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# CONSTRUCTION AND PLANNED OPERATION OF A HYBRID CYCLE POWER PLANT ON A GEOPRESSURED WELL

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## ABSTRACT

The U.S. Department of Energy and Electric Power Research Institute are co-funding a demonstration of the hybrid cycle power concept on a geopressured resource. The power plant was constructed in early 1989 at the Pleasant Bayou geopressured test facility in Texas. This paper presents a review of the design and construction, plus a discussion of the plans for operation.

## INTRODUCTION

In the hybrid cycle power conversion concept, electricity is generated from two or more sources of energy. From a geopressured resource, energy can be recovered from high temperature brine, from dissolved methane, and from hydraulic energy of the high pressure brine. In the demonstration plant, gas is burned in a gas engine to generate electricity directly. Exhaust heat from the gas engine is then combined with heat from the brine to generate additional electricity in a binary cycle. Heat from the gas engine is available at high temperature, thus improving the efficiency of the binary portion of the hybrid cycle.

The Ben Holt Co., under contract to EPRI, refurbished equipment from DOE's Direct Contact Heat Exchange facility in East Mesa, California for use at Pleasant Bayou. In addition, Holt purchased new heat exchangers and other equipment required for a hybrid cycle plant. Construction and operation are under a separate contract funded by DOE. For this work, Holt teamed with Eaton Operating Company (Houston, Texas) and Institute of Gas Technology (Chicago, Illinois).

The primary objective of this project is to demonstrate the hybrid concept for electricity generation. Other objectives include demonstrating electricity generation from a geopressured resource and obtaining data from operating a power plant using geopressured fluids.

## SYSTEM DESCRIPTION

Figure 1 is a flow diagram of the hybrid power cycle which will be installed at Pleasant Bayou. The system is designed to operate on 10,000 BBL/day of geopressured brine containing 22 SCF of gas/BBL. This flow is approximately one half of the total flow from the Pleasant Bayou well. The gas is approximately 87 percent methane with the balance mostly carbon dioxide.

Power can be produced from three forms of energy in the cycle as shown. The first form is hydraulic energy, which can be recovered in the pressure reduction turbine. A pressure reduction turbine was not included in the Pleasant Bayou experiment.

The second form of energy is chemical energy, recovered by burning the methane in a gas engine. A gas turbine could be used instead with minor changes to the process.

The final form of energy recovered is heat. The high temperature engine exhaust gas and the hot geothermal brine provide heat to a binary cycle.

Estimated power generation from the system without the pressure reduction turbine is:

| | |
|---|---|
| Gas Engine | 650 kW |
| Binary Cycle Turbine | 540 kW |
| Parasitic Power | (210 kW) |
| Net Power | 980 kW |

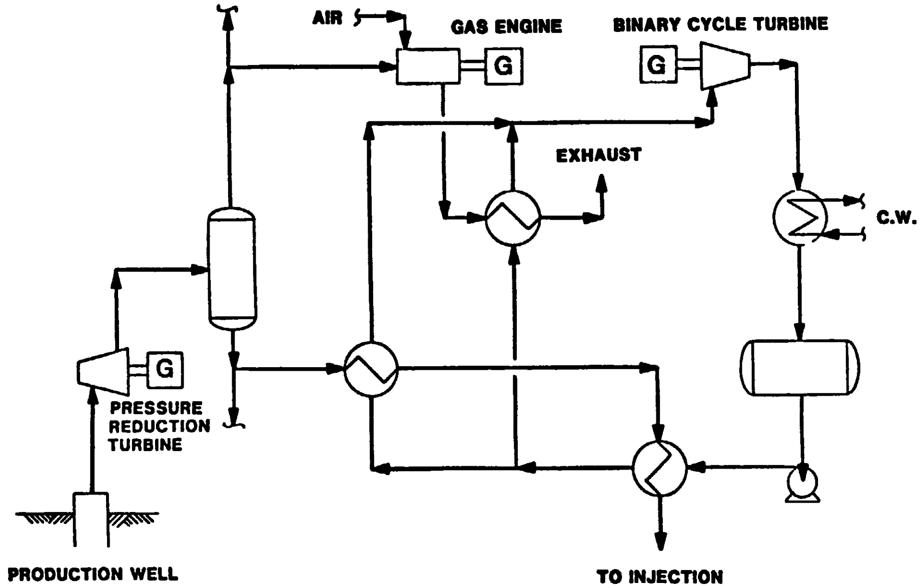


FIGURE 1. HYBRID CYCLE FLOW DIAGRAM

DESIGN AND CONSTRUCTION

Beginning in 1984, The Ben Holt Co., under contract to first EPRI and later to DOE, completed the system design and procured equipment.

Much of the equipment for the binary cycle was donated by DOE from the Direct Contact Heat Exchange (DCHX) test facility at East Mesa, California. Isobutane, used as the working fluid in the DCHX, was also selected for use in the hybrid experiment. Operating conditions were chosen to allow reuse of existing equipment with minimum modifications. Equipment from the DCHX facility was dismantled, refurbished, and shipped to Pleasant Bayou. New equipment, including three heat exchangers, firewater pump, gas-freeing compressor, electrical switchgear, and several instruments were also purchased.

.A concrete foundation was installed in 1986, after which equipment was shipped to the site. The remaining construction began December 1988 and was completed June 1989.

During construction, the major problems encountered were with corrosion of equipment from the DCHX facility. All equipment was cleaned and put into operating condition during the construction period. The evaporative condensers were in the worst condition, with leaks occuring in approximately 12% of the tubes. Leaky tubes were sealed off to prevent loss of isobutane during operation. Sealing off the tubes decreases the condenser surface area, but the range of operating conditions to be encountered at Pleasant Bayou will allow the objectives of this test program to be met anyway.

A major source of problems during operation of the DCHX test facility was the turbine. Early in the construction work, a finite element analysis was made of the turbine rotor. Results of this analysis showed that the existing rotor may be overstressed and would be operating close to critical frequencies. As a result, a new rotor was designed and fabricated for operation in the existing housing. A finite element analysis of the design showed the new rotor to be well designed with respect to strength and critical frequencies.

An area of concern for operation on a geopressured resource is corrosion of the tubes in shell-and-tube heat exchangers. Testing has shown that corrosion is most severe in areas of high turbulence. Therefore, ferrules have been inserted into the inlets of heat exchanger tubes which have brine flowing through the tubeside. These ferrules are in the area of highest turbulence and will be exposed to the highest corrosion. By the time the brine leaves the ferrule, the velocity profile will have smoothed out and corrosion will be reduced.

One change from our original design basis is that two gas engines will be installed instead of one. A single 650 kW engine was not available at the time of construction, so two engines of 350 kW each were installed. A second engine adds to the complexity of operating the plant, but there should be no impact on plant performance.

## OPERATION

Operation began June 1989. The first three months of operation are for start-up, shakedown and testing. During this intensive testing period, the system will be operated under a variety of conditions to yield information on individual system components as well as total plant limitations.

Following the three month intensive test, the experimental facility is scheduled to be operated for nine months on a continuous basis. The intent of this long term test is to demonstrate system reliability and to obtain data over an extended period. Of particular interest during this test will be heat exchanger fouling and binary cycle turbine performance.

Geopressured resource utilization requires that severe problems due to corrosion and scaling be overcome. Corrosion and scaling inhibitors have been successfully used by Eaton and the Institute of Gas Technology while operating the production and brine handling facilities at Pleasant Bayou. However, it is unknown what will happen inside the heat exchangers when the brine cools down by more than 100°F. Heat transfer coefficients will be closely tracked to monitor scaling, and corrosion coupons will be used to detect corrosion. At the conclusion of the operating period, heat exchangers and piping will be inspected, and corrosion and scaling will be measured.