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Open Cycle Cogeneration Project—Placerita Field

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Introduction

The Placerita Oil Field is underlain with thick Pliocene sands containing several hundred feet of oil saturated sand in the Shepard Zone (Saugus) and the Upper and Lower Kraft Zones (Pico). These sands have been exploited somewhat haphazardly since 1920. However, the oil content beneath some of the acreage in the field is of the order of 200,000 barrels per acre. Steam injection will be required to recover the oil, which has a gravity as low as 11^{o} although in some intervals it is as high as 20^{o} API.

Since Placerita is in Los Angeles County, there are many restrictions on what fuel may be used in the steam generators. Natural gas is the preferred fuel, but at this time gas supplies in the area are somewhat more expensive on an equivalent BTU basis than crude oil. In order to be able to contemplate economic development of the field using steam, it is necessary to employ highly efficient processes for burning purchased gas. The scheme that recommends itself is the use of a cogenerator which produces both steam for subsurface injection and merchant electric power.

Tosco Enhanced Oil Recovery Corporation selected GWF Power Systems of Irvine, California to design and install a natural gas-fueled cogeneration system to supply steam and electric power for sale in order to keep the net cost of the former at a sufficiently reasonable level to permit economic recovery of Placerita crude oil by steam injection.

This is an account of the cogeneration system, Placerita I.

Overall Description of Power System

Placerita I is a cogeneration facility which is being constructed by GWF Power Systems on a Tosco Enhanced Oil Recovery Lease in the Placerita Field, near Newhall, in Los Angeles County. It will generate electrical power to be sold to Southern California Edison, and will also produce steam to be used by Tosco for recovering oil from the viscous oil-bearing sands beneath their leases. Pertinent characteristics of the cogenerator are shown in Table 1.

An isometric drawing of Placerita I is shown in Fig. 1. The power source are two Onan 4000 GTU turbine generator sets which consist of Dresser Clark 1E990 turbines, Ideal synchoronous generators and associated controls and auxiliary equipment. The generator sets are mounted in a sound reducing enclosure which is equipped with inlet air filters and coolers. The coolers are of the evaporative type and are intended to limit the air inlet temperature to the turbines to 89^{o}F.

A closed loop control for steam quality is included. The control senses the volumetric flow of the output steam and regulates boiler feedwater to maintain a desired specific volume of the output steam.

Feedwater Supply

The boiler feedwater is produced water that is softened in Tosco's water treating facilities. The water has a total dissolved solids content of less than 4,000 ppm. It is softened to bring the hardness down to less than 1.0 ppm., and the water is substantially free of oxygen. As a precaution, hydrogen sulphite is added just upstream of the boiler to insure oxygen-free feedwater. The treated water is stored in a boiler feedwater tank.

Present Status and Schedule

The design of Placerita I was started in February 1982 and completed in October. The site was activated in October and excavation was begun. In January 1983, all the underground work is complete and all pads are poured . The boiler is in place, the tanks are being constructed, and the switchgear and control buildings are erected. The pad for the electrical substation is complete and SCE is beginning construction.

The long lead items are the Onan 4000 GTU generator sets which are scheduled to be on site in March 1983. Part of the delay is occasioned by the substitutin of digital electronic units for analog fuel controls.

Team Arrangement

The various companies involved in Placerita I are shown in Fig. 2. The plant is located on the Tosco Orwig lease and Tosco is the customer for the steam. All electrical power is sold to SCE.

The facility will be owned and operated by GWF Power Systems Company, Irvine, California, which is a joint venture between Garrett Corporation and Wheelabrator Frye Corporation. The joint venture was established prior to the recent merger of the latter into the Signal Company.

Holmes and Narver of Orange, California was hired by GWF to design and construct Placerita I on a turnkey basis. They have total system responsibility through construction, equipment installation, and checkout.

GWF handled the purchases of the boiler from CE NATCO in Tulsa, and 4000 GTU generator sets from Onan in Minneapolis. In addition, GWF took responsibility for obtaining construction and operating permits from the SCAQMD (Southern California Air Quality Maintenance District) in El Monte.

Cogenerator Performance

A computer model of Placerita I was developed to study its peformance over a range of conditions. A generalized engine model was prepared and programmed with 1E990 performance data. The model can be readily reprogrammed to study other turbine engines. The boiler model is also general, requiring boiler geometry data and certain performance coefficients.

The facility output power characteristics as a function of ambient temperature and relative humidity are presented in Fig. 3. Relative humidity effects performance primarily through the evaporative air inlet coolers. If relative humidity is 100%, the coolers have no effect and that curve represents the performance of the facility without inlet cooling. As relative humidity falls, the cooler becomes more effective and the output of the facility increases, as shown in Fig. 3. For example, if the ambient temperature is 100^{o}F. and the relative humidity is 20%, facility output increases by 900 KW. Such weather conditions are not unusual at Placerita Canyon.

All the data shown on Figure 3, and the succeeding performance curves were run for a water to fuel ratio of 0.5. Since it is planned to operate Placerita I at a water to fuel ratio of 1.0, its power output will be higher than shown on Fig. 3. For example, at 80^{o}F. the facility's output increases about 500 KW when the water injection ratio is increased from 0.5 to 1.0.

Steam output, on an expanded scale, is shown in Fig. 5. Steam conditions are 900 psia. and 85% quality. Over the range of ambient temperatures from 40^{o} F. to 60^{o} F., steam rate increases because exhaust gas temperature rises sharply. From 60^{o} F. on up, the turbine fuel control holds power turbine temperature constant so that exhaust gas temperature increases more slowly. At the higher ambient temperatures, steam production falls off due to the decrease in engine air flow.

The heat rate of the facility is shown in Fig. 5. Here again the benefit of the inlet cooler is seen. At an ambient of 100^{o} F., and 20% relative humidity, the facility heat rate is decreased 7.5% by the action the air inlet cooler.

Summary

Placerita I has been designed around conventional techniques and available equipment, and no serious technical problems are therefore anticipated. It will be run base-loaded around the clock with the objective of obtaining in excess of 8000 operating hours per year. All the equipment selected are consistent with those objectives.

The technique for steam quality control, to our knowledge, is new. It is being used in an attempt to control steam quality closely about the 85% design point. The high quality of the steam (together with short surface distribution lines) was specified by Tosco in order to secure the maximum quantity of latent heat per pound of steam delivered to the subsurface reservoirs.

As mentioned earlier, the steam quality control system is based on measuring steam volume flow. Its principle is based on the large change in specific volume which occurs with changes in steam quality. It is expected that some empiricial calibration will be required to obtain the desired performance.

To date, problem areas encountered have been largely non-technical in nature. These have involved obtaining easements over adjoining land, and obtaining building and environmental permits. As a result of the experience gained in designing and construc-

A supplementary water tank contains sufficient city water for two hours of firefighting.

Fuel Supply

Primary fuel for the turbines, natural gas, is secured from Southern California Gas Company's Quigley scrubbing station, and is brought to the site through a 4000 foot long dedicated four inch pipeline. Gas pressure leaving Quigley ranges from 200 to 525 psia. The 1E990 turbines require a minimum pressure of 220 psia. to maintain base load. Since the gas pressure drops below 220 psia. for only a few hours during the week, it was decided not to include a gas boost compressor in Placerita I. The 1E990 fuel controls can switch from primary to alternate fuel without loss of power. A pressure switch in the fuel gas receiver initiates a switchover whenever gas pressure drops below 220 psia. Operator intervention is then required to go back to primary fuel.

The tank farm of Placerita I includes two alternate fuel (propane) tanks surrounded by an earth dike.

Steam Generation

Exhaust gas from the two 4000 GTU units is ducted together and passed through a CE NATCO HRSG (heat recovery steam generator). Each leg of the ducting has a diverter valve and a bypass stack. The diverter valve is a single vane, electrically actuated unit capable of a tight seal and high reliability. Each diverter valve will either direct flow through the HSRG or up the bypass stack and will cause a minimum pressure loss; 2 inches of water or less.

The diverter valve/by pass stack arrangement has several functions:

1. If one 4000 GTU is inoperative, its diverter valve will isolate it from the exhaust gas of the other unit which can then continue to operate at rated conditions. For this function the diverter has a double seal arrangement with a pressurized air compartment in between.

2. When an inoperative 4000 GTU is to be brought back on line, the diverter valve will bypass through the engine start and acceleration sequences and will then switch to divert gas through the HRSG.

3. If repair or inspection must be done on the HRSG, both diverter valves will bypass. There is a provision for inserting blanking plates between the diverter valves and the HRSG as an added precaution.

4. One or both of the diverter valves can be switched to bypass if steam demand is greatly reduced.

The diverter valves will be operated only in the two position modes; fully in the direction to pass all gas through the HRSG, or fully in the bypass stack direction. Control can be exercised from the control room and is both manual and automatic. The automatic mode will be used to accomodate emergency events, such as an engine shutdown.

The HRSG is a once through boiler designed to provide 47,356 pounds of steam per hour at 85% quality and a maximum pressure of 1500 psig. At Placerita I, it is expected that the HRSG will operate at 900 psi. during the first year or so of steam stimulation, but it is expected that eventually the pressure will be reduced to approximately 400 psi. after breakthrough in the steam drive is achieved. The HRSG will have a back pressure valve to limit steam velocities to 180 feet/sec. within its tubes.

Electric Power Generation

Electrical power is generated at 4160 volts and is taken through underground vaults to the switchgear building. From there it passes through the SCE substation where it is coverted to 17,000 volts and is then sent to the SCE grid.

All the power which is generated is sold to SCE. Power required to operate the facility is then purchased from SCE. This power flow was used because it simplified the electrical interface of the facility and at the time the design was finalized, it also had an economic advantage. A 30 KV diesel generator set is included in the facility to provide emergency power for the lube pump, the DC power supply for control logic and certain plant lighting functions. The facility does not have black start capability.

The Onan 4000 GTU generator sets will be run at base load at all times. In this mode, the turbines are run at a power turbine inlet temperature which is a predetermined function of engine inlet temperature. The turbine's digital electronic fuel controls regulate power turbine inlet temperature in a closed loop manner.

The 1E990 turbines are water injected for emission control. A ratio of one pound of water per pound of fuel will be used to effect a NO_x reduction of 80% over the dry emission level. The engines are equipped with triplex nozzles which inject, separately, fuel, alternate fuel and water. Newhall city water at 350 ppm. is treated in a demineralizer where its TDS is reduced to 5 ppm. prior to injection.

Unattended Operation

The long term objective is to have Placerita I operate unattended. A data link to a service center will indicate current status, and inspections of the control room will be made periodically, perhaps once per shift. At other times the facility would be unmanned. However, until procedures are perfected and confidence is established the facility will be manned round the clock.

ting Placerita I, it is believed that succeeding facilities can be designed and built more expeditiously.

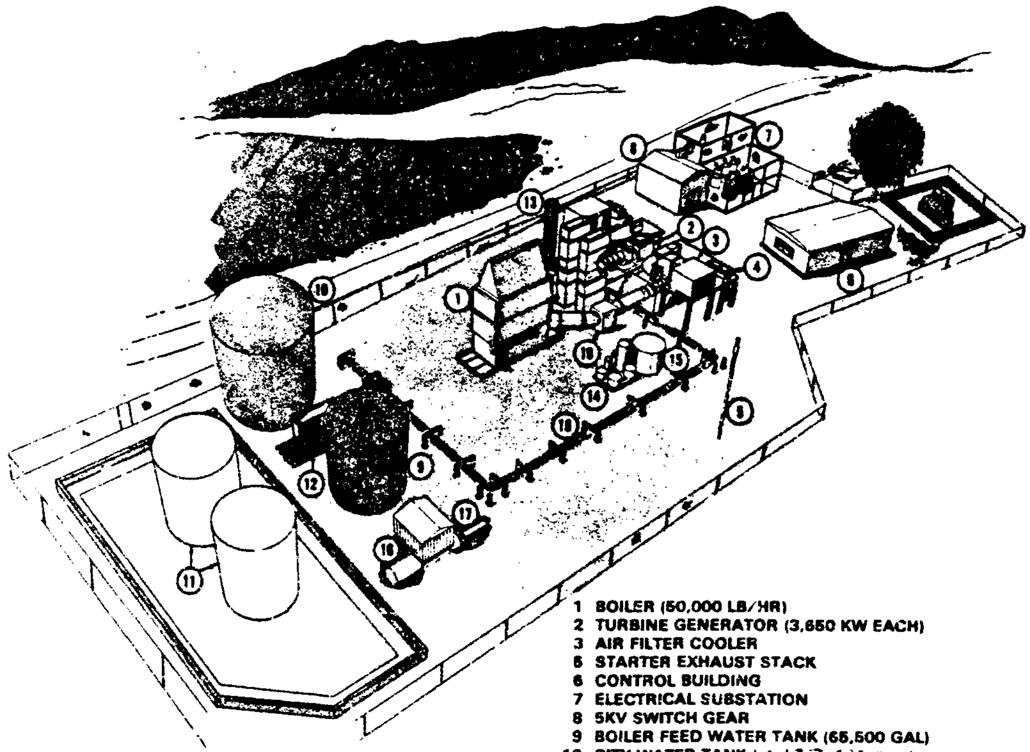
Conclusion

An economic cogeneration system has been designed and is being installed in the Placerita Oil Field which promises to permit the economic recovery of viscous crude despite the relatively high cost of the only available boiler fuel, natural gas.

TABLE 1

DESIGN CRITERIA

Site Elevation	1720 Feet Above Sea Level
Ambient Temperature	115°F Max., 35°F Min., 65°F Avg.
Steam To Customer	
Quantity	47,356 lb/hr
Pressure, Maximum	1500 psi
Quality	85 percent
Gas Turbine Engines	Two Dresser Clark IE990's
Primary Fuel	Natural Gas
Backup Fuel	Diesel, DF-2
Inlet Loss	4 in H_2O
Exhaust Loss	10 in H_2O
Water Injection	0.5 lb/lb Nominal 1.2 lb/lb Max.
Boiler	CE Natco
Design Pinchpoint	30°F, Nominal
Stack Temperature	300°F, Nominal
Electrical	
Output Power (both Gen. Sets)	7600 KW @ 80°F at site
Voltage	4160 volts
Boiler Feedwater	
Source	Produced, treated by Tosco
Injection Water	
Source	Newhall City Water



1 BOILER (50,000 LB/HR)
2 TURBINE GENERATOR (3,650 KW EACH)
3 AIR FILTER COOLER
5 STARTER EXHAUST STACK
6 CONTROL BUILDING
7 ELECTRICAL SUBSTATION
8 5KV SWITCH GEAR
9 BOILER FEED WATER TANK (65,500 GAL)
10 CITY WATER TANK (137,000 GAL)
11 FUEL TANKS (80,000 GAL EACH)
12 PUMP SKID - (FIRE, BFW, CITY WATER, ALTERNATE FUEL)
13 GAS RECEIVER TANK
14 DEMINERALIZER SKID
15 DEMINERALIZER SURGE TANK (5040 GAL)
16 EFFLUENT HOLDING TANK (7000 GAL)
17 DRAIN WASTE HOLDING TANK (1000 GAL)
18 PIPEWAY
19 DIVERTER VALVE (48 IN. DIA.)

Fig. 1—Placerita I cogenerator.

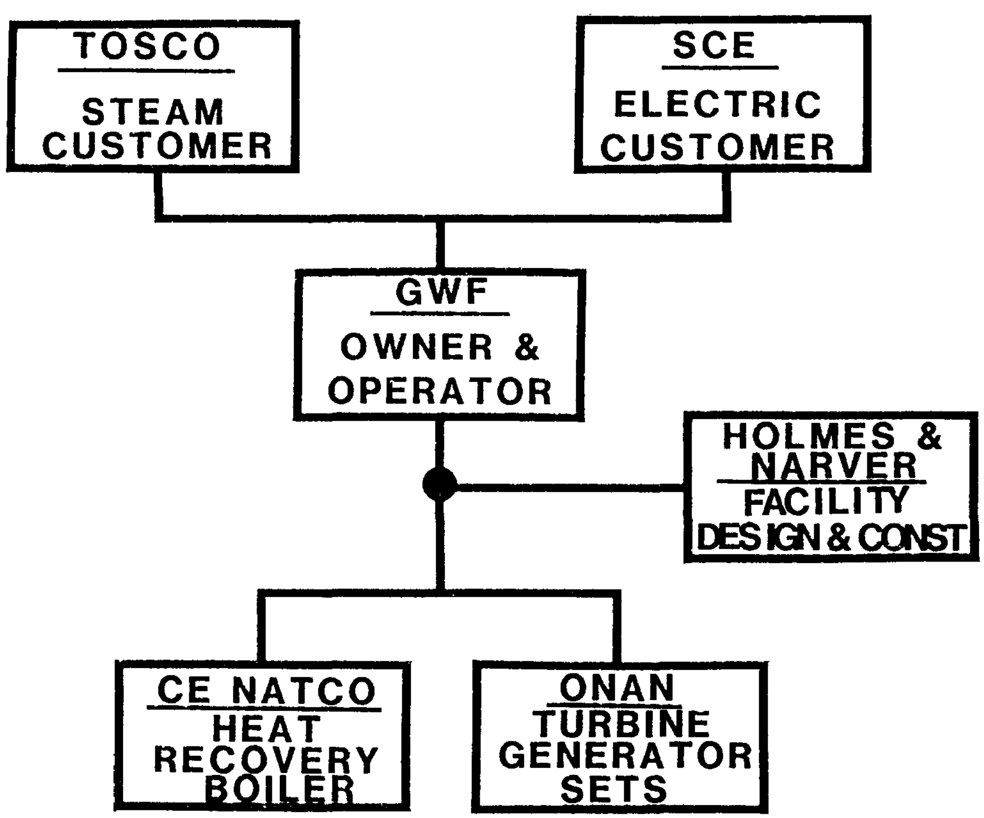


Fig. 2—Placerita I team arrangement.

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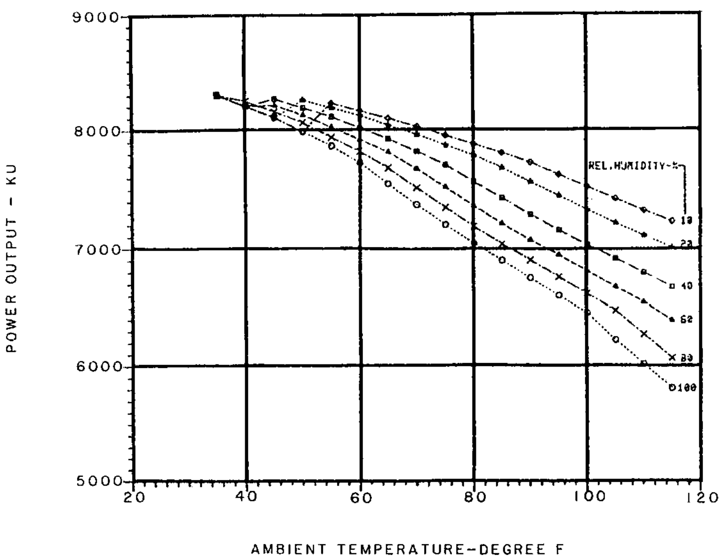

Fig. 3—Placerita I performance, water to fuel of 0.50.

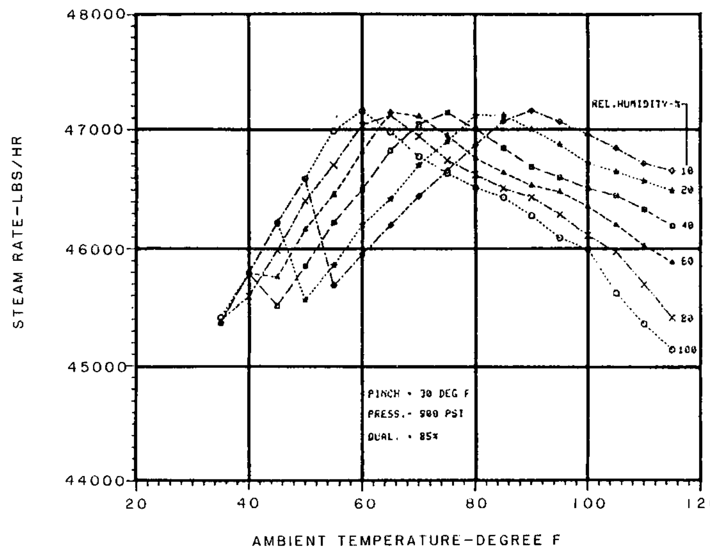

Fig. 4—Placerita I performance, water to fuel of 0.50.

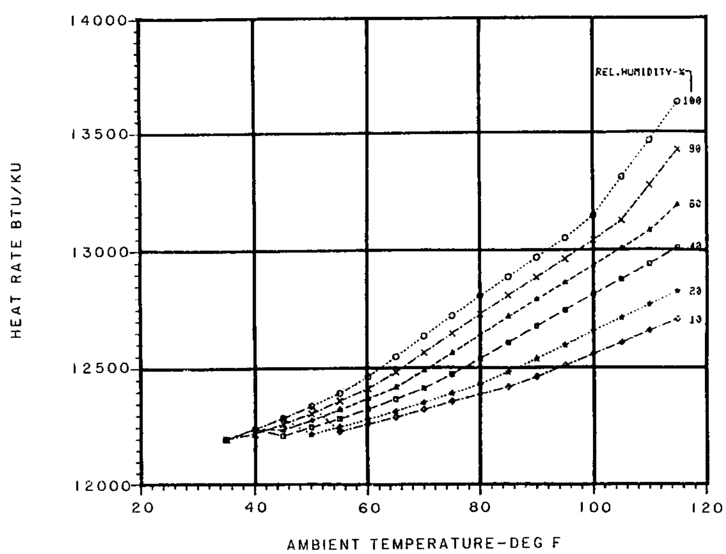

Fig. 5—Placerita I performance, water to fuel of 0.50.

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