Needs Assessment

Mechanical Engineering Senior Design

Team 20

Solar-Powered Phase Change Compressor

Addison Bender
Jesse Diaz
Emmanuel Ferdinand

9 -27 -12

Problem Statement

Air conditioning accounts for a large fraction of household energy costs. The compressor unit is a major component of an HVAC system, which consumes a high amount of power. If a compressor could be developed that is powered by a readily available sustainable energy source, then energy costs could be reduced.

Need

Develop a compressor for an HVAC application that is powered by solar energy.

Background

The client, Grant Peacock, initially represented to the senior design team that he would like to run his home HVAC system using solar power. The client owns a patent on a concept for a compressor which utilizes expansion of fluid undergoing a phase change from liquid to gas to create an increase in pressure. The pressure would actuate an elastic membrane. As the membrane expands, the working fluid (refrigerant) on the other side is compressed. Ideally, concentrated solar energy would be used to generate heat to boil the expanding fluid. It is not well defined how the reciprocation of this membrane will be achieved. The client would like to extend this concept to the practical application of an HVAC compressor.

The concept that the client would like our team to implement draws inspiration from several systems, currently in existence or previously conceptualized. Concentrated solar thermal generating stations, which use heated water to drive steam turbines, are used in several countries. FPL's Martin solar thermal plant in Indiantown, Florida is an example of such a facility. Concentrated solar has a variety of other applications as well. Epiphany Solar Water Systems produces solar water distillation units to treat drinking water in areas with no access to clean water.[1] The FSU Energy and Sustainability Center is developing a solar-thermal tri-generation system. The goal of this system is to use thermal energy collected from the sun to generate power, provide refrigeration, and heat water.[2]

Inventions exist which use heat collected from the sun to add energy to a refrigerant before it enters the compressor, so that less work is required of the compressor. US patent US20110219801 provides an example of such a system.[3] The novel idea of the client is to use concentrated solar, not to add energy directly to the refrigerant, but to power a mechanical pump.

Objective

Design a compressor for an HVAC application, powered by solar energy, which will produce the same amount of useful work as the compressor in a small air conditioning unit. A prototype of the device will be completed by April 2013.

Methodology

The many aspects of our project include thermodynamic analysis, mechanical design, and material selection. We will investigate these areas in the order listed above. The thermodynamic analysis will let us know if our project is actually feasible using the method proposed by our sponsor (Heat using solar reflection to create steam and pressure). It is necessary to determine what specifications the device must meet, specifically, the amount of work produced by the compressor in a small conventional AC unit. Once this has been determined, we will have a better understanding of the power that the solar pump requires to compress a refrigerant. If the Solar thermal method isn't feasible, we will consider a solar electric design.

The next area to investigate will be the mechanics of our compressor. We will investigate how compressors work and try to incorporate our powering method into the compressor we will design. It is possible that a diaphragm compressor may not be suitable for the application. Other compressor designs should be investigated. After having come up with the general compressor design, we will chose suitable materials based on desired properties, while being conscious of the cost. We want to do this with as little of the budget as possible in case we need to correct/rebuild our prototype.

Expected Results

Designing and developing a solar powered compressor for an air conditioning application is the expected result of the senior design project. A reasonable goal is to design a compressor that will serve the same load as that in a 5,000 btu air conditioner, which is capable of cooling a small room. The compressor will be powered by solar energy, eliminating dependency on the power grid. The benefit of a solar-powered unit is that it will save on energy costs and reduce carbon emissions. Reliance on solar energy, poses the ramification that the compressor will not receive power due to cloudy weather and night time conditions. A back-up power system should be considered to circumvent this obstacle.

The working fluids in the unit have not been determined yet, so it is difficult to assess the possible risk involved due to harmful chemicals. Grant Peacock, the sponsor of the project, has given the team a very open ended request in achieving his goal of a solar powered compressor. The few constraints have provided the team with many possibilities to discover a solution. With such broad project guidelines, a significant amount of time will be spent researching various design alternatives. The expected results of the project are based on the postulation that a compressor for a small A/C unit can be powered using Sun as a source of energy.

Constraints

The project budget should not exceed $2,000. The project completion date will be April 2013. Due to the limits of budget and time frame, the primary focus of our design will be the compressor unit rather than an entire refrigeration system.

References

1. http://epiphanysws.com/technology/

2. http://esc.fsu.edu/solarthermal.html

3.http://www.google.com/patents/US20110219801?pg=PA7&dq=solar+powered+compressor&hl=en&sa=X&ei=ctRhULerIpKK9AS6rIGoCg&ved=0CDcQ6AEwAw#v=onepage&q=solar%20powered%20compressor&f=false