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# STUDY ON THE OUTFLOW BOUNDARY CONDITION FOR WILDFIRE SIMULATION BASED ON THE FLUID-COMBUSTION INTERACTION ANALYSIS

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Regardless of the size of the scale, a lot of wildfires have occurred in Japan. Especially, in the end of winter to spring, the fires occur intensively because of dry and windy weather. Although a simulation model was developed in order to predict spread of wildfire and it has been used still now, several weak points in the model have been discussed. For example, although a wind velocity and direction affect spread of fire, the simple wind prediction model only based on the continuity equation was employed. As a result, the resolution of wind was low (only 1 km). It is difficult to consider the local wind field. Moreover, for the prediction of combustion, not chemical reaction equations but experimental relations were coupled. On the other hands, in the countries which has more severe wildfire, such as USA, Australia and EU, they have simulation methods based on CFD and combustion analysis[1]. Therefore, we think that a new accurate simulation method for wildfire should be developed in our country. For the purpose of the simulation of wildfire, we developed a fluid-combustion interaction analysis method by using CFD and chemical reaction model of a wood combustion.

In the present study, continuity equation, Navier-Stokes equation with Boussinesq assumption and energy equation are adopted as governing equations for fluid motion. These equations are discretized by the Finite Element Method. The SUPG/PSPG stabilized method is employed for the continuity equation and Navier-Stokes equation. The SUPG method is employed to the energy equation. To solve these equations, we employ the Crank Nicolson method for a time integration algorithm, the GMRES algorithm for a linear system.

In order to simulate the wood combustion process, the chemical reaction model of a piece of wood proposed by Morvan et al.[2] is employed. In the model, a process of the combustion is described by the three stages. These stages are as follows: 1) water vaporization, 2) pyrolysis, 3) char oxidation. The chemical reactions of each stages are written in ordinary differential equations with the Arrhenius law. The temperature of a piece of wood is calculated from the heat transfer equation combined with the chemical reaction equations. The reaction heat during the combustion of a piece of wood is incorporated into the right hand side of the energy equation of fluid.

In order to check the accuracy of the chemical reaction model, we calculated the variation of mass loss of a piece of wood. We compared our computational result to the experimental result by Vovelle et al.[3]. As shown in figure 1, our result is in good agreement with the experimental result.

We conducted a fluid-combustion interaction simulation. In the computational domain, we set a piece of wood at the centre of the bottom of the domain. A constant heat rate was added to the wood. Figure 2 shows the result of fluid velocity. An upward and periodic fluctuation flow driven by the effect of the buoyancy was observed. However, when the upward flow passed through the upper boundary, strong backward flow from the outside of the domain was occurred. The backward flow made the computation unstable. Therefore, we employed the backward flow prevention technique[4] to the outflow boundaries. As a result, the stable computation was obtained.

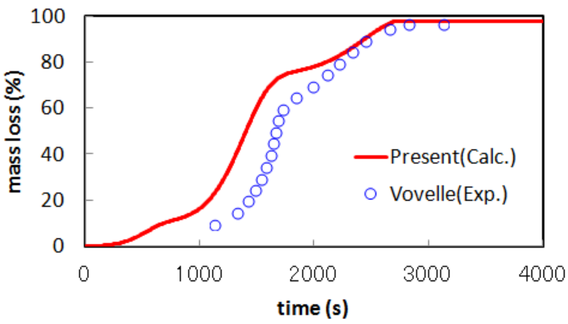


Figure 1 Mass loss rate of a piece of wood

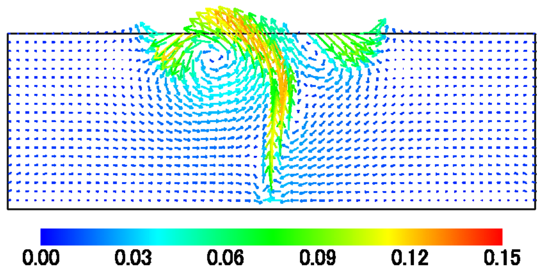


Figure 2 Fluid Velocity distribution

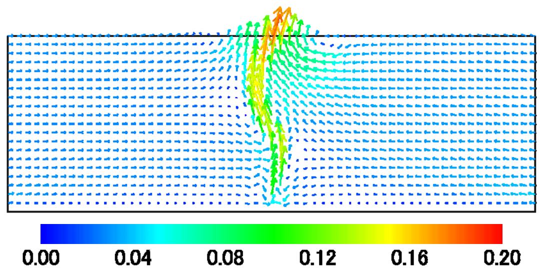


Figure 3 Fluid Velocity distribution with the backward flow prevention

## ACKNOWLEDGEMENT

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