Numerical Investigation of Dropwise Condensation with OpenFOAM: Application to the windshield's defogging

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The exposure of a cold surface to warmer humid air can trigger condensation of water vapor present at the surface, if the surface is colder than the dew point temperature. This condensation appears under the form of tiny droplets. These tiny droplets scatter the light and then can reduce the visibility through the surface. This must be avoided in many applications, for example on the windshield of the car. Thus, it is necessary to predict accurately the formation of fogging during casual and extreme driving conditions to ensure a perfect visibility in each situation without consuming too much energy from the air-conditioning system. The complete simulation of the fogging requires a multiphase flows simulation involving the humid air simulated as a perfect mixture of dry air and water vapour and the liquid water droplets created by the condensation of humid air. Because of the scale difference between the droplets and the length of the windshield, a first "one-phase" simplified model has been developed in OpenFOAM to predict the fogging for several conditions of in-cabin temperature and relative humidity. The model simulate the humid air as a perfect mixture of gases and uses the heat and mass transfer analogy to calculate the heat flux through the windshield, the maximum condensing mass flux on the windshield and the average height of droplets. Other important parameters like the dew point temperature, the relative humidity, the absolute humidity and the minimal radius of the droplets are also calculated. The condensation is simulated using a source term in energy equation. It has been found that several parameters like the conductivity of surface and the conditions of in-cabin and external temperature and humidity strongly influence the beginning of the condensation and the defogging time. The very small droplets play the most important role as they release the most part of the heat transfer. The actual model can predict the fogging pattern for several conditions critical conditions and then when the air conditioning system is necessary and can give important information on the size of the droplets. Experimental observation will be necessary to find the exact distribution of the droplets in order to calculate the heat flux. Then, this heat flux will be compared with the heat flux calculated by the model.