

SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (5)

Author: Prof. Tetsuya Sato
Waseda University, Japan

Mr. Masamitsu Watanabe
Waseda University, Japan

Ms. Hitomi Iizuka
Waseda University, Japan

Mr. Tomoyuki Arai
Waseda University, Japan

Mr. Takato Goto
Waseda University, Japan

Mr. Ayumu Hirayama
Waseda University, Japan

Dr. Hiroaki Kobayashi
Japan Aerospace Exploration Agency (JAXA), Japan

Dr. Hideyuki Taguchi
Japan Aerospace Exploration Agency (JAXA), Japan

Dr. Kenya Harada
Japan Aerospace Exploration Agency (JAXA), Japan

CRYOGENIC FUEL MANAGEMENT ON THE PRECOOLED TURBO JET ENGINE

Abstract

We report a propellant flow simulation with a fundamental experiment of the subscale precooled turbojet (S-engine) engine developed by JAXA (Japan Aerospace Exploration Agency). The engine uses liquid hydrogen as its fuel and also as refrigerant to cool the breathed air heated by aerodynamic heating under the hypersonic flight. The fuel management of the S-engine, especially during the engine start-up, is difficult because the S-engine needs very short duration of start-up (about 20 sec) with keeping the turbine temperature limit (about 950 degC). Additionally, the cryogenic liquid hydrogen easily evaporates and changes to two-phase and gaseous phase by the heat capacity of the un-precooled pipes and valves. This phase change produces drastic density change and then the mass flow control becomes difficult. We have constructed a dynamic simulator to analyze the liquid hydrogen fuel management. This simulator includes the fluid-thermal property model of the two-phase flow based on the other fluid data. However, the result of the simulator does not sufficiently agree with the experimental data because of the lack of the two-phase hydrogen property. In this study, we have conducted the experiment to obtain the fluid-thermal property of hydrogen. Hydrogen is supplied by the pressure-regulated tank and flows in a horizontal vacuum-insulated pipe. After the pipe is cooled down and the phase of the hydrogen becomes completed liquid phase, a coiled wire wound on the tube surface is heated electrically to produce the arbitrary flow patterns such as bubbly flow, slug flow and wavy flow. A new capacitance type void fraction measurement system is produced and tested. This system can also measure the flow velocity using the cross-correlation method. Temperature and pressure measurements are conducted to get the heat transfer and pressure loss property. The test has successfully conducted. The void fraction and flow velocity measured by the capacitance type sensor agree with these analyzed by the high-speed video image. The heat transfer

data in this experiment are compared to the existing two-phase flow model based on the water-air flow. The new model will be created by the data and adopted to the simulator. We show the results of the simulation that used improved two-phase model as well as the experiment.