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Development of Domestic Refrigerator Trainer: An Instructional Material for Beginner Technician

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ABSTRACT

The University of Northern Philippines is one arm of the government in developing skilled manpower. It envisioned produce highly skilled graduates employed in the country and abroad to boost the country's economy and support themselves and their families. The objectives can only be realized if it is properly equipped with laboratory facilities that can provide hands-on training for students. The Technology Department has been facing problems of inadequate instructional materials and facilities, especially those that could help in the development of the student's manipulative skills. The design and development domestic refrigerator trainer used locally available materials. The conceptualization of the trainer is in the intellectual capability of refrigeration and air conditioning faculty researchers. The domestic refrigerator trainer in its advancement in the teaching and learning process is and the principle operations, easy to understand the different connection of electric circuitry in the mechanical components. The trainer can also present the four phases of refrigerant cycle .Its

design focuses on skills training approach to aid the beginner student in an easy and comprehensive way of learning the trade in a very limited time that servicing and repair is in his hands.

Keywords – Technology, design and development of domestic refrigerator trainer, experimental design, Philippines

INTRODUCTION

Educational institutions are given very serious responsibilities such that greater expectations are placed on their capability to mold future citizens for increased and effective participation in national development. It is imperative that schools have to examine critically their curriculum and training programs and suit them to meet new challenges and requirements. Facilities, resources and instruction have to be evaluated if it fits existing needs demands for the successful achievement of goals.

Technical education prepares the individuals for employment in occupations requiring technical knowledge and competence beyond that of skilled craftsman. Likewise, technology education is an education term to connote a form of education intended to provide training to develop skills, abilities, understanding, attitudes, work habits, and appreciation needed by the workers to enter and make progress in an employment on useful and productive basis.

To become an effective instrument of national development, education must not only prepare and equip the young with the needed skills and knowledge in academic courses but also along technical and technological courses to be acceptable for entry into the occupation for which they are trained. Given adequate support and training, skilled manpower developed along technical and technological courses would be certainly contributes in accelerating productivity. In a world swift technological change, it is neither enough nor of importance to equip students with the skills essential to their jobs. The real challenge is to equip them with more core knowledge and skills that will enable them to adapt successfully in the future to changing jobs and environment that might require different skills.

The Commission on Higher Education (CHED) its vision is the key leader of the Philippine higher education system effectively in partnership with other major higher education stakeholders in building the country's human capital and innovation capacity towards the development of a Filipino nation as a responsible

member of the international community. It is mandated to the national government's commitment to transformational leadership that puts education as the central strategy for investing in the Filipino people, reducing poverty, and building national competitiveness and pursuant to Republic Act 7722, CHED shall, promote relevant and quality higher education.

The CHED strategic plan programs for 2011-2016 is the Rationalization of Higher Education Institutions, with in a moratorium period on the opening of new programs especially in oversubscribed disciplines. The objective is to lay the foundation for a more efficient and effective system in delivering quality public higher education services and for a more flexible regulatory framework for private higher education provision. And one of the project components is Job-Skills Matching project.

To produce highly competent and competitive graduates, HEIs are encouraged to offer programs that are in demand and responsive to the needs of industry, both domestic and international. The job- skills matching project includes; formulation of master plans for priority disciplines, review the curricula to make them fit the needs of industries, establishment of labor market information on jobs that are in demand and hard to fill, to guide both students and parents in choosing courses; identification of areas of mismatch and implementation of strategies to address such mismatches; massive information dissemination on employment opportunities among students and HEIs, and periodic conduct of graduate tracer studies. (CHED Strategic Plan for 2012-2016).

Technical and technological education, as an area in the country's overall manpower and human resources development program, has the crucial role of individuals and providing skilled and technical workers required by the Philippine economy. One of the popular criticisms hurled against technical and technological education is the mismatch of graduates to the needs of industry in terms of quality performance. Industries or companies questioned, that school training is inadequate to their needs so they are compelled to exclusive train, or even retrain workers just to meet their immediate needs.

Faced with the need of increasing numbers of skilled workers for expanding industries, as well as rapidly advancing technology, Technological institutions play a very crucial role in moulding or developing the skills and abilities of students and constantly revising the educational facilities to meet these challenges. In recent years, the pressing need for training programs to serve students' various backgrounds and abilities has also become evident.

The University of Northern Philippines is one arm of the government in developing and improving skilled manpower. It has envisioned itself as the

leading institution in technical education in Region 1 in terms of instruction, research, extension and production. It also envisioned be produce highly skilled, value laden graduates employed in the country and abroad to boost the country's economy and support themselves and their families.

Its mission is to provide students the necessary knowledge, skills and attitudes to become highly productive technicians with the potential of becoming managers in their own field of specialization and to extend the services through expert, technical researchers and quality products. The objective of the university can only be realized if it is properly equipped with laboratory facilities that can provide hands-on training for students. For many years the university particularly, its technology department, has been facing the problem of insufficient and inadequate instructional materials and facilities, especially those that could help in the development of the student's manipulative skills.

With this problem, the idea of designing this domestic refrigerator trainer was conceived to facilitate the transfer of learning and also to assist the learning activities of the students, particularly in the Refrigeration and Air conditioning course. Lecture alone do not satisfy the need of the learners .Therefore, Technical knowledge and skills are always supplied with actual performances.

The researchers believe that one of the best ways to help minimize the problem of in adequate equipment is to come up with a trainer that will help facilitate the teaching learning process in the Refrigeration and Air conditioning course at the University of Northern Philippines, hence, this study.

FRAMEWORK

Syamsuri Hasan and Ricky Gunawan (2013) opines, that the goal of teaching process is to enable students in mastering the subject either in theory or in practice, where the latter is a conceptual application in real performance. The application process of the concept will need some aid of medium or educational equipment to perform the goal of a teaching process. This medium has a role in giving the information of teaching material from teachers or other sources which can encourage the students in fast comprehension. The goal of this research is to produce a cheap and representative aid / teaching medium. The aid / teaching medium will be a trainer unit multiple evaporator system model which contributes to the students in the teaching process of conceptual Refrigeration System.

Based on the analyses and discussion, of their study they found that: 1) Trainer unit multiple evaporator system model resulted from this research

has fulfilled the terms of educational medium that is cheaper than the market sale. Furthermore, it is properly used for teaching visual aid and facilitates the conceptual comprehension. Thus, it can basically be applied to the real equipment, either as commercial refrigeration system or in industry. 2) Trainer unit multiple evaporator system model can overcome or eliminate any obstacles in the teaching process of refrigeration system, especially subjects in relation with multi evaporator and can give the basic competence.

Teaching medium consists of all sorts of teaching components available around the student's environment which can stimulate learning (Abdulhak, 2003). Medium or teaching aid is a fundamental necessity and has a supplementary character in reaching the goal of teaching process successfully. Further, Abdulhak (2003) said that the teaching medium may include human, material, equipment or activities used for distributing messages which can stimulate mind, feeling, attention and motivation of the students, so that they get in themselves a learning stimulant. Teaching/learning process in arousing the students' motivation will need an aid device which can concentrate mind, feeling, attention, and motivation of the students in understanding the concept they are studying (Ibrahim & Syaodih, 2003). Obviously the teaching medium is needed in any teaching or teaching/learning process.

The use of teaching/learning medium will need to consider the cheap price, efficiency and affordability of the educational institute without rejecting the possibility in using modern medium according to technological demand. So, educational medium as an aid device must be able to be reached by educational institute with a cheap price and efficiency. According to Nurdin et al. (1982), the requirements of educational medium are:

a) Rational, according to ratio and thinkable by the inventor.
b) Scientific, according to the scientific development.
c) Economical, according to the affordable fund.
d) Practical, can be used in the practical situation in school and simple in characteristic.
e) Functional, useful in the teaching and can be used by teachers and students.

According to Sudjana and Rivai (2001), the advantages of teaching/learning medium are: a) the teaching will be more interesting and so that the motivation will grow, b) the teaching/learning material will be clearer in meaning, easy to understand, and easy to reach its goal, c) giving variation to the teaching

method, and d) the students will do more learning activities. The advantage of teaching/learning medium in the teaching/learning process is the ability to make a more conducive atmosphere and enhance activities. One important factor is that the teaching/learning medium can heighten the students' learning process in the teaching/learning, so that finally it can heighten the achievement result of learning (Sudjana & Rivai, 2001). The existence of teaching/learning medium is to support the teaching/ learning process, so that the students can understand the teaching material and finally can reach a satisfied result.

The effective and efficient teaching is done for example by applying creative teaching from Muhtar (2005). One means of creative teaching is by making a teaching/learning medium which can motivate the students in the teaching process. It is better if the learning medium is made by teachers so as to suit the requirement, and it can be made in a simple form.

The teaching/learning medium is divided in two categories: two dimensions and three dimension. The three dimension model consists of: solid model, cut-away model, and diorama model. Trainer unit as a teaching/learning medium constitutes a combination between working model and mock-up model. Based on the definition given by Sudjana and Rivai (2001), working model is an imitation of an object which exposes the outer side of the original object, and it has some parts of the real object. As for the mock-up model, it is a simplified structure of the main part of a more complicated process or system. The real structure of the main parts is modified so that the main aspects of a process can be easily understood by the students.

Refrigeration System is a process to maintain the room temperature or substance/object so as to stay lower than the surrounding temperature. This process will occur when there is equipment/machine which can be used for this purpose (Sarao & Gaabi, 2001). As an equipment to maintain temperature to stay lower than the surrounding air, refrigeration system is widely used in social life, either for preserving (food) or for producing goods in the industry. Refrigeration equipment/machine consists of four main components: evaporator, compressor, condenser, and refrigerant control equipment (resistant device for refrigerant expansion). Besides, there is an additional device for maintaining the work of the machine according to the desired temperature, e.g. thermostat, compressor control equipment, etc.

According to Ikhsan (2006), Edgar Dale clearly gave a stress about the significance of medium in education through pyramid/cone graphic (see Figure 1).

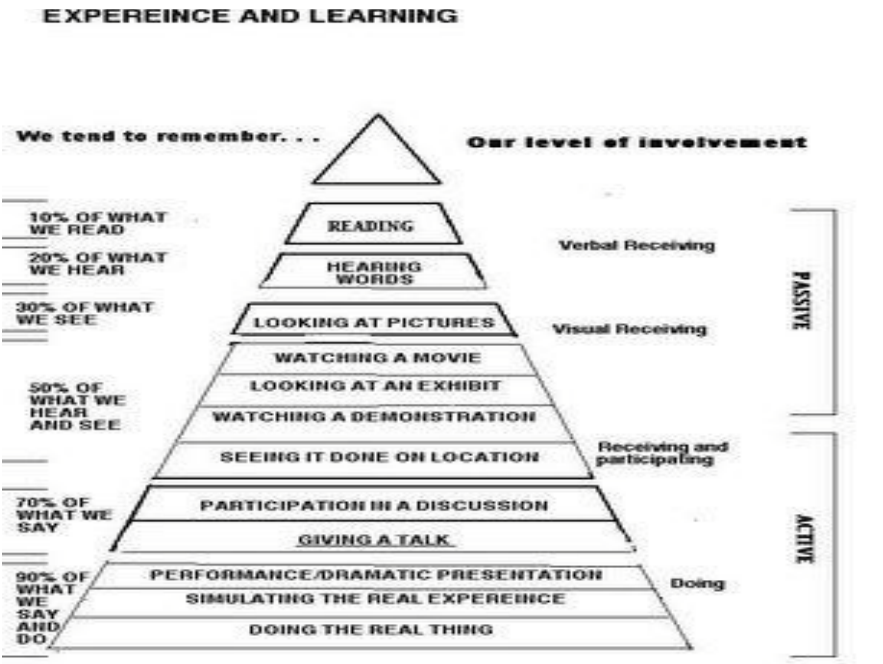

Figure 1. Pyramid/Cone Graphic of Stages in Educational Medium

According to Edgar Dale's pyramid, it can be seen that the students learn conceptually (theoretically) and they just listen, have a low grade of comprehension: about 20%. If the students in the active learning do the job themselves either by simulation or by the real object, so they can get about 90% of the information. Later on they can learn through simulation with multimedia interactive module and after they understand well, they can continue to learn by using Trainer Unit Multiple Evaporator System Model. It is hoped that the students can get as much information as they can from their study result and meet the criteria of Edgar Dale (90%).

The result of the study Syamsuri Hasan and Ricky Gunawan in February 2006, is as follows: 1) the application of refrigeration concept in the assembling of the trainer unit in the subject of Refrigeration System can be done by the students significantly according to the material concerning refrigeration which has already been informed. 2) A medium or a teaching aid equipment has been produced, which can be used in the teaching process. The medium, which is in

the form of trainer unit has been assembled by the students, and it can readily be used for medium or teaching aid equipment in the learning/teaching activity process, especially in the department of Refrigeration and Air Conditioning Engineering Specialist.

The goal of the research is a standard to direct the researcher in searching data so as not diverge from the stated problem. So the goal is to produce teaching medium/aid equipment which is relatively cheap and representative. The teaching medium/aid equipment is in the form of trainer unit multiple evaporator system models, which can be a contribution to the students in the teaching process of Refrigeration System conceptual. The success of this research can give a contribution in solving the educational problem, especially in relation with the teaching process of refrigeration system, so that the relevant competence can be obtained with the field job in refrigeration and air conditioning technology.

The conceptual model showing the variables for the development of the project which guided this study is depicted below in the form of a paradigm. The input includes the ideas on design and construction of the trainer, supplies and materials, tools and equipment needed. The throughput involves the designing, constructing, and assembling of the trainer utilizing old and recycled materials that are locally available it also involves testing of its functionality and effectiveness of the trainer.

The output of the study is a skeleton type domestic refrigerator.

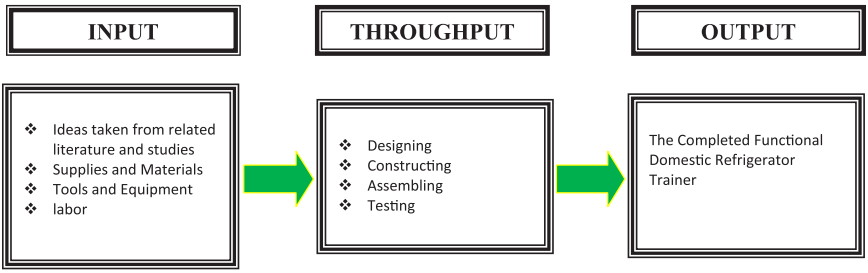

Figure 2. The conceptual paradigm

OBJECTIVES OF THE STUDY

The objective of this study is to design and develop a Domestic Refrigerator Trainer to solve problems of inadequate teaching learning device for students. The student can visualize all the mechanical and electrical components of a domestic

refrigerator. Further, the trainer can present the four phases of refrigerant cycle unlike the actual domestic refrigerator that having the cabinet assembly.

Furthermore, the trainer is more practical and interesting for the students that while discussion is going on students can visualize that all the components are working. The evaporator is icing and the condenser is heating. This will arouse the curiosity of the students that may trigger them to be attentive and eager to learn.

MATERIALS AND METHODS

This study uses a discarded, malfunctioned refrigerator to recycle the serviceable spare part. Malfunction refrigerator do not have the same trouble, it may either one or two spare parts are caused of operational failure.

The study used the project method of research which aims to develop a skeleton type domestic refrigerator trainer that components are transparently seen by the eye. Assembling the mechanical parts, tube systems and installation of the electrical components was done. Further it includes the sequence of the development of the project, from the time it was conceived until it was fully accomplished.

RESULTS AND DISCUSSION

Figure 1 shows domestic refrigeration. Students may not understand the laws of refrigerator that deal with heat temperature and pressure. How heat travels from higher to lower temperature, the heat of compression, evaporation process and condensation process. Also, some of the mechanical, tubing, and the electrical components are hidden.

The Proposed Refrigeration Trainer

The proposed project is shown in figure 2. All the components are traceable, the flow of current and cooling or heating process, that is taking place inside the tube system that the students may experience outside the cabinet. The assembly of the trainer is much easier to explain the respective functions in the system. It is also easier to understand the refrigeration theory, principles and cycles.

Figure 3. Actual Refrigerator

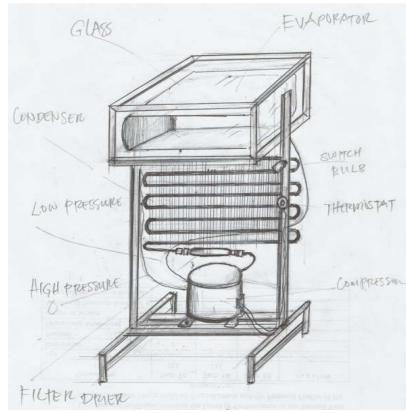

Figure 4. Proposed Trainer

Figure 5. The developed refrigerator trainer

Assemble the Mechanical Component

1. Compressor - Unroll the 5 feet length 3/16 inch diameter copper tube. Swag and join to the dis charge line of the motor compressor. Likewise connect a copper tube 7 feet length ¼ inch diameter at the suction line, while an access valve with a 6 inches length ¼ inch copper will be connecting to the charging port. Silver brazened all connected copper tubes.

2. Condenser - Install the condenser to the frame housing of the trainer. Connect the discharge line tube 3/16 inch diameter of the compressor to the inlet (upper portion) at the condenser. Silver brazened the joining.

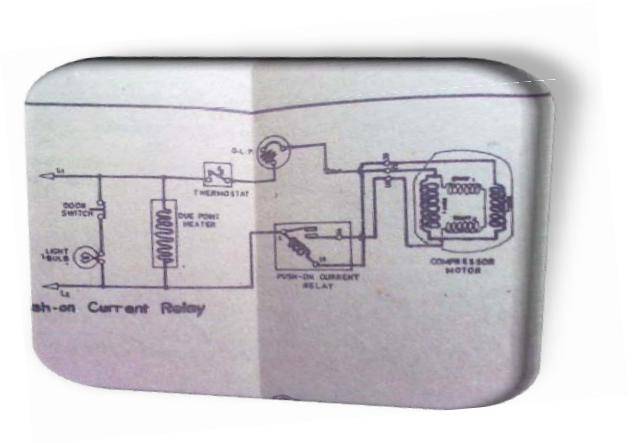

Figure 6. The Electrical Diagram

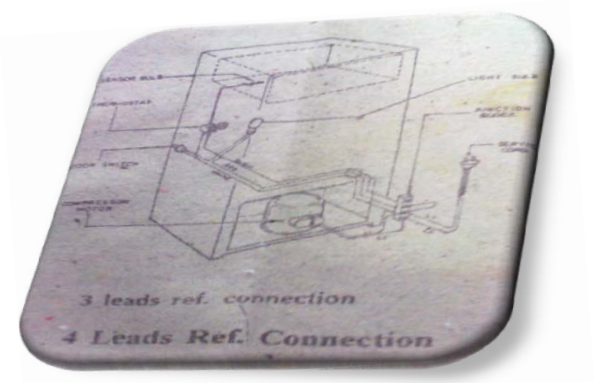

Figure 7. Actual setup of the electrical diagram

3. Capillary tube - From the outlet (lower portion) of the condenser, one end of the capillaries tube. After brazing the capillaries tube to the condenser allow approximately one half of the length to be winded on the suction line of the compressor tube to use a heat exchanger. At the other end of the capillary tube brazed with 6inch length of ¼ diameter copper tube for the installation of the inlet fort of the filter/drier brazens connection.

4. **Filter/ Drier and the Evaporator** – Filter/drier have its marking note to identify the inlet and outlet. Either an arrow or dotted marked. Dotted or arrow mark identify that it will be connected at the evaporator where the flow of refrigerant direction, brazened the connection.

5 Accumulator - From the suction line of the evaporator the accumulator will be installed. At the other end, the suction line of the motor compressor will also be connected, brazened the connection.

The Complete Mechanical Set Up of the Trainer

Cooling units like a refrigerator uses a compressor that follows a tube system to accomplish the cooling and heating process. The tube system starts from the outlet of the discharge valve of the compressor and goes to the discharge line. It is either 3/16 or ¼ of an inch diameter that extend up to the filter/drier approximately 25 to 37 feet for 6 cubic feet refrigerator. Filter/drier in its function in the tube system is to screen all dirt that may enter to free the capillaries tube from clogging.

The capillaries tube is the refrigerant control. It is joined at the outlet of the filter/drier. This is the smallest of all the tubes in the system. At about ½ of the length of this tube is either brazened winded or inserted in the suction line to form the heat exchanger. The end of the capillaries is brazened with the evaporator to control the refrigerant just enough to be used inside these coils for a desired temperature.

Evaporator tube system was bigger to give space for the refrigerant to boil while absorbing heat. The accumulator, the size is much bigger that trap some of the un- boiled refrigerant (flash gas) to protect the moving part of the compressor from wearing out. The last part of the tube system is the suction line which connected the accumulator to the motor compressor. Be sure that all joints connections of the piping lay-out is free from leaks. Leak testing is necessary. Leak is a minor trouble, but it can give more headaches to technicians.

To look for leaks, it takes time and patience and worse the refrigerant will go to the atmosphere and destroys the ozone layer. There are many ways of finding leaks, by using pressurized gas (nitrogen) and using leak detectors or using soap suds.

Installation of the Electrical Component

Electrical system contributes about 75 percent trouble of refrigerator. Therefore, a beginner student must devote to familiarize the electrical component of the refrigerator. Since the motor compressor is the heart of the system, it is best to start to study. The concern of the beginner student is the functional relationships of each subcomponent and how they function.

This analysis is based on the actual connections being dissected into related parts to easily memorize the whole circuit.

1. Motor and its Sub-Component. The motor consists of three terminals where the relay and overload protector connections are attached, the starting, common, and running terminal configuration. Since the motor is the starting point of the circuit, connect the relay and the overload protector.

2. Overload Protection. The overload protector is connected at the common terminal of the motor. It is necessary because the common terminal is the junction that the running and starting winding meet, and that it will protect the winding against overloading.

3. **Thermostat Connection**. This device is to cut off the line when the refrigerator attains its coolness. It can be connected either in line 1 or line 2. It can be along the line of the relay or at the overload protector.

4. Door Switch and Lighting. These electrical devices connection are done as separate circuit from the motor so that the motor is independent, and that no other electrical component can obstruct while the motor is in operation or at in rest.

5. Service Cord. The service cord is the path of current to the entire electrical system of a refrigerator where the male plug is installed.

Summary of the electrical circuits

Since the whole circuits are dissected into segment, it can be seen as a whole. There are three circuits the motor, lighting and the dew point heater.

Starting from the male plug are the two lines that sourced the current. From then, the door switch and the light bulb are connected across the two lines, because it needs no power interruption whether the motor is ON or OFF. The bulb must provide light whenever the user needs something inside the refrigerator.

The second circuit is the dew point heater. This is the heating element of the insulator of the cabinet. The steel plate of the outer shell must be kept dry from the moisture absorbed by the insulator.

The thermostat is used as the switching device when the motor needs rest or operation. The device is connected a series in either one of the line source of power. The other line source of power, the relay is connected.

The overload protector is a "MUST" that is connected in the common terminal of the motor that protects the two windings (the running and starting) of the motor in case of power failure. There were three terminals of the compressor the starting, common and running terminals. Understanding the whole circuitry may the beginner student in visual electrical wirings.

Other Important Roles of the Refrigerator Trainer

Another important role of the Refrigerator Trainer, aside from direct visualizing the mechanical component, the tube system and the electrical connections the beginner students, the trainer can present the four phases of refrigerant cycle. These are; circulation, pressure, temperature and the state of refrigerant that can be properly illustrated the complete appearance of the refrigerator.

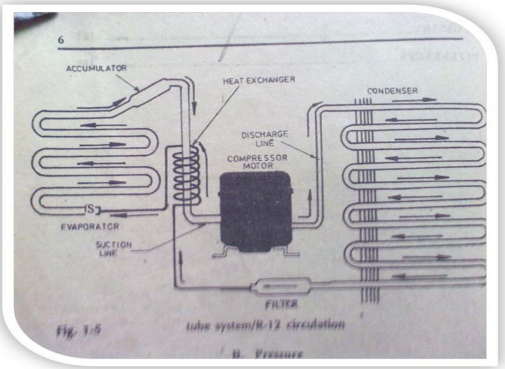

Figure 8. The circulation process of the refrigerant

1. Circulation Process of Refrigerant. Circulation is one of the important parts of the cycle of refrigerant that a beginner student needs to master in the tube system. To start the circulation phase, when the piston of the compressor is down stroke motion, refrigerant is sucked at the low- pressure side of the system. Then, during the upstroke of the piston it is forced. To flow into the discharge line and passes through the filter/drier then into the capillaries tube. From this tube, it enters the evaporator coils and the accumulator passing through the suction line and back to the suction valve. The circulation repeated in the entire operation.

2. Pressure Cycle of Refrigerant. Another important factor, without the specific pressures in each set of tube, cooling is hindered. The trainer demonstrates as in the diagram in figure 6 that pressure a force exerted by the compressor to let the refrigerant circulate inside the vacuumed tube. Circulation starts when the piston is in its down stroke position. The compressing chamber pressure is approximately 250 to 500 psi. Refrigerant while travelling in the different set of tube sizes it reduces its force. In the condenser, the pressure is slightly high up to the filter, this lowered as it passes the capillaries tube because its inside diameter is reduced. Refrigerant as it enters the evaporator it is much lowered to allow it to boil and absorb heat. Low pressure refrigerant goes to the accumulator and into the suction line which is approximately 20psi. Refrigerant pressure is divided into two, high and low side of the system. High side constitutes the high pressure starting from the discharge valve of the compressor up to the filter/drier. The low side is from the junction between the capillaries tube and filter/drier up to the suction valve of the compressor.

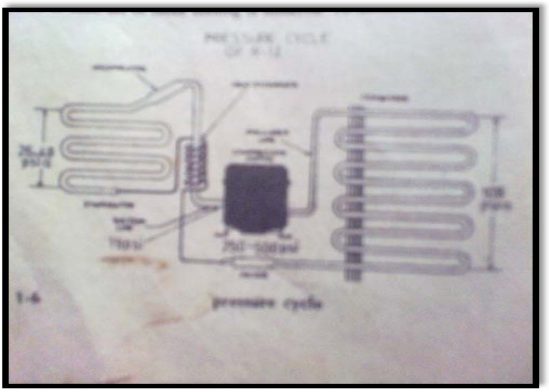

Figure 9. Pressure Cycle of Refrigerant

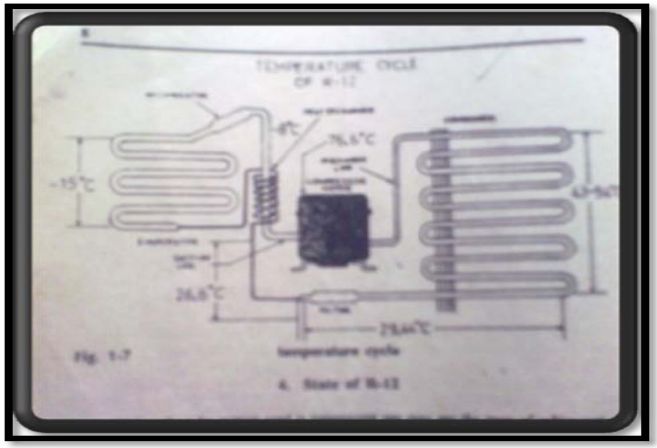

Figure 10. The temperature cycle

3. Temperature Cycle -The temperatures cycle is repeated all over the set of tubes of the system is in normal operation. Failure to follow this condition means a problem in the system. The tube is divided into different size, the smaller diameter tube set has higher temperatures while the bigger sets of tubes have lower Temperature. The lower temperature starts at the junction of large tube of the evaporator and the small tube of the capillaries meet. It is in this part, refrigeration starts.

4. State of Refrigerant - Unless the tube system used transparent one like the trainer, one may see the state of refrigerant while it is moving inside the vacuum tube system transforming from one state to another. This aspect is one of the important information that a beginner analyse possible student can have in order to causes of troubles along this line. This can be a basis of scientific investigation that leads to the proper diagnose and solution of the problem. The refrigerant inside the service tank is at ambient temperature is in liquid form. By the nature, only liquid substances can absorb heat, thus this refrigerant starts its cycle from liquid to vapour and from vapour back a liquid state again.

CONCLUSIONS

The design and development domestic refrigerator trainer used reconditioned and locally available materials. The conceptualization of the trainer is in the

intellectual capability of refrigeration and air conditioning faculty. The cost of production is incomparable in terms the economy for the reason that this trainer has no commercial counterpart.

The domestic refrigerator trainer in its advancement in the teaching and learning process is and the principle operations, easy to understand the different connection of electric circuitry in the mechanical components. The trainer can also present the four phases of refrigerant cycle. Its design focuses on skills training approach to aid the beginner student in an easy and comprehensive way of learning the trade. In a very limited time that servicing and repair are in his hands.

RECOMMENDATIONS

Refrigeration and air conditioning faculty are encouraged to make use of this trainer in the transfer knowledge and skills training in the trade to bridge the gap between lecture and hands- on application.

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