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Modeling of Unsteady Dispersion Spray during Low Needle Lift with Mini Sac Nozzle for Diesel Engines

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Sac internal flow and spray characteristics in diesel mini sac nozzle depends on needle lift. During low needle lift, vortex flows and string cavitation form in sac are visualized. It results in a larger spray angle. Zhang et al. reported the spray angle increases during low needle lift, forming a hollow high dispersion spray by X-ray spray analysis.

Many models were developed to reproduce fuel spray by three-dimensional numerical analysis, and many breakup models were applied spray breakup process. However, there are no injection model affected by flow internal sac, and fuel spray numerical analysis cannot reproduce the unsteady dispersion spray during low needle lift. Unsteady injection characteristics by flow internal sac during low needle lift influences spray characteristics such as droplet size distribution and concentration distribution, and on combustion characteristics such as flame shape and ignition delay period. The combustion characteristics affect soot formation and cooling losses, so it is important to reproduce unsteady fuel spray characteristics.

In this paper, modeling the effect of needle lift on the sac internal flow and high dispersion spray due to sac vortex flow during low needle lift at the initial and end stages of injection are reported. As shown in Figure 1, proposed injection model in this study uses the newly proposed Dispersion Injection model during low needle lift and the previous Blobs model during high needle lift. Dispersion Injection model calculated absolute directional injection velocity and vortex directional injection velocity by estimating the sac pressure and the sac vortex energy. The injection droplet diameter was calculated by the liquid film thickness during high dispersion spray. Classification of the initial and end stages of injection and mid stage of injection were determined by presence or absence of string cavitation. In addition, proposed injection model in this study was introduced into KIVA3V for CFD analysis and compare with previous model and experimental results of fuel spray. The results show that the proposed injection model can reproduce the unsteady dispersion characteristics of spray during low needle lift.

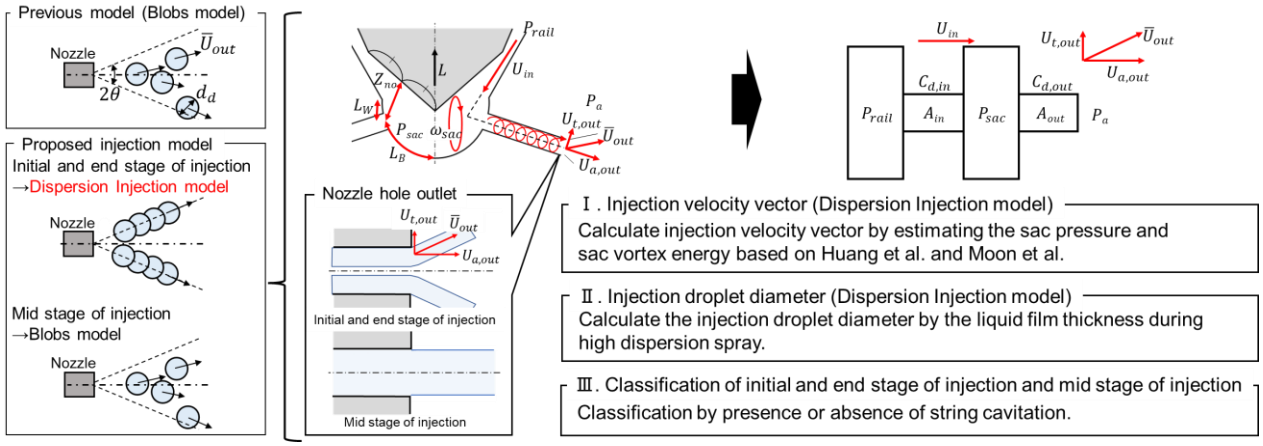

Fig.1 Schematic of proposed injection model in this study and comparison with previous injection model (Blobs model)