Article **ECORFAN-Spain Journal**
December 2018 Vol.5 No.9 47-52

Alternative for teaching the air conditioning and refrigeration course

Alternativa para la enseñanza de la asignatura de aire acondicionado y refrigeración

HERNANDEZ-GOMEZ, Víctor†, OLVERA-GARCÍA, Omar, GUZMAN-TINAJERO, Pedro and MORILLÓN-GÁLVEZ, David

Universidad Nacional Autónoma de México, FES Cuautitlán, Estado de México y Cd. Universitaria, Ciudad de México, México

ID 1st Author: *Víctor, Hernandez-Gomez* / **ORC ID**: 0000-0001-9315-5869, **Researcher ID Thomson**: S-6575-2018, **CVU CONACYT ID**: 122247

ID 1st Coauthor: *Omar, Olvera-García* / **ORC ID**: 0000-0001-6386-9772, **Researcher ID Thomson**: S-6644-2018, **CVU CONACYT ID**: 706478

ID 2nd Coauthor: *Pedro, Guzman-Tinajero* / **ORC ID**: 0000-0002-2297-7758, **arXiv Author ID**: PEDRO_GUZMAN_T**, CVU CONACYT**: 251228

ID 3rd Coauthor: *David, Morillón-Gálvez* / **ORC ID**: 0000-0002-9178-3092, **Researcher ID Thomson**: S-6702-2018, **CVU CONACYT ID**: 253013

Received September 28, 2018; Accepted December 20, 2018

Abstract

This paper describes an alternative for the teaching of the subject of air conditioning and refrigeration for the career of Electrical Mechanical Engineer of the School of Facultad de Estudios Superiores Cuautitlán. With the support of students, experimental prototypes were designed and built that allow us to appreciate the behavior of air, in terms of the variation of its temperature and humidity in a conventional air conditioning system, you can also observe the different phases of a refrigerant, as well as the temperature and pressure in a compression refrigeration system and finally, you can see how the air temperature and humidity changes when using a passive humidification and dehumidification system. The agenda includes alternatives to reduce the thermal load of the room to be heated, such as the support of thermal insulators, the use of building materials according to the climate and the use of passive air conditioning systems.

Air Conditioning, Temperature, Humidity

Resumen

En este trabajo se describe una alternativa para la enseñanza de la asignatura de aire acondicionado y refrigeración para la carrera de Ingeniero Mecánico Electricista de la Facultad de Estudios Superiores Cuautitlán. Con el apoyo de alumnos, se diseñaron y construyeron prototipos experimentales que permiten apreciar el comportamiento del aire, en cuanto a la variación de su temperatura y humedad en un sistema de aire acondicionado convencional, también se puede observar las diferentes fases de un refrigerante, así como la temperatura y presión en un sistema de refrigeración por compresión y por último, se puede observar cómo se modifica la temperatura y humedad del aire al utilizar un sistema de humidificación y deshumidificación pasiva. En el temario se incluyen alternativas para reducir la carga térmica del cuarto a climatizar como es el apoyo de aislantes térmicos, el empleo de materiales de construcción de acuerdo al clima y el uso de sistemas pasivos de climatización.

Climatización, Temperatura, Humedad

Citación: HERNANDEZ-GOMEZ, Víctor, OLVERA-GARCÍA, Omar, GUZMAN-TINAJERO, Pedro and MORILLÓN-GÁLVEZ, David. Alternative for teaching the air conditioning and refrigeration course. ECORFAN Journal- Spain. 2018, 5-9: 47-52.

* Correspondence to Author (email: vichugo@unam.mx)
† Researcher contributing first author.

Introduction

The School of Higher Studies Cuautitlán of the UNAM, has a variety of careers, among them, the Electrical Mechanical Engineer. This career had a curriculum approved since 1993, causing some of the subject curricula to be overdue. In the case of the subject of air conditioning and refrigeration, the calculation and selection of conventional air conditioning equipment and the cooling cycle was explained for its delivery.

The subject did not have a laboratory, therefore, in the subject of Thermal Machine Laboratory, a practice was taught where in a team the psychrometric processes were appreciated, that is, the heating, cooling, humidification and dehumidification of the air. Fortunately, the curriculum was updated and a 2012 version was approved, in which the authors of the article had the opportunity to participate and issue recommendations for the updating of the subject syllabuses.

For the subject in question, the study program was modified so that the student not only learned how to calculate and select a conventional air conditioning system, but had the ability to air-condition spaces without the need to use electrical energy, taking care of the environment, for which sections were included with the topics of passive systems of air conditioning and the reduction of the thermal load of the building to air condition. In addition, the refrigeration issue was given more depth, including the existing refrigeration systems and the equipment that make up the refrigeration system. Finally, it was possible to include workshop or laboratory hours, in order that the student could know and handle some of the equipment mentioned in the subject.

The purpose of this article is to disseminate the actions taken to improve the delivery of the subject. These actions contemplated the design and construction of experimental equipment in which students could observe the phenomena seen in class, in addition, edit a manual of laboratory practices and new notes for the subject. To achieve this, it was proposed that teachers, as well as students enrolled in social service or thesis, participate in these activities, supported economically by institutional programs that UNAM has, such as the Program of Support for Projects for Innovation and Improvement of the Teaching (PSPIIT). Fortunately, we have had the support of projects PE102015 and PE101218, with which it has been possible to generate:

- Practices manual
- Class notes
- Prototypes to observe psychrometric processes
- Refrigeration system

The experimental prototypes have been designed and built by the students of the Mechanical Electrician and Food Engineers, in the facilities of the Research Laboratory in renewable energies of the FES Cuautitlán.

Notes of the subject

The syllabus of the subject was modified to include the topics related to passive air conditioning systems, mechanisms to reduce the thermal load of the building to be heated and the cooling part was complemented. These changes were reflected in the notes of the subject as follows:

In chapter four named "Conditions of comfort" were included concepts to understand the interaction of the climate with the building and its inhabitants, with the aim of visualizing a comfort strategy. The following topics were included:

4.3. Feeling comfortable
4.3.1. Thermophysiological indices of thermal stress.
4.3.2. Thermo-psychological indices of thermal comfort.
4.4. Letters of comfort.
4.4.1. Bioclimatic letter of Olgyay.
4.4.2. Bioclimatic letter of Givoni.

In order for the student to know the ways in which it can generate heating or ventilation flows, and to increase the humidity or decrease it in a passive building, chapter six was added under the name "Alternatives for air conditioning". This section also teaches how to use the thermal insulation of the envelope of a building, the construction materials and their geographical orientation, in order to use them in our favor. The following topics are included:

6.1. Passive heating systems.
6.2. Passive cooling systems.
6.3. Passive humidification systems.
6.4. Passive dehumidification systems.
6.5. Combination between them.
6.6. Thermal insulation of the envelope.
6.7. Solar architecture and bioclimatic design.

In order to give more depth to the refrigeration part, the chapter of "Heating and cooling" that was had was divided in two as follows:

ISSN: 2444-3204

7. Heating
7.1. Heat distributor equipment.
7.2. Heating systems.
7.3. Central heating.

8. Refrigeration
8.1.Definition, importance and refrigeration applications.
8.2. Mechanical refrigeration cycle.
8.3. Compression cooling.
8.4. Elements of the compression cooling system.
8.4.1.1. Compressors
8.4.1.2. Capacitors
8.4.1.3. Expansion devices.
8.4.1.4. Evaporators.
8.5. Absorption refrigeration.
8.6. Refrigerants, lubricants, pipes and accessories.
8.6.1. Classification and selection of Refrigerants
8.6.2. Classification and selection of lubricants.
8.6.3. Pipes, valves and refrigeration accessories.
8.6.4. Cooling control systems
8.7. Heat pumps.

In figure 1 you can see the cover of the notes that were edited.

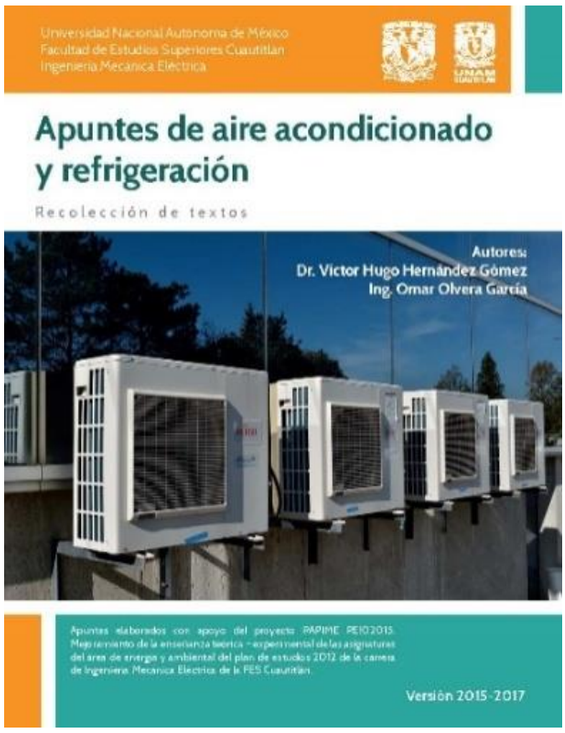

Figure 1 Written notes compiling information from different authors
Sourse: Own Elaboration

Prototype to visualize psychrometric processes

A prototype was built to study the heating, cooling, humidification and dehumidification processes, as well as combinations between them. The equipment was designed with the necessary instrumentation to observe and measure the changes suffered by the air in each process, that is, 3 interchangeable modules were created for the study of each psychrometric process and its possible combinations.

The cooling and dehumidification module includes a variable speed fan at the inlet. The air supplied by the fan passes through a system of finned condensers in order to remove the heat from it. In figure 2 the mentioned module is shown.

Figure 2 Cooling and dehumidification module
Sourse: Own Elaboration

The air passes over the finned surface of the copper tubes that make up the condenser to remove the heat. Here you can only remove the heat from the air (cooling) or you can lower the air temperature up to the dew temperature to condense your moisture (dehumidification).

The heating module consists of a set of resistors located inside a tunnel, through which passes the air coming from the fans. The air passing through the resistance arrangement shown in figure 3, captures the heat by increasing its temperature (heating).

The humidification module is constituted by a system of sprinklers that add water to the air that passes through the tunnel. The water that is not dragged by the air, is captured in the lower part of the module to be recirculated by means of a pump to the sprinklers. The air is passed through the module where the sprinkler system shown in figure 4, add water at the desired temperature, in order to increase the humidity of the air.

ISSN: 2444-3204

Figure 3 Resistor arrangement
Sourse: Own Elaboration

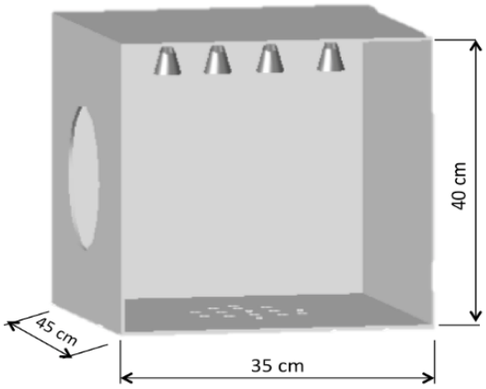

Figure 4 Humidification module with sprinklers.
Sourse: Own Elaboration

It should be mentioned that, depending on the temperature of the water, the air temperature can be modified, that is, combinations of the psychrometric processes can be made to obtain heating and humidification or cooling and humidification. In figure 5 you can see the complete equipment.

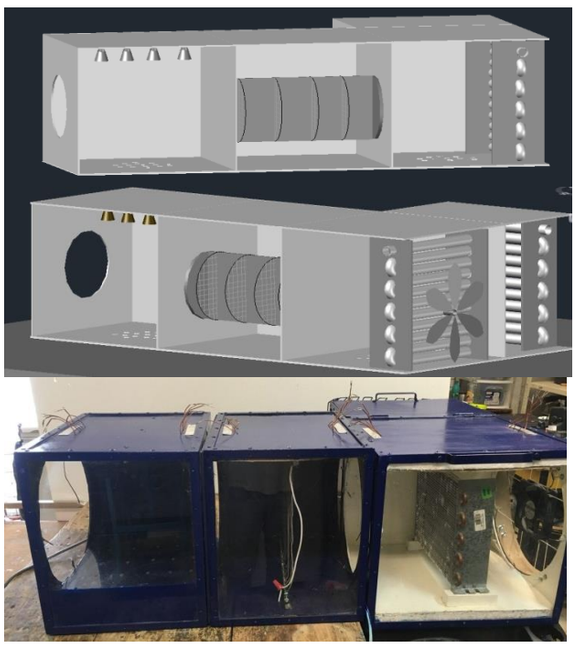

Figure 5 Prototype to observe psychrometric processes
Sourse: Own Elaboration

Prototype cooling system

A prototype of refrigeration system was built, which allows to simulate and observe the operation of the basic refrigeration cycle, which has the adequate instrumentation so that the student can take readings, create tables, execute calculations, develop their own practices and generate conclusions.

An acrylic wall box with metal structure was built, in order to observe the operation of the equipment that integrates the cooling system such as the condenser, evaporator, valves and compressor.

Peepholes, thermometers and pressure gauges were installed in different points of the system to visualize the status, temperature and pressure of the refrigerant used.

To move the system a compressor of 1/8 of Hp was selected, for the evaporator a domestic evaporative unit was used for R134A, for the condenser it was used flexible copper tube of 1/4 "and a fan of 6" to 120 Volts, which are shown in figure 6.

Figure 6 Equipment that integrates the refrigeration system
Sourse: Own Elaboration

Figure 7 shows the prototype finished and in operation.

Figure 7 Refrigeration system
Sourse: Own Elaboration

Practices manual

In addition to the modifications to the notes of the subject, eight laboratory practices were generated, which are divided into four parts as follows:

A. Construction of Psychrometric Chart.

– Practice 1.- Construction of the Psychrometric Chart for Cuautitlán, Estate OF Mexico.

B. Options for the modification of Temperature and humidity of the air.

– Practice 2.- Processes of heating, cooling, humidification and air dehumidification, using conventional methods.

– Practice 3.- Heating and humidification processes, heating and dehumidification, cooling and humidification and air cooling and dehumidification, using conventional methods.

– Practice 4.- Heating, cooling, humidification and dehumidification processes of the air, using passive systems.

– Practice 5.- Heating and humidification processes, heating and dehumidification, cooling and humidification and cooling and dehumidification of the air, using passive systems.

C. Reduction of the thermal load of the space to be heated.

– Practice 6.- Reduction of the thermal load using thermal insulators.

– Practice 7.- Reduction of the thermal load using reflective paints, solar control film and orientation of the building.

D. Refrigeration system

– Practice 8.- Principle of operation of a refrigeration system.

In these practices the two prototypes described above are used and a prototype that was designed to perform heat transfer tests (for practice 6). In the references of this document you can consult other articles that talk more about these prototypes. The cover of the practice manual is shown in figure 8.

Figure 8 Manual of practices of the subject of air conditioning and refrigeration.
Sourse: Own Elaboration

Acknowledgement

We thank the National Autonomous University of Mexico who, through the Program of Support for Projects for the Innovation and Improvement of Teaching (PSPIIT), projects PE102015 and PE101218, have supported economically for the preparation of the notes and manual of practices of the subject of air conditioning and refrigeration, as well as the construction of the experimental prototypes mentioned in this document.

Conclusions

The way in which the subject of air conditioning and refrigeration was taught has changed drastically. Before, they were taught how to calculate and select conventional air conditioning equipment.

ISSN: 2444-3204

Because there are a lot of these equipment in the buildings, their teaching has been preserved, but it has been complemented with techniques that allow them to reduce the thermal load of the building, that is, to reduce the size of the equipment or even to eliminate it. Now they are taught that before using a conventional air conditioning system, it is necessary to perform the thermal balance of the building and together with the bioclimatic charts, select actions, such as thermal insulators or passive systems, to bring the building closer to comfort conditions required, without the need to use electrical energy that causes, due to its origin, greenhouse gases and fossil fuel consumption.

This didactic material has been implemented in the groups of the subject that we have had the members of the article and the students have commented that: the notes have helped them prepare for each class, as well as to clarify doubts, that the power to visualize the processes psychrometric allows them to understand the phenomenon that happens in each of them, especially in the processes of dehumidification; and that with the prototype of refrigeration can observe and understand the changes of state suffered by the refrigerant and what is its function in the refrigeration system.

References

Juan Carlos Espinal Arellano, Omar Olvera García, Víctor Hugo Hernández Gómez. (2016) Diseño de un prototipo experimental para la enseñanza de los mecanismos de transferencia de calor. Memorias del Congreso Científico Tecnológico de las carreras de Ingeniería Mecánica Eléctrica, Industrial y Telecomunicaciones, sistemas y electrónica, AÑO 1. No. 1. ISSN-2448-7236.

Omar Olvera García, David Morillón Gálvez y Víctor Hugo Hernández Gómez. (2016) Deshumidificación del aire que ingresa a una vivienda a través de desecantes. Memorias del Congreso Científico Tecnológico de las carreras de Ingeniería Mecánica Eléctrica, Industrial y Telecomunicaciones, sistemas y electrónica, AÑO 1. No. 1. ISSN-2448-7236.

V. H. Hernández Gómez, O. Olvera García y D. Morillón Gálvez. (2016) Reducción del consumo de energía en sistemas de aire acondicionado. Tecnologías modernas para la industria y educación, primera edición septiembre de 2016. ISBN Obra Independiente: 978-607-95255-7-6.

Omar Olvera García, Víctor Hugo Hernández Gómez, David Morillón Gálvez. (2017) Diseño de un sistema de deshumidificación por medio de celdas termoeléctricas. Memorias del Congreso Científico Tecnológico de las carreras de Ingeniería Mecánica Eléctrica, Industrial y Telecomunicaciones, sistemas y electrónica, AÑO 2. No. 2. ISSN-2448-7236.

Iveth Sánchez Barrera, Yarabi de la Rosa Flores, Alan Castañeda Monroy, Omar Olvera García, Víctor Hugo Hernández Gómez. (2017) Diseño, construcción y caracterización de un prototipo experimental para la enseñanza del funcionamiento de un sistema de aire acondicionado. Memorias del Congreso Científico Tecnológico de las carreras de Ingeniería Mecánica Eléctrica, Industrial y Telecomunicaciones, sistemas y electrónica, AÑO 2. No. 2. ISSN-2448-7236.

Juan Carlos Espinal Arellano, Luis Gerardo Sánchez Cancino, Alan Castañeda Monroy, Omar Olvera García, Víctor Hugo Hernández Gómez. (2017) Resultados de pruebas experimentales realizadas a un prototipo para la enseñanza de los fenómenos de transferencia de calor. Memorias del Congreso Científico Tecnológico de las carreras de Ingeniería Mecánica Eléctrica, Industrial y Telecomunicaciones, sistemas y electrónica, AÑO 2. No. 2. ISSN-2448-7236.

ISSN: 2444-3204