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Board 190B: A New Way to Solar for an Increased Efficiency

Daniel Kelly Green
Dr. Nick M. Safai, Salt Lake Community College

Dr. Nick M. Safai is an ASEE Fellow. He has been an ASEE officer and member for the past 35 years. He has served as the division chair for ASEE. He has been elected six-time as the Program Chair of the ASEE International Division for approximately the 15 years. Three times as the Program Chair for the Graduate Studies Division of ASEE. He has also served as treasurer and other positions in various divisions. Nick has had a major role in development and expansion of the ID division. Under his term as the International Division Program Chair the international division expanded, broadened in topics, and the number of sessions increased from a few technical sessions to over eighteen sessions in the recent years. The ASEE International Division by votes, has recognized Nick's years of service through several awards over the past years. Nick has been the recipient of multiple Service awards (examples: 2013, 2010, 2006, 2004, 1996), Global Engineering Educators award (example: 2007, 2005), Best Paper award (examples: 2016, 2010, 2005, 2004, 1995) and other awards from the International Division for exceptional contribution to the international division of the American Society for Engineering Education. Examples of some Awards from other Professional Organizations: • American Society of Civil Engineers (ASCE): Engineering Educator of the Year Award 2004. • Utah Engineers Council, UEC: Engineering Educator of the Year 2005 award, in recognition of outstanding achievements in the field of engineering and for service to society. • SLC Foundation; Salt lake City, Utah: Teaching Excellence Award 2004 and 2012. * SLCC Faculkty Exemplary Service Award April 2015 and 2016. • American Society of Civil Engineers (ASCE): Chapter faculty Advisor recognition award 2002. • Computational Sciences and Education; recognition for outstanding contributions and for exemplary work in helping the division achieve its goals1998. • Engineering Division; recognition for outstanding contributions and for exemplary work in helping the division achieves its goals 1995. • Science and Humanities; recognition for outstanding contributions and for exemplary work in helping the fields achieve its May 1994. • Math & Physical Sciences; appreciation for academic expertise February 1994.

Academics: Nick Safai received his PhD degree in engineering from the Princeton University, Princeton, New Jersey in 1979. He also did a one year post-doctoral at Princeton University after receiving his degrees from Princeton University. His areas of interest, research topics, and some of the research studies have been; • Multi-Phase Flow through Porous Media • Wave propagation in Filamentary Composite Materials • Vertical and Horizontal Land Deformation in a De-saturating Porous Medium • Stress Concentration in Filamentary Composites with Broken Fibers • Aviation; Developments of New Crashworthiness Evaluation Strategy for Advanced General Aviation • Pattern Recognition of Biological Photomicrographs Using Coherent Optical Techniques Nick also received his four masters; in Aerospace Engineering, Civil Engineering, Operation Research, and Mechanical Engineering all from Princeton University during the years from 1973 through 1976. He received his bachelor's degree in Mechanical engineering, with minor in Mathematics from Michigan State. Nick has served and held positions in Administration (Civil, Chemical, Computer Engineering, Electrical, Environmental, Mechanical, Manufacturing, Bioengineering, Material Science), and as Faculty in the engineering department for the past twenty seven years.

Industry experience: Consulting; since 1987; Had major or partial role in: I) performing research for industry, DOE and NSF, and II) in several oil industry or government (DOE, DOD, and NSF) proposals. Performed various consulting tasks from USA for several oil companies (Jawaby Oil Service Co., WAHA Oil and Oasis Co., London, England). The responsibilities included production planning, forecasting and reservoir maintenance. This production planning and forecasting consisted of history matching and prediction based on selected drilling. The reservoir maintenance included: water/gas injection and gas lift for selected wells to optimize reservoir production plateau and prolonging well's economic life.

Terra Tek, Inc., Salt Lake City, UT, 1985-1987; Director of Reservoir Engineering; Responsible of conducting research for reservoir engineering projects, multiphase flow, well testing, in situ stress measurements, SCA, hydraulic fracturing and other assigned research programs. In addition, as a group director have been responsible for all management and administrative duties, budgeting, and marketing of the services, codes and products.

Standard oil Co. (Sohio Petroleum Company), San Francisco, California, 1983-85; Senior Reservoir Engineer; Performed various tasks related to Lisburne reservoir project; reservoir simulation (3 phase flow), budgeting, proposal review and recommendation, fund authorizations (AFE) and supporting documents, computer usage forecasting, equipment purchase/lease justification (PC, IBM-XT, Printer, etc.), selection/justification and award of contract to service companies, lease evaluation, economics, reservoir description and modeling, lift curves, pressure maintenance (gas injection analysis, micellar-flooding, and water-flooding), Special Core Analysis (SCA), PVT correlations, petrophysics and water saturation mapping.

Performed reservoir description and modeling, material balance analysis. Recovery factors for the reservoir. Administrative; coordination and organization of 2 and 6 week workplans, 1982 and 1983 annual specific objectives, monthly reports, recommendation of courses and training program for the group. Chevron Oil Company, 1979- 1983; Chevron Overseas Petroleum Inc. (COPI), San Francisco, California 1981-1983. Project Leader/Reservoir Engineer, Conducted reservoir and some production engineering work using the in-house multiphase model/simulators. Evaluation/development, budgeting and planning for international fields; Rio Zulia field – Columbia, Pennington Field – Offshore Nigeria, Valenginan, Grauliegend and Rothliegend Reservoir – Netherlands. Also represented COPI as appropriate when necessary.

Chevron Geo-Sciences Company, Houston, TX, 1979-1980 Reservoir Engineer Applications, Performed reservoir simulation studies, history matching and performance forecasting, water-flooding for additional recovery (Rangeley Field – Colorado, Windalia Field – Australia), steam-flooding performances (Kern River, Bakersfield, California), gas blowdown and injection (Eugene Island Offshore Louisiana) on domestic and foreign fields where Chevron had an interest, using Chevron's CRS3D, SIS and Steam Tube simulator programs.

Chevron Oil Field Research Co. (COFRC), La Habra 1978-1979, California. Research Engineer, Worked with Three-Phase, Three-Dimensional Black Oil Reservoir Simulator, Steam Injection Simulator, Pipeflow #2. Also performed history matching and 20-year production forecast including gas lift and desalination plants for Hanifa Reservoir, Abu Hadriya Field (ARAMCO).

A NEW WAY TO SOLAR

Abstract

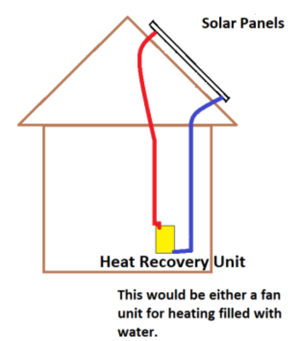
This study which is performed by students from a two-year college proposes combining the principles of refrigeration with those of solar to improve efficiency. This student-led project opened excellent research opportunities for community college students, motivated retention, and prompted innovative teaching and studying. It also inspired more students to participate in academic research and aspire to higher levels of education, including possibly continuing for masters and doctorates in engineering.

The educational benefits would be different disciplines working on a project, the student and teacher working together, using teamwork, getting more inspired to participate in future academic research, and helping other students become interested in early research during their years at the two-year institution.

Introduction

As solar panel efficiency increases, we begin to reach a point where almost all usable light is absorbed, leaving mostly ultraviolet and infrared. This study proposes that we combine the principles of refrigeration with solar. It is possible that we can increase the efficiency levels of solar panels by harnessing the heat load on the panels by using refrigeration to absorb the excess heat and deposit this excess into either heating the home or water. Figured i is a simple design of the system.

The idea would be to use the heat produced by the solar panel to force refrigerant to phase change from a liquid to a gas, absorbing the excess heat created from the radiation of the sun on the panels. Then piping the refrigerant through either a fan and coil for home heating or through the cold water. This would allow the refrigerant to return to a liquid state giving off the excess heat created from the panels into the respective mechanical function of the home. Then pipe back into the panels in a liquid state ready to begin to process of removing heat from the panels. As a bonus, the panel's efficiency level should improve as excess heat on solar panels. As a bonus, the panel's efficiency level should improve as excess heat on solar panels can reduce efficiency.



i. basic diagram of system

Body

The process of refrigeration revolves around a phase change fluid such as refrigerant. The fluid in a low-pressure gas before it enters the compressor and leaves as a high-pressure gas, this is then piped through the evaporator coil. Changing into a liquid and giving off heat. It is then piped to a metering device, which causes a restriction and lowers the pressure as it leaves. After it leaves the fluid picks up any available heat and returns to the compressor as a hot low-pressure gas to begin the cycle again. The process mentioned can be affected by many factors, including the temperature at each coil of the evaporator, and condensing. This process and be reversed and heat can be moved to each area as needed. This could act as an ice remover in places that are not prone to high temperatures or fluctuating regions. Most panels are not generally designed with heat in mind as much as efficiency this could also provide an opportunity to investigate materials that would be better suited.

Solar Power is a promising alternative energy source with potential cost savings. However, it is important to understand the factors that can impact its efficiency and how they can be mitigated. According to Boston Solar, solar panels are rated to perform at peak efficiency between 59°F and 95°F. However, during the summer, solar panels can reach temperatures as high as 149°F [1], which can cause the degradation of photovoltaic cells and lower the efficiency of the panels, resulting in less electricity generation One such factor is the Temperature Coefficient of Power (TCp). TCP is the rate at which the power output of a solar panel changes as the temperature changes. The TCP of most solar panels is negative, which means that as the temperature increase, the power output decrease. The drop in efficiency can be measured by the Temperature Coefficient of Power.

$$Power = (P_{max} - P_{min})/(T_{max} - T_{ref}) * (T - T_{ref})$$

Power = is the amount of thermal energy

Where Pmax and Pmin = are the maximum and minimum heat on the panel. Measurements would consider ambient temperature as this can affect transfer rates.

Tmax = the maximum temperature difference across the panel, measured in Kelvin (K)

Tref = the temperature it is tested at

T = operating temperature

For every 1°F above 77°F, solar power generation decreases by 0.21% according to an article on the temperature coefficient of power and if it matters for solar panels are usually tested at 77°F (25°C) [2], the average solar panel has an efficiency of around 25% [3], while new research from NREL has produced a cell that is 39.5% efficient [4]. This means that it can be tested to find an optimal temperature the panels will operate and could serve as thermal generators. To achieve this, excess heat from the back of the solar cells can be transferred through a thermally conductive material, which would act as a heat sink to transfer heat into a condenser coil. As the temperatures rise, the system can transfer the excess heat to a thermal battery. A thermal battery is a device that stores energy [5]. For this, water could be used for testing (explored later). This system could be tested with major appliances such as refrigerators and ovens/stoves, with the idea being to store and redistribute the energy needed to heat the water.

The potential energy that can be harnessed can be represented by the heat transfer equation

$$Q = A \times G \times \eta \times \Delta T$$

Q(BTU) = the amount of heat gathered and stored

A = the surface area

G = solar irradiance (BTUs/hour)

η = the efficiency of the solar pane

ΔT = the temperature difference between the panel temperature and the storage material temperature.

With this equation, you can estimate this difference with a 2ft solar panel operating at 100°F and with 25% efficiency, although the actual heat that can be stored will depend on many factors such as the design and materials of the solar panel, the efficiency of the energy storage system, and specific operating conditions. The ambient air temperature as well as the transfer rate of the fluid.

Thermal Storage

With harnessing this energy there needs to be a way to store it. There are many ways in which this could be done, the task will be finding one that is going to be best suited for the needs of the home. One such possibility is just water. Water absorbs "4,184 Joules of heat (1 kilocalorie) for the temperature of one kilogram of water to increase 1°C" (1.8 F) [7]. To calculate this would use the same heat transfer formula changing the figures.

The heat transfer formula is $Q = M \times Cp \times \Delta T$.

Where Q(Btu) is the amount of capacity, M is the mass of the fluid (Ib/hr), Q is the heating capacity (BTU/hr), M is the mass of the fluid per hour (Ib/hr), Cp is the specific heat of the fluid, and ΔT is the temperature between the entering and leaving the fluid., we can determine how much can be stored for the heated water in the home if considering a 1-gallon tank.

M = mass of water = 1 gallon = 8.34 lbs

CP = specific heat of water = 1 Btu/lb·°F

ΔT = temperature difference = 1 °F

Using the heat transfer formula, $Q = M \times Cp \times \Delta T$, we can solve for ΔT, the temperature difference between the entering and leaving fluid, which will give us the amount of heat that can be stored in the 1-gallon tank of water.

$$\Delta T = Q / (M \times Cp)$$

The amount could be higher or lower, and this does not consider the potential loss of thermal energy as the refrigerant moves through the line sets.

Sun to Radiator

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Conclusion

This ability to further the efficiencies of photovoltaic cells and capture additional energy in the form of heat could be a way to potentially increase the value of photovoltaic cells and reduce some of the needs of the home. This was intended to outline the idea of recovering heat from photovoltaic cells and redistributing this energy later. The idea would be to recover heat from the refrigerator as well as distribute it for general heating needs such as hot water. This idea is in its infancy and further research would be needed to determine the potential benefit in a wide variety of factors.

This project will be of benefit to Students as the process of designing and constructing will require the combined efforts of various disciplines in engineering and will offer students a project that they can work together to learn from each other and will give them the opportunity to work hands-on to learn the principles they are learning in their studies. Below is a similar paper from Salt Lake Community College, which shows the value of projects like this and how the students can benefit from working together.

Example of Survey Questionnaire

SURVEY QUESTION 1

On a scale from 1 to 5, 5 being 'Very Open' and 1 being 'Not Open At All,' how open are you to learning from peers of other cultures from your own?

1 2 3 4 5

SURVEY QUESTION 2

On a scale from 1 to 5, 5 being 'Gets Along Excellently' and 1 being 'Does Not Gets Along At All' how well do you get with peers of other cultures from your own?

1 2 3 4 5

SURVEY QUESTION 3

On a scale from 1 to 5, 5 being 'Very Comfortable' and 1 being 'Not Comfortable At All,' how comfortable are you around peers of other cultures from your own?

1 2 3 4 5

[8]

The following figures show the results of the students that worked on the previous project and how they felt before and after working together on the previous project. The red shows before they began their project, and the blue represents after the project was completed. Figure II is the quality of interactions with peers from another culture.

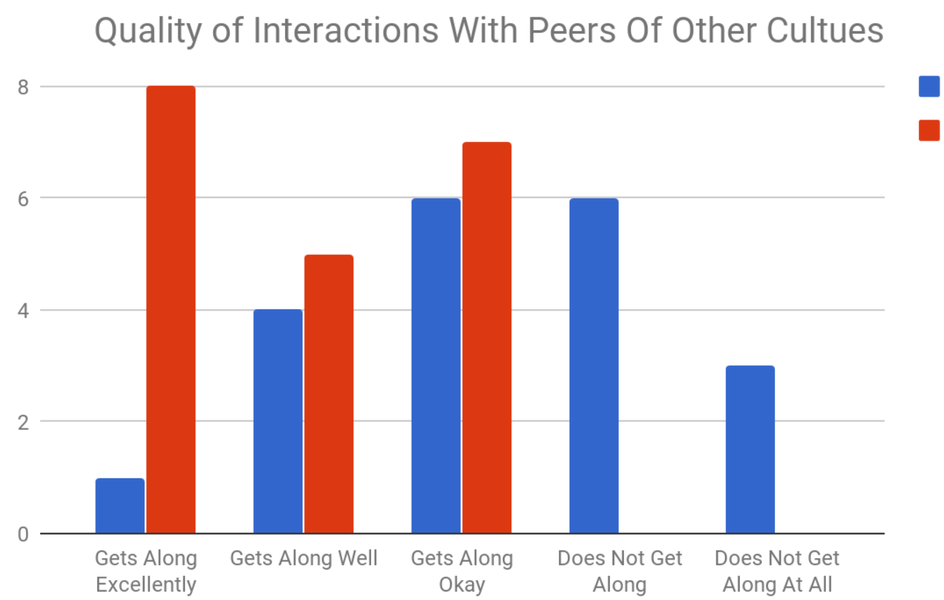

Figure II Levels of overall comfort amongst peers of other cultures [8]

Figure III shows the comfort level of the students before and after the project.

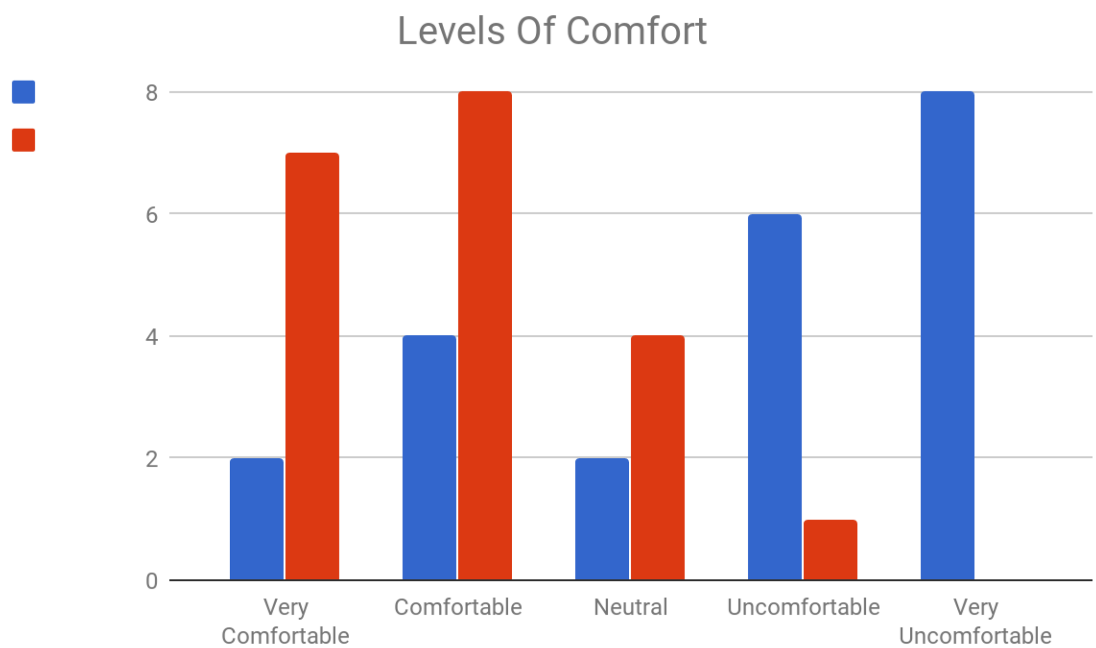

Figure III Student's comfort level with each other [8]

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