

Laboratory experiment of sound propagation characteristics in rarefied atmosphere for developing PDI to be on-board

KIHARA, Daiki^{1*}, MORINAGA, Takatoshi¹, YAMAMOTO, Masa-yuki¹

¹Kochi University of Technology

Sound propagation characteristics in middle and upper atmosphere basically depend on atmospheric temperature and wind. Mainly, it can be derived by atmospheric models. But this measurement is comparatively difficult and previous experimental results are very limited. In 1960's, multiple bombs on-board a sounding rocket were used for measuring the sound propagation of explosions at multiple sites on ground in order to obtain temperature and wind profiles in middle and upper atmosphere. In 1990's, a measurement method by using MU-Rader with RASS(Radio Acoustic Sounding System), sending low-frequency sound from the ground. However, in-situ sound measurement in middle and upper atmosphere has never been carried out.

In-situ observation of an altitude profile of sound propagation characteristics quantitatively by using rocket borne sound transmitter and receivers will be carried out with sending low-frequency sound from a sound generator of RASS to be installed at Uchinoura launch site. The sound generated on ground will also be observed by the on-board microphones. In addition, audible sound and infrasound to be generated by rocket motor could be measured not only by infrasound sensors on ground but also by the on-board microphones. A plan to perform comparative verification between the in-situ measurement and the ground observation is scheduled in 2012.

The on-board instrument PDI (Propagation Diagnostics in upper atmosphere by Infrasonic/ Acoustic waves) consists of a speaker as sound source, one main microphone and two sub microphones as sound detectors, and a sound generator circuit. Those devices will be operated by sending 7 fixed-frequency sound waves between 10 Hz and 1 kHz into the surrounded atmosphere. And Observation of audible sound by rocket motor burning, operation sound of nose cone open and payload separation will also be carried out. The RASS speaker will generate high-power pulsating sound at about 100 Hz before the rocket launch from the ground so as to perform a trial measurement by the on-board microphones.

At present, as a laboratory experiment, by putting a main microphone and two sub microphones and a speaker in vacuum chambers at Kochi University of Technology and ISAS/JAXA, measurement of sound wave propagation characteristics in rarefied atmospheric environment has been performed 100 km altitude level (10^{-4} Pa). As a result, it was confirmed that received signal strength was decreased in rarefied condition. It is because the sound wave can propagate by vibrating molecules in the atmosphere and the decreasing signal strength is related on number of molecules in rarefied atmospheric environment.

Based on the result of the laboratory experiment, it was confirmed that the PDI to be on-board the S-310-41 sounding rocket will operated in middle and upper atmosphere.

Keywords: S-310-41, sound wave, sounding rocket, PDI