The Application of LabVIEW in Data Acquisition System of Solar Absorption Refrigerator

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Abstract

In order to enhance the coefficient of performance of solar absorption refrigerator and analyse the system performance, it was necessary to collect the operation parameters in the system. This paper put forward to combine the technique of visual instrument and the characteristic of solar absorption refrigerator, using National Instrument’s product LabVIEW, to develop an effective data acquisition (DAQ) system. This DAQ system can realize the real-time data acquisition of temperature, water flow rate and pressure as well as data transmission, processing, and display, in addition to provide users with historic data inquire. It saved a lot of labor power and material resources so that it made measurement more convenient and fast.

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Keywords- LabVIEW, solar absorption refrigerator, DAQ system, Agilent 34970A

1. Introduction

The usage of electricity in refrigerating systems has increased in the past decades. While the conventional refrigeration cycles driven by traditional vapor compression in general contributed significantly in an opposite way to the concept of sustainable development, because of two major problems: the global increasing consumption of limited primary energy and the refrigerants used cause serious environmental problems [1]. During the last few decades, an increasing interest has been concentrated on the technology developments that can offer reductions in energy consumption, peak electrical demand and energy costs without lowering the desired level of comfort conditions [6]. By reason that solar refrigeration technologies have the advantage of removing the majority of harmful effects of traditional refrigeration machines, the development of solar refrigeration technologies became the worldwide focal point for concern [4]. Solar absorption refrigerators are one of the most appealing
technologies proposed. In the various absorption solar refrigeration systems, LiBr-H$_2$O and H$_2$O-NH$_3$ are the major working pairs employed in these systems. It was reported that LiBr-H$_2$O has a higher COP than H$_2$O-NH$_3$, and its low cost and excellent performance made it the favorable candidate for use in solar refrigeration cycles [2]. For these reasons, the lithium bromide-water system was considered to be better suited for most solar-absorption refrigeration applications, and a self-made solar lithium bromide-water absorption refrigerator was set up for this research. There needed a lot of testing during the research, development and manufacturing process of solar absorption refrigeration equipment, and manual testing using the traditional instruments was difficult, long period, and high cost. LabVIEW itself was a graphical development environment for creating flexible and scalable test, measurement, and control applications rapidly and at minimal cost. Using the virtual instrument technology can make full use of computer resource, generalizing instrument hardware. It can not only improve test efficiency and precision, but also promote the development process of refrigeration equipment. This paper will discuss the data acquisition (DAQ) system of the solar absorption refrigeration unit based on LabVIEW 8.2.

2. METHODOLOGIES

2.1 NI Labview Technology

The use of computers for data acquisition, data analysis and instrumentation control in HVAC systems has increased rapidly in the last several years. LabVIEW is a powerful and versatile graphical programming environment which was developed primarily to facilitate instrumentation control and data acquisition and analysis. Applications created with LabVIEW are referred to as virtual instruments (VIs). VI source code is created using the graphical programming language G in a window called the block diagram. Input and output interfacing with the VI is performed in another window called the front panel. The graphical icon-based source code and interfacing creates very user-friendly applications and eliminates typing in lengthy character-based code [3]. LabVIEW implements a dataflow paradigm in which the code is not written, but rather drawn or represented graphically similar to a flowchart diagram. LabVIEW has several key features which make it a good choice in an automation environment. These include simple network communication, turnkey implementation of common communication protocols (RS232, GPIB, etc), powerful toolsets for process control and data fitting, fast and easy user interface construction and an efficient code execution environment.

2.2 The solar absorption refrigeration system description

In this section, the description of the solar absorption refrigeration unit utilized in this research was presented firstly and the data acquisition system to collect the experimental data based on LabVIEW 8.2 was then described. Finally, the approach of the experiment performed to collect the experimental data was shown and explained.

The solar-assisted refrigerator consisted of a series of interconnected components. There were the components of the refrigeration unit, a single-effect lithium bromide absorption refrigerator, a flat plate solar collector which was simulated by an electric heater providing different generating temperature and a cooling tower. Figure 1 showed a schematic diagram of the solar absorption refrigerator used for this research. The solar energy was gained through the collector and was supplied to the generator to boil off water from a solution of lithium bromide + water. The water vapor was cooled down in the condenser and then passed to the evaporator where it again was evaporated at low pressure, thereby providing cooling to the required space. Meanwhile, the strong solution leaving the generator to the absorber passed through a
solution heat exchanger in order to preheat the weak solution entering the generator. In the absorber, the strong solution absorbed the water vapor leaving the evaporator. Cooling water from the cooling tower removed the heat by mixing and condensation[7-9].

![Diagram](image_url)

**Figure 1. Schematic diagram of the solar absorption refrigerator**

### 2.3 Data acquisition system

During the research and development process of the solar absorption refrigeration equipment, there needed to do a lot of experiments in order to improve the coefficient of performance of the solar absorption refrigerator. There were many parameters affecting the overall performance of the absorption system, which should be collected. For the above-mentioned advantages of LabVIEW, a data acquisition (DAQ) system based on LabVIEW 8.2 was set up. The composition of the DAQ system for the purpose of acquiring experimental data was described below. This setup consisted of both hardware and software components since the main operations of the experiment were run from a computer. The main components of the hardware configuration for the solar absorption refrigerator consisted of an Agilent 34970 data acquisition switch unit, a personal computer and all kinds of sensors. Figure 2 showed a schematic diagram of the DAQ system set up for this research.

The Agilent Technologies 34970A combined precision measurement capability with flexible signal connections for the production and development test systems. Three module slots were built into the rear of the instrument to accept any combination of data acquisition or switching modules. Two blocks of 34901A 20-Channel Armature Multiplexer Module were fixed to the Agilent 34970 data acquisition switch unit. The combination of data logging and data acquisition features maked this instrument a versatile solution for the testing requirements. Different parameters of thermocouples, RTDs, thermistors, dc voltage, ac voltage, resistance, dc current, ac current, frequency, and period could be measured by...
Agilent 34901A 20-Channel Armature Multiplexer Module directly. The Agilent 34970 data acquisition switch unit was connected to a personal computer by serial port RS232. NI-VISA protocol was used to read and write to serial port RS232, accomplishing data switching, as showed in Figure 3.

![Figure 2. Schematic diagram of the DAQ system](image)

The performance of the solar absorption refrigerator was dependent upon the system design and optimization of parameters. All these parameters should be measured and monitored during the operation process, and so the DAQ system contained 17 measuring points in all was set up. Temperature signal was collected by copper-constantan thermocouple (T type) sensors. There were 13 temperature measuring points, including absorber inlet and outlet cooling water temperature, condenser inlet and outlet cooling water temperature, condensing temperature, evaporating temperature, evaporator inlet and outlet chilled water temperature and environmental temperature. Generator pressure was collected by Druck PMP 4000 pressure sensor and converted to -5~+5V standard direct current voltage signal. Flow rate was collected by LWGB style revolving flowmeter and converted to standard 4-20mA direct current signal. There were 3 flow rate measuring points, including absorber cooling water flow rate, condenser cooling water flow rate and chilled water flow rate. All these collected signals were modulated by Agilent 34970A data acquisition switch unit, and then input into the PC.

The software configuration was programmed by LabVIEW 8.2. As we all knew, LabVIEW was an industry-standard graphical programming environment that could be used to quickly and easily acquire, analyze, and present data from the Agilent 34970A data acquisition switch unit. National Instruments provided a free LabVIEW instrument driver for the 34970A, which gave everyone programmatic control over the unit from his PC, while having to do little or no programming himself. An instrument driver was a set of software routines that controlled a programmable instrument. Instrument drivers utilized a set of commands provided by the instrument vendor to communicate with the instrument, often through GPIB, Serial, Ethernet, or USB. Each routine that composed the driver corresponded to a programmatic operation such as configuring, reading from, writing to, or triggering the instrument.
LabVIEW itself was a graphical development environment for creating flexible and scalable test, measurement, and control applications rapidly and at minimal cost. Unlike other programming environments, all programming in LabVIEW was done graphically through intuitive flowchart-style coding and functional blocks. Hundreds of functional blocks for analysis, signal processing, and mathematics were built-in to the environment, making LabVIEW a smart choice for manipulating raw data collected with the Agilent 34970A data acquisition switch unit. The driver included a full set of functional building blocks that can be used to create a completely custom 34970A application in LabVIEW. The set of LabVIEW functions installed with the instrument driver provided all the building blocks the DAQ system needed. In LabVIEW, each of these programmatic building blocks was called a virtual instrument, commonly referred to as a VI.

Any custom LabVIEW application was composed of two sections: one section was a front panel, which was the graphical user interface (GUI), on which the parameters required to the study on how to enhance the performance of the solar absorption refrigerator were displayed. As mentioned above, these parameters consisted of temperature, flow rate, and pressure signals. Figure 4 showed the front panel of the LabVIEW GUI developed for this DAQ system. As shown in figure 4, the front panel could not only show all the important parameters instantly but also let us set the sampling interval. The other section was a block diagram, the core of the whole software, where the flow chart-style code was created with these functional blocks (VIs).

As we all knew, DAQ was simply the process of measuring a real-world signal, such as a voltage, and bringing that information into the computer for processing, analysis, storage, or other data manipulation. Thus, the block diagrams of the DAQ system in our research consisted of DAQ modular, data dynamic display modular, data processing modular and files storage modular. When the LabVIEW instrument driver for the 34970A was installed, palettes containing high-, mid- and low level instrument driver VIs were available in LabVIEW. The EZ measurement VIs which was low level instrument driver offered the quickest and easiest use. However, they did not let us have different types of measurements in the same scan list. While as was mentioned earlier, there were three types of measurements, such as temperature, water flow rate and pressure. Therefore, we set up a scan list consisting of the three different measurement types on different channels using the advanced configure VIs, including HP34970A Conf Current, HP34970A Conf Temperature, HP34970A Conf Voltage, HP34970A Scan list, HP34970A Scan, HP34970A Trigger and HP34970A Read. Figure 5 showed the program block diagram of the DAQ modular in this DAQ system. For this program could only collect data for once, we added a while structure to it, which made it accomplish continuous data acquisition.

![Solar Absorption Refrigerator DAQ SYSTEM](image)

Figure 4. The front panel of the Labview GUI
After acquiring data in the DAQ modular above, we wished to present all the parameters to user as we needed. For example, the generator pressure signal was converted to standard -5--5V direct voltage, and on the front panel of the above DAQ modular the quantity of dc voltage was shown. Obviously it was not convenient for the user, for we wanted the pressure readings directly. For this purpose, by utilizing the functions for manipulating arrays and expression node, we could easily achieve that functionality to our application. For further analysis and research on the performance of the solar absorption refrigerator, all these collected data should be logged to files. LabVIEW could also be used to interface with a data management system, whether that consisted of a simple spreadsheet file or a relational database. The block diagram in Figure 6 extended the functionality of our previously created code to gain the direct readings of each parameter and log those values to a spreadsheet file compatible with Excel.
3. Results and discussion

In this research, based on Agilent 34901A 20-Channel Armature Multiplexer Module and programming with Labview 8.2, the DAQ system was developed quickly and easily, for the advantages of LabVIEW 8.2, such as graphical programming, data acquisition and instrument control. This DAQ system could acquire, process and store these required parameters of the solar absorption refrigerator. The acquired data will be used for further research and investigation. Through practical data acquisition, it was proved that the performance of DAQ system was stable, the operation was reliable and each measurement precision met the testing requirement. However, it should be noted that we must setup the correct parameters of serial port from the LabVIEW, such as baud rate, parity, stop bits, identical to the serial configuration of Agilent 34970A. Otherwise once the DAQ program was run, a fatal error would occur.

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