Solar based Air Compressor System using PIC Controller

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Abstract---This paper will describe a novel system for generating compressed air energy generation system using solar thermal energy combined with PIC controller for usage and storage. The essential subsystems include solar panels directly coupled to air compressors, battery, and a PIC controller. Solar power is produced by collecting sunlight and converting into electricity. This is done by using solar panels, which are large flat panels made up of many individual solar cells. It is most often used in remote locations, although it is becoming more popular in urban areas as well. Interfacing of air controller with solar cells claims to be able to produce compressed air. This compressed air generation system will be particularly useful to inflate tires and for spray painting tool, with areas of high solar radiation for intermittent energy. This solar system would be a more economical means for achieving zero-emission, firm capacity.

Keywords: Solar, PV cells, energy storage, air compressor, controller.

I. INTRODUCTION

Renewable energy such as solar energy is clean and available as long as the sun shines. Two main disadvantages of these energy sources are their intermittency and their availabilities do not often correspond to power demand. Variations in solar intensity make integrating solar energy into the electric power grid a challenge. An energy storage system can provide steady and predictable power by storing excess energy and releasing it when the demand is greater than supply [1].

Solar can satisfy the requirement of firm capacity during peak periods (late afternoon and early evening during summer months). To make solar, a variety of energy storage concepts have been proposed – compressed air, thermal storage (for solar) and electrochemical systems (i.e. batteries and electrolysis/fuel cells) [2]. It should be considerably more economical, however, to integrate solar-thermal and the appropriate energy storage media with PIC controller in a single system, than to separately design. This is the objective of the work described in this paper.

The "photovoltaic effect" is the basic physical process through which a PV cell converts sunlight into electricity. Sunlight is composed of photons, or particles of solar energy. When photons strike a PV cell, they may be reflected or absorbed, or they may pass right through. Only the absorbed photons generate electricity. When this happens, the energy of the photon is transferred to an electron in an atom of the cell. The electron is able to escape from its normal position associated with that atom to become part of the current in an electrical circuit. By leaving this position, the electron causes a "hole" to form. Special electrical properties of the PV cell a built-in electric field provide the voltage needed to drive the current through an external load [3].

Photovoltaics (PVs) are arrays of cells containing a solar photovoltaic material that converts solar radiation into direct current electricity. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide/sulfide. Due to the growing demand for renewable energy sources, the manufacture of solar cells and photovoltaic [4] arrays has advanced dramatically in recent years.

Photovoltaic production has been increasing by an average of more than 20 percent each year since 2002, making it the world's fastest-growing energy technology. Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaics has declined steadily since the first solar cells were manufactured [5].

Air compressors, sometimes referred to as gas compressor, are devices or tools that reduce the volume of a gas thus creating pressure and heat in the gas being compressed [6].

But still there are some disadvantages you will want to consider.

A. Cost: Initial start-up cost of this system is considerable more but when consideration is given to the years of maintenance free solar power expected, the cost is rapidly defrayed.

B. Climate: It is true that the climates have a great advantage in solar power usage; climates with cloudier, cooler skies can also use solar power.

C. Cloudy Days: Cloudy days are, not the best for generating electricity. Even when the sky is mostly cloudy, any sunlight breaking through will bounce off the bottoms of the clouds. This can actually give more solar power than a cloudless sky.

D. Storage: For some, the task of storing solar power is a disadvantage, as that will provide power during dark hours. Such batteries are readily available, however, and do not consume a huge amount of space.

E. Space: PV solar power panels require space. Home systems can require the entire roof. Modern PV panels supply more solar power with fewer panels, too, since efficiency has been increased.

II. SYSTEM DESCRIPTION

Figure 1 illustrates the concept under investigation. The essential subsystems include:

- solar panel directly coupled to battery for the energy storage and also used to power air compressor.
- with the use of PIC controller the controlling is done to operate the air compressor.

- A collector system consisting of air compressor is used to collect compressed air and can be used later.
- Air compressor collects compressed air storage as high as 150 psi.

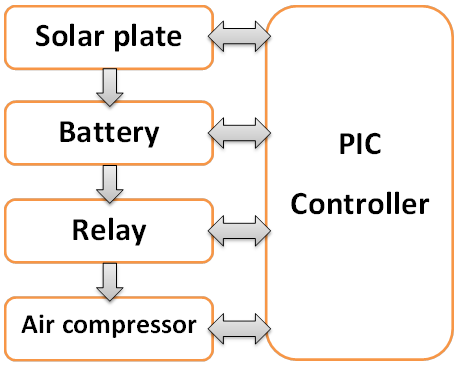

Fig. 1: Schematic Diagram of Concept

The user interface is designed as to be a dialog based application. Keil software is used for the development of the program for the operation of air compressor. After developing the program it is converted into ".hex" file and loaded into the PIC controller through the loader. The input to the system can be identified as

- solar panel output
- battery energy level status
- relay logic
- status of pressure in air compressor

The analysis of the system is to be done to perform the following tasks which can be display on the LCD display:

- display the output status of the solar panel
- display battery energy status
- display the status of the air compressor

The LED is also provided with the Buzzer so that from the distance the status can be seen as well as hear the sound during critical situation.

When the air compressor reaches it upper set limit the controller turns the compressor into off condition.

This proposed system has several advantages over separately applying electrical energy facilities. They are:

- no need for electric transmission connection to it,
- free air for inflating vehicle/bike tires,
- awareness of importance of tire pressure to save money,
- Keeping proper tire pressure dramatically decreases CO_2 emissions.
- No need for cooling water (solar thermal plants typically use steam as working fluid so condenser cooling water is needed).
- The battery is provided to store the energy generated from solar energy.
- Also, since wind energy production tends to be higher in winter and spring, and solar is highest in summer months, seasonal fluctuations in energy supply tend to even out when the PIC controller is combined in an integrated system.

III. The Challenges Facing Solar Panels Generating Less Power Than Rating

These all data and graphs are taken as reference from the books and the internet. When we got our Solar Panels we expected that they would generate electricity at a constant rate and that they would be the same whenever the sun was shining. The reality is rather different. The output of solar panels is affected by the length of the day, the temperature, the height of the sun in the sky and the cloud cover.

If we are finding our solar panels have a low Peak Output, much lower than the nominal kWp output that they are rated at then the most likely cause is temperature. PV Solar panels are less efficient the hotter they get and their rated output is measured at 25C. It is very noticeable that on a cloudy day the output can peak at very high levels, close to the maximum rating of the panels.

For some mixed sunny/cloudy days in April we got 3kW peak output from our 3kWp solar panels when the sun came out from behind a cloud. For consistently sunny days during May the daily peak has been far lower at around 2.3kW.

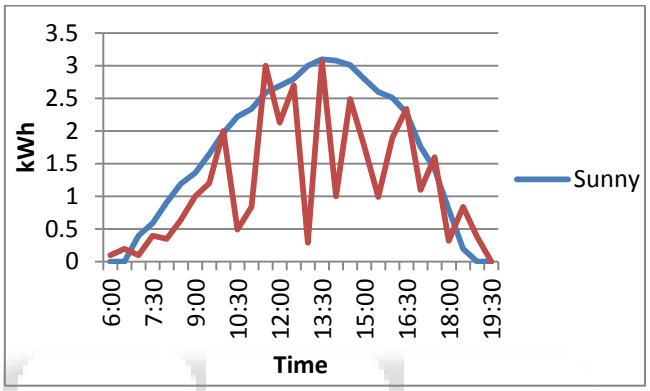

Fig. 2: Output Curve during Sunny and Cloudy days

Figure 2 is the energy generating capacity output curve shown during Sunny and Cloudy days. The absolute ceiling on solar development, however, will be the difference between night time energy generation and the level of stored capacity that must be kept operating for system reliability.

Clearly adding energy storage alleviates this problem and facilitates the addition of more solar capacity. Other economic benefits of storage can be computed by viewing the hourly prices of electric energy and computing the value of the current time profile of solar generation and comparing this to the value of the same daily energy production scheduled to generate during the highest peak hours. Such an analysis was performed for the months of February, March, April and May assuming a 6 hour storage system. The value of the scheduled generation from storage was 80 % greater than the value of solar system for other months.

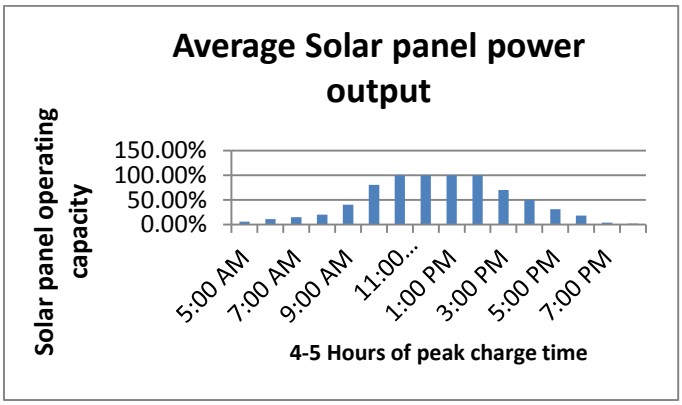

Fig. 3: Average Solar panel power output

A third benefit of adding PIC controller is its ability to enable renewables to effectively substitute for conventional generating capacity – i.e. the value of fully control of the system to its peak operation without wasting energy.

Figure 3 is the average solar power energy generating output graph shown with peak charge time.

Figure 4 is the varying efficiency of solar panel output graph shown with temperature.

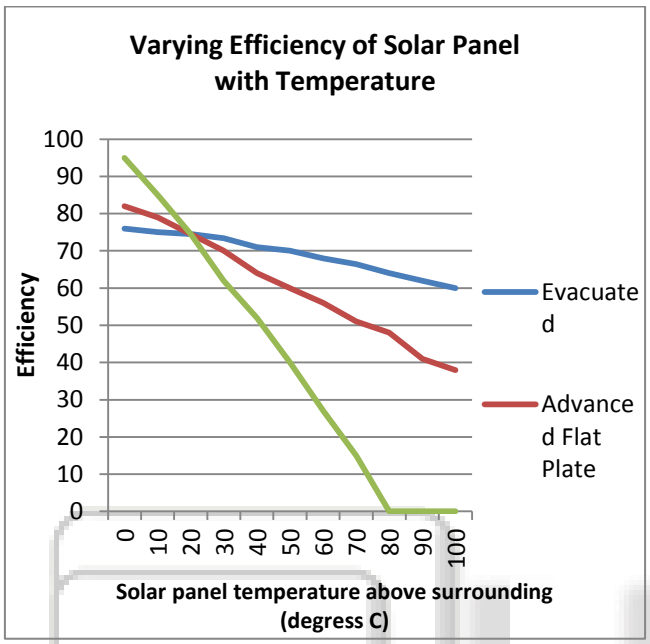

Fig. 4: Varying efficiency of Solar panel with temperature

IV. Energy Storage Options

The two categories of utility-scale energy storage technology are flow batteries, and compressed air with storage. Currently, compressed air is far more developed (and more economical) than flow batteries.

In a compressed air energy storage system, off-peak electricity is used to power motor-driven air compressors and the compressed air is stored in the storage tank. In the generation mode, the pressurized air is withdrawn from the storage tank, and then expanded through a pipe which can be used to inflate tires of automobile vehicles or can be used to spray paint system.

Preheating the compressed air prior to expanding it is necessary for two reasons. One is to significantly decrease the amount of air required per unit of energy produced by the expander; the second is to avoid clogging the air turbine with ice (from moisture in the air) since expansion of highly compressed air has a significant (cryogenic) cooling effect.

A battery is a type of energy storage that offers benefits that traditional line-operated storage supplies lack: mobility, portability and reliability. A battery consists of multiple electrochemical cells connected to provide the voltage desired [7].

The essence of the Solar based Air compressor system using PIC controller is substituting compressed air storage for pressurized air usage.

V. Conclusions

Till now solar based air compressor is being made but it has some limitations in it as it output is less.

Solar based compressed air energy storage systems have been presented with the advancement of putting PIC controller in it. This will increase the efficiency of the system as well as the output of the system. A continuous averaged system for a liquid piston air compressor is extracted from the cycle-to-cycle operation with optimal compression. The architecture allows simple controllers to be designed to capture maximum solar energy, maintain system pressure, and generate the require power. This also allows high power output demand to be handled via hydraulic components only.

The system can capture solar power beyond the capability of the electrical components and operate at a high capacity factor. The improved system operation is obtained by using PIC controller. This will eventually make solar energy a base power source that replaces the equivalent amount of electricity. Further investigations are needed to integrate and optimize the transient and steady power controllers, and for the design, modeling and operation of a multi-stage air compressor.

VI. Future SCOPE

Technical issues to be addressed include:

- Perform optimization to determine the best inlet temperature for the operation of air compressor output ; higher temperatures increase the output per kg of pressurized air, but higher temperatures also require more complex solar collector systems (i.e. sun-tracking systems for concentrating solar)
- Analyze power variation under various combinations of air temperature and flow rate entering the air compressor, in order to quantify the seasonal variation in power output capability
- Select the most suitable energy and compressed air storage media.
- Design the solar collector in such a way so that more energy can be generated.
- Perform cost estimates and conduct cost/benefit analyses.

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