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Author: Mr. Mansu Navaneethan
Vikram Sarabhai Space Centre (VSSC), India

THEORETICAL PERFORMANCE OF PLATE-FIN HEAT EXCHANGERS FOR HSP MISSION

Abstract

Environmental control and life support system (ECLSS) is one of the most critical systems devised for Human Spaceflight Project as its primary function involves maintaining the crew cabin at a habitable environment for the full duration of the mission. A critical component of an environmental control system for the crew cabin of a manned spacecraft is the heat exchanger which is used for thermal conditioning of the cabin air, usually a gas-liquid type. For ensuring the required temperature level, it has been decided to incorporate heat exchangers with a stipulated heat removal capacity. Since space and mass optimization is essential for a flight, it was decided to propose compact heat exchangers for temperature requirements. This study aims at designing a compact plate-fin heat exchanger for transferring the required heat load of 300 W. The coolant is ethylene-glycol mixture due to its superior heat carrying capacity. In the initial phase, so as to predict the temperature variation for the fluid and the separating plate, we performed an analytical study based on steady state conditions by considering parallel and counter flow arrangement of the fluid streams incorporating heat conduction through the separating plate. In addition to that, we have developed a generalized algorithm for the performance prediction of compact plate fin heat exchangers by assuming counter flow, parallel flow and cross flow arrangements for both steady and transient cases. In connection with this, a numerical study is carried out to determine the temperature distribution for working fluids and the separating plate for the plate fin heat exchangers by considering the energy equations for fluid and solid domain. The approach involves two dimensional heat conduction effects for the separating wall and also the axial heat conduction for the fluids by considering the effects of Peclet number. The effect of temperature non-uniformity at inlet is also considered as it may affect the performance of the heat exchanger during flow regulation. In the second phase, an attempt is also made to extend the current study for the performance prediction for multi-pass heat exchangers, by assuming that the adiabatic plane or plane of symmetry exists at the location corresponding to half fin length. The governing equations are discretized using finite difference scheme wherein central difference is applied for second order spatial derivatives are and upwind scheme is used for the first order spatial derivatives. Transient problem is solved using implicit method coupled with Gauss-Seidal iterative technique.