News Magazine of The Institution of Engineers(India), Kerala State Centre

Voice of Kerala Engineers

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CHAIRMAN SPEAKS

Er. K.K Gopalakrishnan Nair FIE

Student Chapter of the Civil Engineering Division was inaugurated in the Marian College of Engineering , Thiruvananthapuram on 27th January.

The message at the beginning of Centenary year of the Institution was that the membership should be doubled during this year. But the growth is not up to the expected rate. Each one of us should get at least one more member enrolled into the Institution.

The vacation class for the High School students will be conducted this year during April- May.

The next meeting of the Council will be held at Nagpur on 27, 28 and 29th March. The new President Sri Narendra Singh FIE will preside over.

REPUBLIC DAY CELEBRATION

The Institution of Engineers (India), Kerala State Centrecelebrated the 71st Republic Day of our Nation on 26th January 2020. Er.N. Rajkumar, Immediate Past Chairman, IEI KSC hoisted the National Flag at Visvesvaraya Bhavan, Thiruvananthapuram in the presence the Honorary Secretary, IEI KSC, Membersof the State Committee, Corporate Members, staff and students.

HONORARY SECRETARY'S DESK

Er. Asok Kumar K FIE

05.02.2020 Talk on "*Rocket Science at Microscopic Scale - Self-propelled colloids*" by Dr Akhil Varma, PhD, Laboratory of Hydrodynamics (LadHyX), Ecole Polytechnique, Paris, France.

12.02.2020 23rd Er.C.S.Padmanabha Iyer Morial Lecture on "*Energy Conservation*" by Er. K.G. Chandrasekharan, Former Member (Civil), Kerala State Electricity Board & Past Chairman, IEI Kerala State Centre

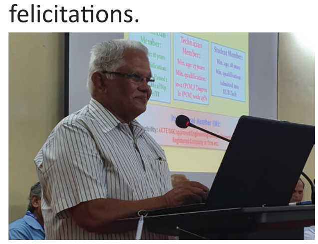
19.02.2020 Talk on '*Dynamics of two-phase flow- Modeling challenges and road forward*' by Dr.Pradeep Kumar, Associate Professor, Department of Aerospace Engineering, IIST.

26.02.2020 Talk on '*Some Decision Problems in Uncertainty*' by Dr. N. Narayana Pillai, Professor Emeritus, Amrita School of Engineering, Coimbatore.

05-03-2020 World Engineers' Day Celebrations.

STUDENT CHAPTER

Inauguration of Students' Chapter in the Department of Civil Engineering, Marian Engineering College, Kazhakuttam, Thiruvananthapuram was held on 27th January 2020. Er.K.K.Gopalakrishnan Nair, FIE Chairman inaugurated the Chapter. Er.Asok Kumar K., FIE, Honorary Secretary, IEI Kerala State Centre presented the activities of IEI. Er.S.Radhakrishnan, FIE, Director, CERCON delivered felicitations.



100 years of relentless journey towards engineering advancement for national building

THERMAL AND HUMIDITY CONTROL SYSTEM OF CREW MODULE FOR HUMAN IN SPACE PROGRAM

L Aravindakshan Pillai, Group Head; Propulsion and Plasma Research Group, VSSC, Trivandrum-22

Paper presented during the one day Colloquium "AGNI 2019" on "Space Systems Heat Transfer" organised by IE(I) Kerala State Centre in association with the Indian Society for Heat & Mass Transfer Regional Centre, Trivandrum (ISHMT RCT) on 23-11-2019.

Introduction: Thermal and humidity control system (THCS) is one of the major subsystems of Environmental Control and Life Support System (ECLSS) of any human in space programme. It essentially maintains a comfortable temperature and humidity in the crew cabin during its orbital flight. In the crew module, heat is added to the cabin air due to human activities and also the working of avionic packages. It is estimated that each crew is liberating around 150-200 watts of heat and 1.5 liters of water per day due to human metabolism. THCS is basically designed to remove this heat and the moisture continuously to maintain the temperature and humidity within the comfortable limit.

Even though different methods and approaches are available for maintaining the temperature and humidity in the crew cabin, two fluid thermal and humidity control system, shown in **figure 1**, is the most common. Here two types of heat exchangers, one in cabin called Air-to-Liquid heat exchanger (ALHE) and other in the Service module called Liquid-to-Liquid heat exchanger (LLHE), are used for absorbing the heat from the crew cabin and transfer to space radiator through the LLHE.

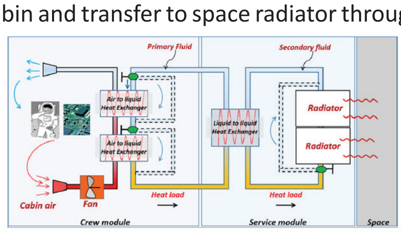


Fig.1. Two fluid thermal and humidity control system

Space radiator is mounted on the outer surface of the service module and radiates out the heat to the deep space. Its surface properties, viz. IR emissivity and solar absorptivity are very imporant to ensure adequate heat dissipation with available radiator area. To achieve high heat rejection capacity, special thermal paints are applied on the radiator surface, which provides very high emissivity (of the order of 0.91) and low absorptivity (of the order of 0.01).

Integrated design of the thermal control system: The major components in the thermal control system are ALHE, LLHE and space radiator. Since the outlet of each component is the inlet to the next component, the design of the system should be carried out in an integrated manner. Heat exchangers should be selected for light weight and should occupy less space. Configuration should be selected to get minimum pressure drop in the fluid lines and air passages. This will result in the low pumping power requirements for heat transfer fluid and the air.

The main constraints for the sizing of the liquid to liquid heat exchanger are hot fluid outlet temperature, which is required to be maintained at suitable temperature and cold fluid inlet temperature, which is required to be below certain limit (to be arrived at through the design of radiator with given constraint on the available area) to maintain the cabin air temperature within $23^{\pm 3}$ ^{0}C

The design of space radiator is critical for effective thermal control of the crew cabin especially for manned space programs. An efficient design of a space radiator should ensure minimum exposed surface area and coolant pumping power. Pumped liquid radiators with flat fin panels are the conventional type of radiators used for space applications. **Figure 2** shows a plane type radiator which is a tube and fin type. It consists of multiple units of tube and fin. One set of tube and fin is considered as single radiator unit. These units are arranged in parallel mode such that all the units are connected to a common header and collector. All these units receive equal amount of coolant and dissipate equal amount of heat. Hence, the design of a single unit to dissipate known amount of heat load ensures that the multiple numbers of similar units can be assembled together to dissipate required amount of heat load.

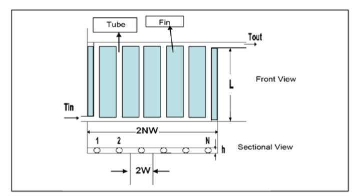


Figure 2 : Plane type space radiator.

Selection of the Heat transfer fluids: The selection of the heat transfer fluid for heat exchangers is very important as it should not lead to any danger/safety concern to crew in case of an inadvertent leak of the fluid in the cabin. Also it should have good thermo physical properties like high heat capacity, low freezing point and low viscosity at lower temperatures. Primary heat transfer fluid which is passing through cabin heat exchanger should be nontoxic, non-flammable and human compatible. It should have moderate freezing point and low viscosity. Most of the fluids that have low freeze temperatures such as fluorocarbons and ammonia are high vapor pressure oxygen displacers or are toxic to crew members and cannot be used inside the pressurized spacecraft volume for fear of an inadvertent system leak and crew exposure. Water- ethylene glycol mixture (50:50) and water-Propylene glycol (70:30) are commonly used as the primary heat transfer fluid.

As the secondary heat transfer fluid is flowing through the outer loop, it is possible to get cooled to very low temperatures due to deep space visibility. The freezing point of the secondary fluid is usually specified as less than -100^{0}C. Some of the commonly used secondary heat transfer fluid are: PMS 1.5 , KF96L-2cs, Galden HT 70 , 3M Novec 7200 and 3M Novec 7100 whose freezing point are between -120^{0}C to -136 ^{0}C

Humidity Control System: Humidity control is achieved by continuously removing the excess moisture in a controlled way from the crew cabin. Absorbent type materials in the canister kept in the air flow passage can be used, but weight of the total system will be more. In early space flights, silica gel is partly used. It can absorb water up to 30 % of its weight.

Condensing type heat exchanger along with slurper bar and cyclonic moisture separator, shown in **figure-3**, is used for long duration flights.

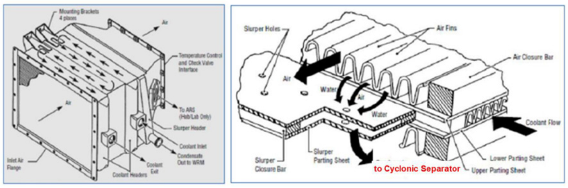


Fig.3. Condensing type heat exchanger along with slurper bar.

The working principle of slurper bar is that, mixture of air and the condensed moisture flows through the slurperbar which is attached at the exit of the condensing type heat exchanger. Slurperbar contain large number of small dia holes through which mixture (condensate and part of air) will get entered in the cyclone separator through the application of vacuum. The condensed moisture (liquid form) is separated in the cyclonic separator and air goes back to the crew cabin. The separated liquid is stored in the storage tanks.

Nafion based dehumidifiers, shown in **figure-4**, is also used effectively for the humidity control in the crew cabin.

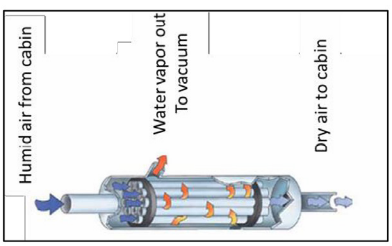


Fig.4. Nafion based dehumidifiers.

The working principle of Nafion based dehumidifiers is that, the transfer of water vapor through membrane and is driven by humidity gradient and evaporates into the surroundings by a process called pervaporation. Because of very high water-of-hydration of sulfonic acid, each molecule can absorb 13 molecules of water. Nafion absorbs 22% by weight of water. The main advantages compared to slurper bar are 1) No moving parts 2) Minimum energy requirement and 3) Minimum maintenance with high shelf life.

Redundancy in thermal control system: For dual redundancy of the thermal control system, two independent heat transfer loops are provided and each loop consists of the inner and outer loop designed for removing full heat load. Cold plates are used for removing the heat generated by avionics packages and are being cooled by circulating heat transfer fluids coming from both loop. Cold plates are designed to operate normally even with fluid flow from one loop. Each loop is connected to the radiator panels independently so that it will give full redundancy. For normal working of the system, each loop will be working in half of its heat transfer capacity. This is achieved by operating pumps in the circuit and fan in the ALHE duct at half its nominal flow rate conditions. In case of failure of one of the loops, the other loop will be operated in the nominal operating condition and cater to full heat transfer requirements. In addition to this, dual redundancy is provided for pumps and also for fan in air duct.

Temperature control inside the crew cabin: It is required whenever temperature goes beyond the specified range ($23^{\pm3}\ {}^{0}C$). Temperature can go below $20^{0}C$ when the heat generation in the cabin goes below designed value. Then the temperature can be maintained in the cabin within set limits by invoking any of the following:

a) Reducing the flow rate of the heat exchanger fluids in both heat transfer loops

b) Allow metered flow of fluid to bypass the radiator panels

c) Isolating radiator panels

d) Isolating one of the heat transfer loop.

Temperature can go above $26^{0}C$ when the heat generation is above the designed value. Then the temperature can be maintained in the cabin within set limits by invoking any of the following:

a) Increase the air flow rate through the heat exchangers b) Reduce the heat generation by putting off some of non-critical electrical equipment

c) Increase the fluid flow through the heat exchangers

These control requirements are included in the automated controller of the cabin thermal control system.

Thermal Control during lift off and re-entry: During liftoff and reentry phases, the radiator is not effective/ not present for heat removal. An additional liquid –to- Liquid heat exchanger is provided to cool the cabin to about $18^{0}C$ using the thermal control system components and chilled fluids from ground before liftoff, as shown in schematic **figure 5.** Similarly, before reentry, the radiator will be operated for its full capacity to pre-chill the cabin to less than $18^{0}C$. Then the service module with radiator will be separated from the crew module during re entry and the crew module alone enters the earth's atmosphere and finally the landing.

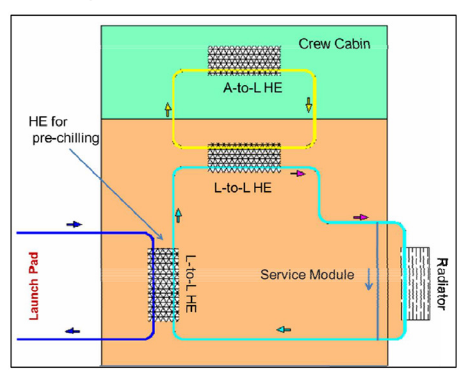


Fig.5. Schematic of thermal control system components and chilled fluids from launch pad.

Conclusion: Thermal and humidity control system is essential to maintain a comfortable temperature and humidity within limits in the crew cabin of any human in space flight. A widely used two fluid thermal control system is explained along with brief idea of integrated design and the humidity control in the paper.

GUIDANCE CLASSES AT IEI KERALA STATE CENTRES

Summer Vacation Class for High School Students

Admission starts from March 2020 and classes starts from 6th April for 1 month duration.

Training programme includes both theory and practicals. Theory classes on Science Education, Energy Management, Sustainable Development and various safety practices are handled by experts from schools, colleges and Government Departments.

Practical class include assembly and testing of an electronic device, which can be taken home after the course.

GATE 2020 (Graduate Aptitude Test in Engineering)

Admission starts from April 2020 and classes starts from May 2020 for following branches. Course duration: 8 months (Saturdays & Sundays only)

- Civil
- Mechanical
- Electrical & Electronics
- Electronics & Communication
- Computer Science & Engineering

Good GATE score will help students in getting admission to M.Tech programme in reputed colleges like IITs/NITs and also employment in many private and public sector undertakings.

IEI Members are requested to give wide publicity for these courses and enrol maximum Number of students.

SPECIAL MEMBERSHIP DRIVE

IEI plan to increase the membership by 10% in this Centenary year. All Corporate Members are requested to contribute to this effort by bring in new members. The application forms can be downloaded from the website **www.ieindia.org** or obtained from Kerala State Centre / respective Local Centres.

Kerala State Centre- WEDNESDAY TALKS - Glimpses

01.01.2020 **'Waste Management'** Mr. P. Ajayakumar, Technical Officer-Waste Management, Haritha Kerala Mission.

15.01.2020 **'Innovation at Apple – Steve Jobs Way'** by Mr.Rajith Nair, Corporate Trainer, Mentor of Change, Niti Ayog, ATL Mission, Managing Director, Centriq Academy for Training & Mentor.

22.01.2020 **'Lean Six Sigma'** by Er.E.J.Francis, Retd. Group Director, VSSC

29.01.2020 **'Internet of Things to the Internet of Everything'** by Dr.Raveendranathan K.C., Professor and Principal, Rajadhani Institute of Engineering and Technology, Thiruvananthapuram.

MEMBERS IN NEWS

Er. Balakrishnan Nair received Best paper Award in Engineering Congress for his paper 'Technology Strategy for Improved 'Safety Management in Steel Industry'.

Dr V Narayanan, Director, Liquid Propulsion System Centre, Indian Space Research Organisation, Trivandrum, received Best Design Award of NDRF.

Er. Venugopal S., DGM, HLL Lifecare Ltd., received National Award for Best Trainer in Rubber Skill Development, 2018-19.

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