

Spray Combustion Model of Fuel Droplets



Analysis settings

Fuel droplet	Sauter mean diameter 20 [μm] (Nukiyama-Tanazawa distribution for diameter distribution)
Spray flow rate	0.005 kg/s (Parcel approximation 10,000 s^{-1})
Spray velocity	15 m/s
Spray pattern	Hollow cone Spray angle 110 - 120°

For 1 second, only air and spray air are flowed in. The fuel spray begins after 1 second.
The latent heat of the fuel droplets is 200 [kJ/kg], and n-Decane is used for the constants of the Antoine equation.

Analysis Results

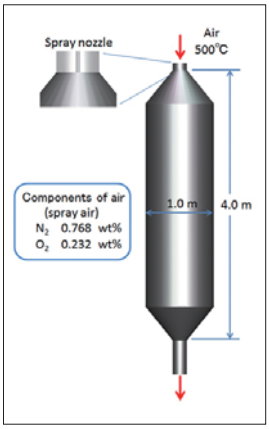


Figure 3: Combustion chamber

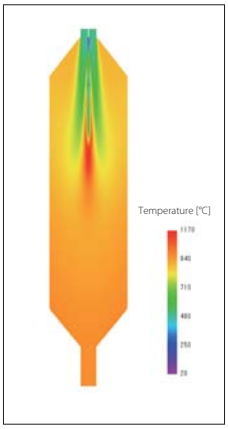


Figure 4: Behavior of fuel droplets and temperature distribution (8 sec.)

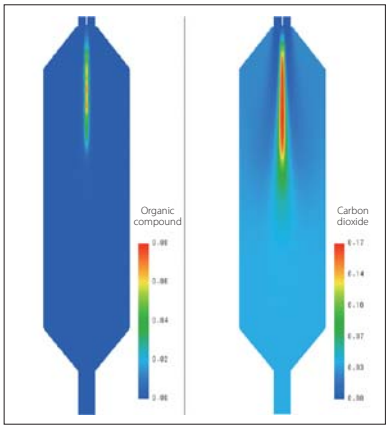


Figure 5: Mass fraction distribution of combustion gases (8 sec.), organic compound (left), carbon dioxide (right)

Notes

From the analysis result of spray air nozzle, it can be seen that hollow cone spray is cooling the gas slightly faster in comparison. From the analysis result of spray combustion, it can be seen that temperature of the combustion gas in the chamber rises due to combustion of the fuel droplets.