Effects of Mesh Size on Wrinkle Behavior of H_2-Air Premixed Flame inside of a Vessel: Numerical Simulations by using XiFoam

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Abstract Wrinkle behavior of H_2-air premixed flame inside of a vessel was numerically investigated with changing mesh size of 2.0mm to 0.625mm by using the open source code, XiFoam. When the mesh size was smaller, larger number of ignition cells was obtained and wrinkle flame formation was observed, and then flame temperature heightened and flame radius became large.

Keywords: H_2-air premixed flame, Wrinkle behavior, Numerical simulation, Mesh size, Flame temperature, Flame radius

1. Introduction

The awareness must be taken on the risk of hydrogen combustion and explosion due to contamination of hydrogen (H_2) generated by radiolysis of water inside of high-level radioactive waste vessels under the long-term storage. In hydrogen safety management, besides the experimental investigations, CFD approaches in predictions of flame propagation phenomena and characteristics are of important role. In this numerical simulation, XiFoam solver [1] was modified by adding a new laminar flame speed model deduced from experiment by Katsumi et al. [2]. It reproduced the propagation of H_2-air premixed flame, and we clarified the effects of mesh size on wrinkle behavior of flame front since choosing a mesh size appropriate for selected model is one of the important points in the numerical simulation.

2. Simulation Setup and Results

The parameters of premixed flame of H_2-air at their unity equivalence ratio obtained by the experiment [2] were introduced in numerical simulation, and meshes for three-dimensional one-eighth of a vessel (0.21m in each side) were generated with different mesh sizes of 2.0mm to 0.625mm. Total number of cells for largest and smallest mesh size were 1,157,625 and 37,933,056, respectively. Initial temperature and pressure were set to 298K and 101,325Pa, respectively. Figure 1 shows the temperature distributions of flame at t = 0.01s for mesh sizes of 2.0, 1.0 and 0.625mm. Figure 2 shows the maximum flame temperature and radius for different mesh sizes.

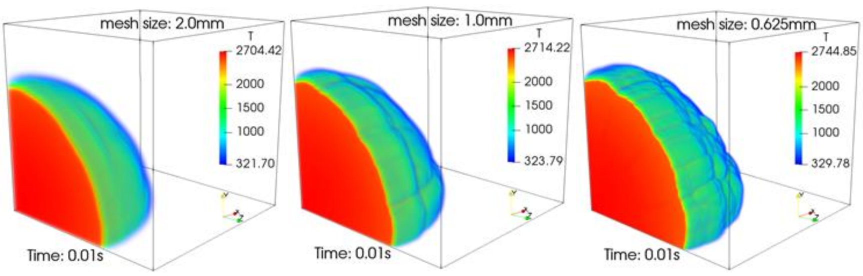

Fig 1. Temperature distributions of H_2-air flame at t = 0.01s.

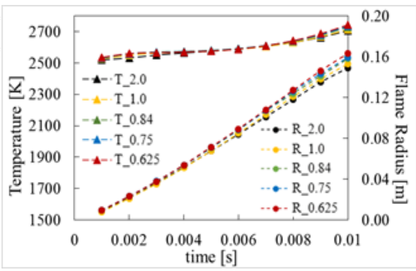

Fig 2. Flame temperature and radius.

3. Conclusion

The results showed that the mesh size should be equal to or less than 1.0mm to observe the wrinkle behavior of flame in which the flame characteristics such as temperature and radius for each mesh size were almost same at 0.003s to 0.006s in this model. After 0.006s, the flame front became more unstable due to intrinsic instabilities, and hence the flame temperature increased and flame radius became large. The wrinkle shape of flame front from the numerical simulation was similar to that from the experiment [2] when the mesh size became small.

References

[1] OpenFOAM User Guide v1712, https://openfoam.com/releases/openfoam-v1712/

[2] T. Katsumi et al., Journal of the Combustion Society of Japan, 2017, Vol. 59 No.189, pp. 210-215 (in Japanese)