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THE TESTING PROJECTS OF ELECTRIC POWER PRODUCTION FROM GEOTHERMAL ENERGY OF THE RADIAL-INWARD TURBINE-GENERATOR WITH NC4H10 AS WORKING FLUID

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ABSTRACT

The testing projects of binary cycles use a secondary fluid of organic nature (nc4H10) to generate power is achieved at the Xiongyue Geothermal Testing Station of Liaoning Province Research Institute Of Energy Resources PR China in 1982. nC_4H_{10} working fluid is evaporated to a temperature of 56°c, 5.75kgf/cm^2 by geothermal heat through a heat exchanger, it then expands in a turbine which drives a generator and is condensed in a condenser, releasing heat to a cooling system in which cooling water has a tempera—— of 18°c, to be finally pumped again in the evaporator. An axial flow steam turbine generator is installed in parallel in the system for comparison with each other. The designed capacity of the each generator is 100 KW. This paper detalled the testing project of the radial-inward turbine -generator. Its relative inner efficiency is 90%, and its maximum electricity-generating capacity come8 to 120kw. The available energy efficiency of the system is 37%.

INTRODUCTION

The Xingyue Geothermal Testing Station of Liaoning Province Research Institute of Energy Resources is located at the Xingyue Town which is located at middle of Liao East Peninsule in China. Deposit of geothermal reservoir is about 4000Ton/24h in the geothermal field. Geothermal reservoir is about temperature of 90° c. A Qo1-100 kw axial flow steam turbine-generator was installed in 1978, and a N52XXC-100 kw single-stage overhung radial-inward turbine -generator was installed in 1982 at the station. Both of them are parallel in the system for comparison with each other (Fig 1).

DETAILS OF THE SYSTEM

First temperature of geothermal water

$t_{R_1} = 82^0$ c

Flow of geothermal water

$G_R =$ 90Ton/h

Average first temperature of cooling water

$t_{L_1} =$ 18 c

Flow of cooling water

$G_L =$ 200Ton/h

Working fluid; nC_4H_{10}

Binary cycles use a secondary fluid of organic nature to generate power.

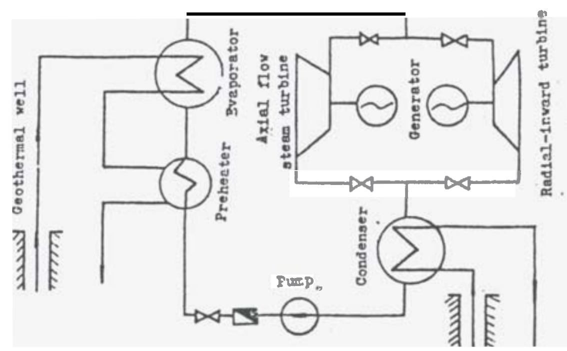

Fig 1 Heat Cycle System

DETALLS OF THE RADIAL-INWARD TURBINE-GENERATOR

lame: Single-Stage overhung Radial-Inward Condensing Steam Turbine

Type: N52XXC

Power: 100 kw

Evaporation pressure: 5.75 kgf/cm^2

Evaporation temperature: 56° c

Inlet pressure: $P_1 =$ 5.5 kgf/cm2

Inlet temperature: $t_1 = 55.5^0$ c

Inlet enthalpy $i''_{10} =$ 111.8 kcal/kg

Ideal exhaust enthalpy: $i''_{20} =$ 106.1 kcal/kg

Exhaust pressure $P_2 =$ 3.1 kgf/cm^2

Evaporation rate of working fluid:

$G_1 =$ 20.4 Ton/h = 5.67 kg/s

Steam consumption: 204 kg/kw·h

Turbine speed: $n_1 =$ 5500 RPM

Generator speed: n_2= 1500 RPM
Exhaust mode: axial-centre
Type of main inlet control valve: butterfly valve
Inside diameter of exhaust pipe: 250mm
Inside diameter of main inlet valve and inlet pipe: 200mm
Type of seal: mechanical seal
Type of speed controller: steel-band heavy-hammer centrifugal governor

TESTING CONTENT AND METHOD

Following tests are made for testing the radial inward turbine:

1. Optimum liquid level in evaporators.
2. A test of generation under optimum evaporation temperature.
3. A test of changing back pressure of turbine
4. A test of a mechanical seal.
5. A test of transfer of heat of evaporator and a condenser.
6. A test of comparing the radial-inward turbine with the axial flow steam turbine.
7. A test of output of a generator.

RESULT OF THE TEST

The curves of a ton geothermal water generating capacity changing with liquid level in the evaporators with nC4H10 as working fluid are shown in Fig 2. Result of the test indicated that both of optimum liquid level in the evaporators when a preheater is used or isn't used in the system.

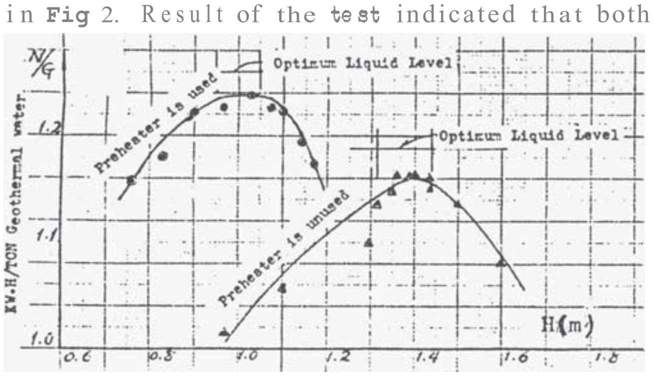

Fig 2 The Curves of Optimum Liquid Level In The Evaporators

When the preheater is used in the system, the optimum liquid level in the evaporator (h_0) is 900--1000 mm; when the preheater isn't used in the system, the optimum liquid level in the evaporators (h_0) is 1300--1400 m, the former is lower than the latter. A result of the test Indicated that changing of optimum liquid level with nC4H10 as working fluid is smaller than with F-11 as working fluid.

The testing result of the optimum liquid level in the evaporators is similar to the testing result of vertical pipe-evaporator in-pipe boiling. Through the test of optimum liquid level in the evaporators, we found that reaction of the radial-inward turbine to steam humidity is stronger than that of the axial flow steam turbine, running of the radial-inward turbine is unsteady ;load is wavering and the electric system is unsteady too. However, when liquid level in the evaporator is 2000 mm, and steam humidity is big enough, the running of the axial flow steam turbine is steady.

A testing result of generation under optimum evaporation temperature is shown in fig 3 and Fig 4.

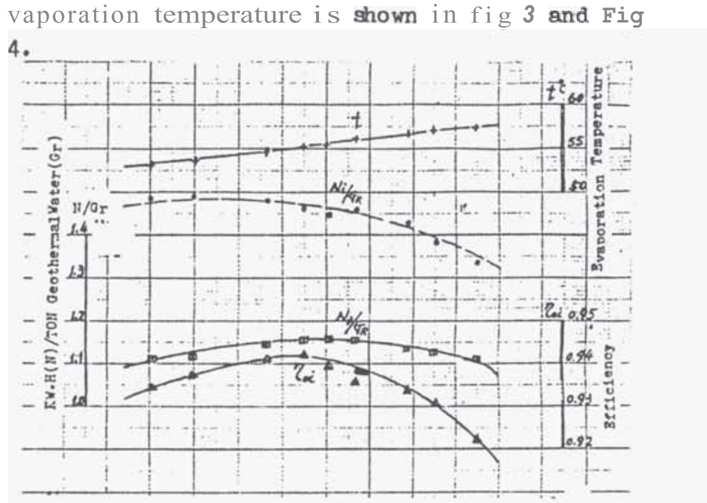

Fig 3 The Curves of A Test of Generation Under Optimum Evaporation Temperature When Preheater isn't used

A result of the test indicated, under optimum liquid level in the evaportors, design condition of cool and heat sources, when internal power, generation power and relative internal efficiency of the radial-inward turbine-generator are bigest, optimum evaporation temperature(t_1) is 57°C under used preheater (Pig 4), and that (t_2) is 55°C under unused preheater. (Fig 3). This is identical with the result of design in theory, if heat loss of from the evaporator outlet to the turbine inlet is considered.

The test result indicated obviously thatoutput

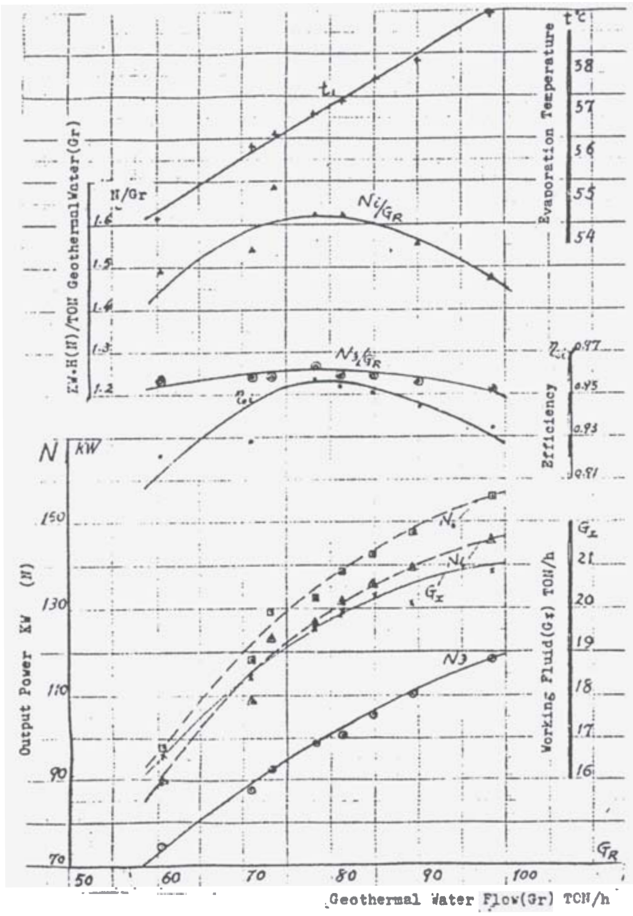

Fig 4 The Curves of a Test of Generation under Optimum Evaporation Temperature When Preheater is used

of the turbine unit followed changes in its back pressure. When its back pressure increases, its output decreases. This is indicate in Fig 5.

The test results indicated that relative internal efficiency of the radial–inward turbine has achieved ninety per cent, however under various regime, its efficiency change is small, and its efficiency always is close to optimum.

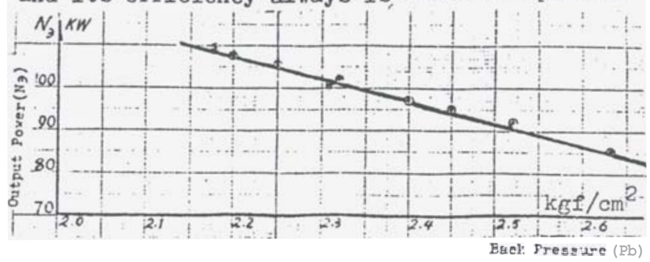

Fig 5 Changing back pressure of the turbine (preheater isn't used)

CONCLUDING REMARKS

Design of the N52XXC Single–Stage Overhung Radial–Inward Turbine is rational. This turbine is noted for its simple structure, making easy and high efficiency.

Aminimum output of the radial–inward turbine generator is 120kw, and a maximum output of it is 150kw really under the temperature, flow of geothermal water and cooling water at present, however, design output of it is 100kw.

It is successful to design and use butterfly valves which are installed in inlet steam line as a control valve and a main Stop valve. The pressure loss is mall ($0.05 kgf/cm^2$). There are performances of simple structure, reliable airtight and flexible regulating in the valve.

Testing operation indicated that the airtight performance of lines devices in the system is very good, the operation is normal, output of electric power, flow of geothermal water, cooling water and flow of working fluid are regulated easy and reliably.

The available energy efficiency of the system is 37%.