Hindusthan College of Engineering and Technology
An Autonomous Institution

Department of Mechanical Engineering

Research facilities in Mechanical Engineering Department

List of Laboratories available

S. No	Laboratory facility available
1.	Basic Engineering Laboratory
2.	Manufacturing laboratory
3.	Heat Power laboratory
4.	Dynamics of Machinery laboratory
5.	CAD/CAM Laboratory
6.	Metrology laboratory
7.	Fluid Mechanics and Stregth of Materials laboratory
8.	Energy Engineering Laboratory
9.	Fabrication laboratory
10.	Project laboratory
11.	Messer-cut Centre of Excellence
12.	SAE Baja laboratory

List of Major equipments available

S. No	Research facility available	No Resesrch scholars benifited	Publications
1.	Heat Pump Water and dryer using packed bed evaporator	01	05
2.	Heat pump dryer	01	-
3.	Solar photovoltiac water pumping systems	01	03
4.	Heat pump dryer using packed bed evaporator	01	01
5.	Two stage cascade heat pump	-	-
6.	Walk in cooler	-	-
7.	Robotic Integrated in flexible Manufacturing system.	-	-
8.	3D Printing	-	-
9.	Coputerized Internal Combustion Engines	01	-
10.	Coordinate measuring machine	-	-

List of Minor equipment available

S. No	Research facility available	No Resesrch scholars benifited	Publications
1.	Solar air collectors using packed bed absorbers	01	02
2.	Solar air collectors using pin-fin absorbers	01	02
3.	Forced convection Solar dryer	01	04
4.	Solar stills using heat storage materials	01	04
5.	Heat pump assisted solar stills	01	04
6.	Forced convection Solar dryer	01	04
7.	Solar stills using heat storage materials	01	04
8.	Two stage evaporative coolers	-	-
9.	Compression chiller with cooling tower	-	-
10.	Heat pump water heaters	-	-
11.	Vibration measurement and control	-	-
12.	Temperature controlled universal testing machine	-	-
13.	Fire sprinklet testing appratus	-	-
14.	Domestic refrigerator test rig	-	02
15.	Solar water heater using packed bed	01	01

	absorber		
16.	Solar green-house dryer	01	-

Heat Pump Water Heaters using Solar Photovoltaic-Thermal Hybrid Evaporators

Specifications:

PV-T collector Area: 1.6 sq mts; Compressor rated power: 450 W

Condenser: Shell and coil type; Condenser heat output: 1.3 kW

Capacity of water heater 125 litres; Expansion device: Capillary tube

Research Progress

1. One Ph.D scholar is pursuing his Ph.D research work titled "***Investigations on direct expansion PV-T hybrid heat pump system using binary zeotropic refrigerants"*** to ensure uniform panel cooling". Mr. J. Yogaraja.

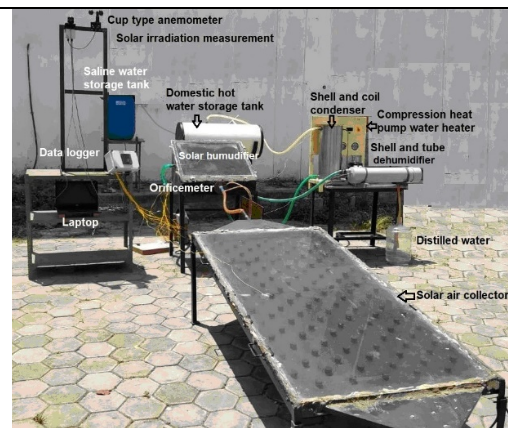
Research Publications

1. N. Gunasekar, **M. Mohanraj,** V. Velmurugan. (2015). Artificial neural network modeling of a photovoltaic-thermal evaporator of solar assisted heat pumps. ***Energy- An International Journal*** 93 (1) 908-922. Elsevier publishers.
2. **M. Mohanraj,** N. Gunasekar, V. Velmurugan. (2016). Comparison of energy performance of heat pumps using a photovoltaic-thermal evaporator with circular

and triangular tube configurations. ***Building Simulation- An International Journal*** 9 (1) 27-41. (Springer Publishers).

3. J. Alosh, **M. Mohanraj**, M. Srinivas, S. Jayaraj. 2021. Thermal analysis of photovoltaic-thermal collectors – A review. ***Journal of Thermal Analysis and Calorimetry*** Vol. 144 1-39.
4. A. James, M. Srinivas, **M. Mohanraj**, Arun K Raj, S. Jayaraj. 2021. Experimental studies on photovoltaic-thermal heat pump water heaters using variable frequency drive compressors. ***Sustainable Energy Technology and Assessments*** 45 101152.
5. J. Yogaraja, M. Mohanraj, J. Manikandan, P. Muthusamy. Performance of direct expansion photo-voltaic thermal evaporator assisted compression heat pump water heaters using zeotropic mixtures. Solar Energy 2024; 272: 112435.

Forced Convection Solar Air Heater using Pin-fin and packed bed absorber plates



<u>**Specifications**</u>

Absorber area: 2 m^2; Absorber plate: Packed bed using paraffin wax

Air flow: Forced convection; Applications: Drying and Desalination

Outcomes

Two Ph.D scholar have completed their Ph.D research work using this research facilities in the department. The thesis titled are as follows:

- ***Investigations on forced convection solar air collector using packed bed absorber platee***. by Dr. R. Arulkumar 2018.
- ***Experimental studies on solar air collector and heat pump integrated humidification***-dehumidification thermal desalination systems. By Dr. S. Sivakumar 2024.

Publications:

1. R. Arulkumar, B. Ganesh Babu, **M. Mohanraj.** Thermodynamic performance of a forced convection solar air heaters using packed bed solar air heaters packed with latent heat storage materials. ***Journal of Thermal Analysis and Calorimetry*** Vol. 126 (3) 1657-1678. (Springer Publishers).
2. R. Arulkumar, B. Ganesh Babu, **M. Mohanraj.** 2017. Experimental investigations on forced convection solar air heater using packed bed solar air heaters. ***International Journal of Green Energy*** 14 (15) 1238-1255. (Taylor and Francis).
3. S. Sivakumar, K. Siva, **M. Mohanraj**, 2019, Thermodynamic analysis of forced convection solar air heater using pin-fin absorber plate. ***Journal of Thermal Analysis and Calorimetry***. 136, 39-47 (Springer Publishers).

Solar assisted heat pump dryer and water heater using packed bed collector

Specifications

Evaporator - collector Area: 1.6 sq mts; Configuration: Packed bed serpentine configuration

Compressor rated power: 1.0 kW; Condenser: Shell and coil type

Condenser heat output: 4 kW; Capacity of water heater 125 litres

Expansion device: Capillary tube; Drying chamber: 200 litres

Outcomes

One Ph.D scholar is pursuing his Ph.D research work titled "Investigations on direct expansion solar thermal heat pump dryer using packed bed evaporator-collector"

Publications

1. **M. Mohanraj.** (2014). Performance of a solar-ambient source hybrid heat pump drier for copra drying under hot-humid weather conditions. ***Energy for Sustainable Development*** Vol. 23 165-169. (Elesvier Publishers).
2. M. Kuan, Ye. Shakir, **M. Mohanraj,** Ye. Belyayev, S. Jayaraj, A. Kaltayev, 2019. Numerical simulation of a heat pump assisted solar dryer for continental climates. ***Renewable Energy****.* 143, 214-225. (Elsevier Publishers).
3. **M. Mohanraj,** Yerzhan Belyayev, S. Jayaraj, A. Kaltayev. 2018. Research and Developments on Solar assisted Compression heat pump Systems – A Comprehensive review (Part-A: Modeling and Modifications). ***Renewable and Sustainable Energy Reviews*** 83, 90-123. Elsevier publishers.
4. **M. Mohanraj,** Yerzhan Belyayev, S. Jayaraj, A. Kaltayev. 2018. Research and Developments on Solar assisted Compression heat pump Systems – A Comprehensive review (Part- B: Applications). ***Renewable and Sustainable Energy Reviews*** 83, 124-155. Elsevier publishers.

Solar stills using heat storage materials

Specifications

Basin area: 0.7 sq. m

Absorber: Pin-fin absorber with PCM and solid pin-fins

Maximum productiity: 3 lts / day

Outcomes

One Ph.D scholar has completed his Ph.D research work titled "investigations on performance enhancement of solar stills". Mr. R. Dhivagar.

Publications

1. R. Dhivagar, **M. Mohanraj,** K. Hidouri, (2020). CFD modeling of a gravel coarse aggregate sensible heat storage assisted single slope solar still". ***Desalination and Water Treatment*** (Accepted for Publication).
2. R. Dhivagar, **M. Mohanraj,** K. Hidouri, Ye. Belyayev. 2021. Energy, Exergy, Economic and Enviro-economical (4E) analysis of a coarse aggregate sensible heat storage assisted single slope solar still. ***Journal of Thermal Analysis and Calorimetry*** Vol. 145 (2) 475-494.
3. R. Dhivagar, **M. Mohanraj,** Ye. Belyayev. Performance of a bio-mass evaporator assisted solar still. ***Environmental Science and Pollution Research.*** Accepted for Publication.
4. R. Dhivagar, **M. Mohanraj.** Assessment of single slope solar still using block and disc magnets via productivity, economic and enviro-economic analysis: A

comparative study. ***Environmental Science and Pollution Research.*** Accepted for Publication.

5. R. Dhivagar, **M. Mohanraj.** 2021. Thermodynamic analysis of single slope solar still using graphite plates and block magnets at seasonal climatic conditions. ***Water Science and Technology***. Accepted for Publication.

Solar Photovoltaic water pumping system

Specifications

Photovoltaic module type: Polycrystalline; Area: 2.1 sq. m; Cooling: Forced convection air cooling; Water pump: 0.5 HP; Power supply: 3 phase; Controls: MPPT

Outcomes

- One Ph.D research scholar has completed his Ph.D research work titled "Investigations on photovoltaic water pumping systems". Mr. C. Gopal.

Publications

1. C. Gopal, **M. Mohanraj,** P. Chandramohan, P. Chandrasekar: (2013). Renewable Energy source water pumping systems- A literature review.

Renewable and Sustainable Energy Reviews Vol. 25 (1) 351-370. (Elsevier Publishers).

2. **M. Mohanraj,** P. Chandramohan, M. Sakthivel, K. Sopian. 2019. Performance of photovoltaic water pumping systems under the influence of panel cooling. ***Renewable Energy Focus*** 31 30-41. Elsevier Publishers.
3. C. Gopal, **M. Mohanraj,** P. Chandramohan, M. Sakthivel. 2017. Modeling of a photovoltaic asssited water pumping sytem under the influence of panel cooling. ***Thermal Science: International Scientific Journal*** 21(S2) 399-410.

Air-to-Air heat pump assisted solar still

<u>Specifications</u>

Solar still: 0.7 m^2; Compressor: 450 W; Condenser: Fin and tube air cooled condenser

Evaporator: Fin and tube air cooled evaporator; Expansion device: Capillary tube expansion device

Instruments: Solar irradiation and cup type anemometer

Outcomes:

One research scholar is pursuing his Ph.D work titled "Investigations on Heat Pump assisted regenerative solar still" Mr. L. Karthick.

Publications

1. M. Mohanraj, L. Karthick, R. Dhivagar, 2021. Performance of heat pump assisted solar still integrated with heat storage materials. *Applied Thermal Engineering* Vol. 196 117263.
2. Y. Belyayev, M. Mohanraj, S. Jayaraj, A. Kaltayev. 2019. Thermal performance simulation of a heat pump asssited solar desalination system for Kazakhstan conditions. *Heat Transfer Engineering* 40; 1060-1072. (Taylor and Francis Publishers).
3. K. Hidouri, M. Mohanraj, 2019. Thermodynamic analysis of a heat pump assisted active solar still. *Desalination and Water Treatment.* 154 (1), 101-110.

Desiccant assisted forced convection solar dryer

Specifications

Collector area: 2 m^2; Drying chamber volume: 1 m^3

Mode of air circulation: Induced draft; Number of trays: 3

Holding capacity: 75 kg

Research outcomes

1. G. Padmanabhan, P.K. Palani and M. Mohanraj, 2017. Performance of a desiccant assisted packed bed passive solar dryer for copra processing. *Thermal Science: International Scientific Journal* 21 (S2) 419-426.
2. K.R. Arun, G. Kunal, M. Srinivas, C.S. Sujith, M. Mohanraj, S. Jayaraj, 2020. Drying of untreated Musa nendra and Momordica Charantia in a forced convection solar cabinet dryer with thermal storage. *Energy* 192,116697 (Elsevier Publishers).

Heat pump water heater assisted solar HDH desalination system

Specifications

Heat pump: 450 W rated input power reciprocating compressor

Condenser: Shell and coil condenser; Expansion valve: Capillary tube

Evaporator: Shell and tube evaporator; Solar air collector: 2 sq. m

Solar humidifier: 0.7 sq m.; Hot water storage tank: 100 lits.

Research outcomes

One scholar is pursuing his Ph.D work titled "Investigations on solar air collector-heat pump integrated solar humidifier desalination system".

Publications

1. S. Sivakumar, K. Siva, **M. Mohanraj**, 2019, Thermodynamic analysis of forced convection solar air heater using pin-fin absorber plate. ***Journal of Thermal Analysis and Calorimetry***. 136, 39-47 (Springer Publishers).

Domestic refrigerator

Specifications

Volume of refrigerator: 200 liters

Compressor: Reciprocating compressor 90 W

Refrigerant: R134a

Condenser: Wire and tube condenser

Evaporator: Shell and tube evaporator

Publication Outcomes

1. **M. Mohanraj.** 2019. Experimental investigations on R430A as drop-in substitute to R134a in domestic refrigerators. ***Proceedings of Mechanical Engineering Part-E: Journal of Processes Mechanical Engineering*** 233 (4) 728-738. (Sage Publishers).
2. **M. Mohanraj:** (2013). Energy performance assessment of R134a and R430A as an alternative in domestic refrigerators, ***Energy for Sustainable Development*** Vol. 17 (3) 471-476. (Elsevier Publishers).

Heat pump dryer

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<u>Specifications</u>

Evaporator : Finned tube evaporator

Compressor rated power: 1.0 kW

Condenser: Finned tube condenser

Compressor: Reciprocating type 1 kW

Expansion device: Capillary tube

Drying chamber: 600 litres

Outcomes

- One scholar is working for his Ph.D research work titled "Investigations on Heat Pump assisted solar dryer for processing of selected fruits and Vegetables.
- Identification of suitable refrigerant for heat pump dryers.
- Thermodynamic studies on performance enhancemnt of heat pump dryers.

Deep freezers

Specifications

Volume of refrigerator: 200 liters

Compressor: Reciprocating compressor 450 W

Refrigerant: R134a

Condenser: Forced convection air cooled Condenser Wire and tube condenser

Evaporator: Plate type evaporator

Outcomes

- Involving B.E Mechanical Engineering students to take-up their acedamic projects.
- Identification of suitable refrigerant for replacing R134a and R404A.
- Optimizing the processes parameters of the system.

- To identify a suitable PCM for retaining the cooling in the freezer cabin.
- Thermodynamic studies on performance enhancemnt of deep freezers.

Compression chiller with cooling tower

Specifications

Evaporator: Shell and coil evaporator

Expansion device: Capillary tube

Cooling tower: Induced draft

Condenser: Shell and coil condenser

Evaporator loading: Electrical resistance loading

Compressor rated power: 1.0 kW

Refrigerant: R134a

Expansion device: Capillary tube

Outcomes

- The B.E Mechanical Engineering students are involved for their academic projects. Moreover, the performance was evaluated using different environment friendly working fluids.

Walk cooler for food preservation of high value food products

Specifications

Evaporator : 3.5 kW Fin and tube evaporator; Temperature:0 to 10 deg C

Compressor rated power: 1.0 kW; Condenser: Fin and tube condenser

Cold room volume: 800 litres; Expansion device: Capillary tube

Outcomes

- The B.E Mechanical Engineering students are involved for their academic projects. Moreover, the performance was evaluated using different environment friendly working fluids.
- The performance of this cooler is also tested for ripening processes of selected fruits and vegetables.

- Exergy studies have been carried out to identify the inefficient component in the system.

Phase Change Material Packed bed solar water collector

Specifications

Absorber area: 2 m^2

Absorber plate: Packed bed using paraffin wax

Water flow: Forced convection

Applications: Drying and Desalination

Outcomes

- The B.E Mechanical Engineering students are involved for their academic projects.
- The performance of solar collector using packed bed absorber plate was tested under various climatic conditions.
- Standardization of the collector and optimizing the water flow rate and PCM quantity.
- Exergy studies have been carried out to quantify the losses in the collector absorber.

Heat Pump Assisted Evaporative Cooler

<u>Specifications</u>

Heat pump: 450 W

Stages: 2 stages

Air flow: 50 CFM

Temperature drop: 10 deg C

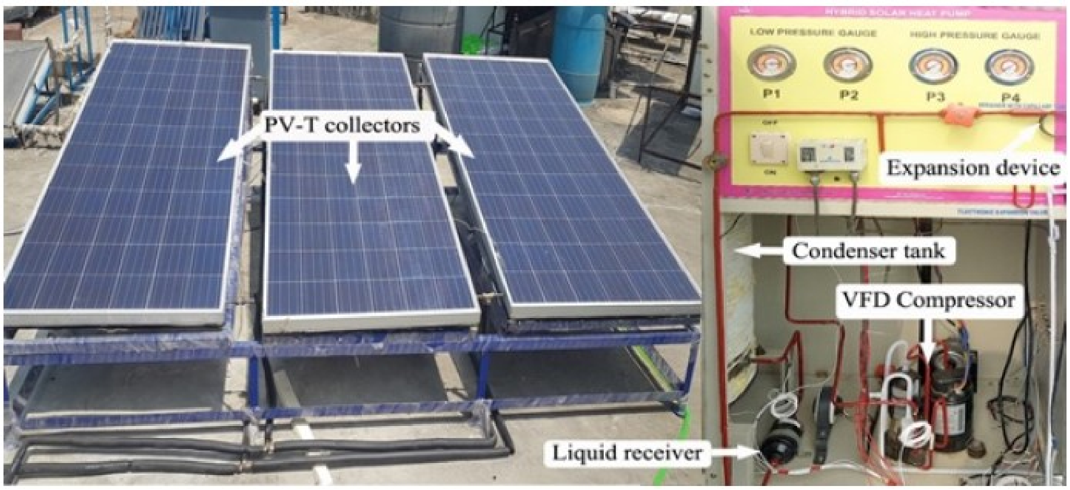
Outcomes

- The B.E Mechanical Engineering students are involved for their academic projects.
- The performance of this cooler is also tested for ripening processes of selected fruits and vegetables.
- Exergy studies have been carried out to identify the inefficient component in the system.

Collaborative Research projects

With National Institute of Technology, Calicut- India

In associate with National Institute of Technology, Calicut as a Co-Principal Investigator for the DST research project titled "***Development, testing and standardization of solar assisted photovoltaic heat pump water heater***". (January 2017-December 2020: Completed).



Research Outcomes

Established a research network with National Institute of Technology, Calicut.

Publications

1. J. Alosh, M. Mohanraj, M. Srinivas, S. Jayaraj. 2021. Thermal analysis of photovoltaic-thermal collectors – A review. *Journal of Thermal Analysis and Calorimetry* Vol. 144 1-39.
2. A. James, M. Srinivas, M. Mohanraj, Arun K Raj, S. Jayaraj. 2021. Experimental studies on photovoltaic-thermal heat pump water heaters using variable frequency drive compressors. *Sustainable Energy Technology and Assessments* 45 101152.
3. A.A Ammar, K. Sopian, M. Mohanraj. (2021). Photovoltaic-thermal collector assisted heat pumps using environment-friendly refrigerants. *Part-E Journal of Processes Mechanical Engineering*. Vol. 235 694-706.

With Al Farabi Kazakh National University, Almaty. Republic of Kazakhstan

In associate with Al Farabi Kazakh National University, Almaty for the project titled "***Development of two stage direct expansion cascade heat pump for space heating applications in extremely cold climates of Kazakhstan***". Funded by National Council for Science and Technology Evaluation, Ministry of Education, Republic of Kazakhstan.

Research outcomes:

- Established research collaborations with Al Farabi Kazakh National University, Almaty, Republic of Kazakhstan.
- Published more than 10 research articles in SCI Journals.
- Establishing Research network with other universities around the world.

Publications

1. A. Abdurashid, M. Mohanraj, Yerzhan Belyayev, S. Jayaraj, A. Kaltayev. 2017. Numerical modleing of photovoltaic-thermal evaporator for heat pumps. *Bugarian Chemical Communications* 48 (1) 135-139.

2. Yessen Shakir, M. Mohanraj, Yerzhan Belyayev, S. Jayaraj, A. Kaltayev. 2017. Numerical simulation of a heat pump assited regenerative solar still for cold climates of Kazakhstan. *Bugarian Chemical Communications* 48 (1) 126-132.
3. Yessen Shakir, Yerzhan Belyayev, A. M. Mohanraj, S. Jayaraj. 2017. Numerical simulation of a heat pump assisted regenerative solar still working with and without heat storage for clod climated of Kazakhstan. *Thermal Sciences:The Scientific Journal* 21 (S2) 411-418.
4. M. Mohanraj, Yerzhan Belyayev, S. Jayaraj, A. Kaltayev. 2018. Research and Developments on Solar assisted Compression heat pump Systems – A Comprehensive review (Part-A: Modeling and Modifications). *Renewable and Sustainable Energy Reviews* 83, 90-123. Elsevier publishers.
5. M. Mohanraj, Yerzhan Belyayev, S. Jayaraj, A. Kaltayev. 2018. Research and Developments on Solar assisted Compression heat pump Systems – A Comprehensive review (Part- B: Applications). *Renewable and Sustainable Energy Reviews* 83, 124-155. Elsevier publishers.
6. Y. Yerdesh, Y. Belyayev, D. Baiseitov, M. Mohanraj, 2018. Modeling two-phase flow in pipe of the solar collector, *International Journal of Mathematics and Physics* 9 (1), 12-19.
7. G. Saktashova, A. Aliuly, Ye. Belyayev, M. Mohanraj, R.M. Singh, (2018) Numerical simulation of heat transfer in hybrid solar-ground source heat pump in Kazakhstan climates. *Bulgarian Chemical Communications* Accepted for Publication.
8. Y. Belyayev, M. Mohanraj, S. Jayaraj, A. Kaltayev. 2019. Thermal performance simulation of a heat pump asssited solar desalination system for Kazakhstan conditions. *Heat Transfer Engineering* 40; 1060-1072. (Taylor and Francis Publishers).
9. M. Kuan, Ye. Shakir, M. Mohanraj, Ye. Belyayev, S. Jayaraj, A. Kaltayev, 2019. Numerical simulation of a heat pump assisted solar dryer for continental climates. *Renewable Energy.* 143, 214-225. (Elsevier Publishers).
10. Ye. Yerdesh, Z. Abdulina, A. Aliuly, Ye. Belyayev, M. Mohanraj, A. Kaltayev. 2020. Numerical simulation on solar collector and cascade heat pump combi

water heating systems in Kazakhstan Climates. *Renewable Energy* 145 1222-1234. (Elsevier Publishers).

11. R. Dhivagar, M. Mohanraj, K. Hidouri, Ye. Belyayev. 2021. Energy, Exergy, Economic and Enviro-economical (4E) analysis of a coarse aggregate sensible heat storage assisted single slope solar still. *Journal of Thermal Analysis and Calorimetry* Vol. 145 (2) 475-494.
12. R. Dhivagar, M. Mohanraj, Ye. Belyayev. Performance of a bio-mass evaporator assisted solar still. *Environmental Science and Pollution Research.* Accepted for Publication.

In associate with Satbayev University, Almaty, for a research project on "***Development of high lift auto cascade heat pumps for space heating applications in continental climatic conditions***". Funded by National Council for Science and Technology Evaluation, Ministry of Education, Republic of Kazakhstan. (Under progress).

Research Collaboration as Co-Principal Investigator Kazakh National Research Technical University named after K. I. Satbayev for the project titled ***"Study of heat transfer enhancement mechanisms of vertical type borehole heat exchanger to ensure high heat pump performance"*** Ministry of Education and Science of the Republic of Kazakhstan.
(Under Progress).