Proc 12th New Zealand Geothermal Workshop 1990

GEOTHERMAL APPLICATION FOR THE RUNNING WATER FISHERY

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ABSTRACT

The running luke-warm water fishery is an advanced technological process with smaller land, high output, convenient management and rapid cycle of breeding.

It is reported in this paper that the utilization of low-temperature geothermal water in the running water fishery provides a scientific basis for geothermal application to the programme and design of fishery by means of the living examples.

INTRODUCTION

Kunning luke-warm water fishery in high-density is one in the running luke-warm geothermal water. The output by the fishfarming is dosens of times higher than that by normal way, and even more than one hundred times. Because of its high rate of income to expenditure, the fishery has been paid close attention to over the world.

in the recent yenrs, we have made the programme, engineering design and experimental fishfarming at the running luke-warm fisnfarm of the several geothermal sites in Fujian, China. The results are successful.In this paper, we take the geothermal fishfarm in Fuchuan, Fuzhou, Fujian as an example and introduce the main method for our programme and engineering design of the fishfarm and the actual results of the experimental fishfarming, whicn can supply some valuable information for exploration and utilization of the luke-warm geothermal resources.

PROGRAMME OF FISHFARM

The aim of programme is for determing the scale of fishfarm appropriate to its geothermal resource.

1. Survey of the Natural Conditions and the Geothermal Resources.

Fuchuan is located at north altitude 25°51', east longitude 118°52' and elevation 50m. The weather belongs to subtropics, the mean annual airtemperature is 19.5°C, the mean lowest temperature of the five successive days in January is 9.6°C, the relative humidity is 762, and the mean wind velocity is 1.8m/s. .

The spilling location of geothermal water is at the cross of two rivers with the mean water temperature 20.6°C, the lowest water temperature 11.40°C in January and the highest 32.7°C in July. The flow capacity of the two rivers is 20-3000m^3/s. There are no pollutants at the upper reaches. The water quality is good and the soluable oxygen in the rivers is steady and saturated, which accords with Water Criterion for Fishery. The temperature at the spilling site is 36°C. According to the prospecting geologic information, the exploitable amount (G) of geothermal water is 7700m^3/day. The type of the water quality is HCO_3-SO_4-Na,the mineralization degree is 0.52g/l, PH is S.13, and the total water hardness is 0.35mN. Because of nonpoisonous substances, the geothermal water is fit to use directly.

2. Determination of Pool Area over Winter.

1) Heat Capacity of tne Geothermal Site

The largest heat capacity in this site is showed as below, where the optimum tezperature 18°C for fry to live through winter is taken as criterion:

$$Q = 4.19 \times G \times \Delta t$$
$$= 4.19 \times 7700 \times 10^3 \times (36-18)$$
$$= 5.81 \times 10^8 \ KJ/day$$

2) The Heat Load of the Pool over Winter

The heat load of the pool includes these heat losses: evaporation, convection, conduction and radiation. It is explained on the basis of our calculating that value of the later two items is muck smaller than that of the front two ones, in which the later ones can be neglected when we make programme ana design.

a. Heat Loss of Evaporation

Evaporative amount is calculated as following equation on the basis of the open surface of the pool:

$$H = 0.39 \ (Pm-P) \ (1+0.135 \ Vm)$$

In this equation,

H: Evaporative amount of the surface, mm/day.m^2

Pm: Saturated steam pressure in water, mmHg. Here, Pm= 15.47 mmHg.

P: Steam Pressure in air, mmHg. Here, P =6.81 mmHg.

Vm: Wind velocity on the surface, m/s. Here, Vm = 8m/s.

The calculated result : the evaporative amount in January H= 7.02 mm/day.m^2

Heat loss of evaporation:

$$Q = rH$$

In this equation, "r" is heat of vaporization, KJ/kg. Here, r = 2458 KJ/kg.

Therefore,

$$Q = 2458 \times 7.02 = 1.73 \times 10^4 \ KJ/day.m^2$$

b. Heat loss of Convection

neat loss of convectior.is defined on Newton Law:

$$Qcv = a \Delta t \tau$$

In this equation,

a = coefficient of convection heat, KJ/m^2°C.Here,

$$a = 0.00116 \ (1 + 0.3 \ Vm) = 0.00394$$ KJ/m^2°C.

Δt = temperature dirierence between waters in the pool and in the air, °C.

Here,

$$\Delta t = 18-9.6=8.4°C$$

τ: time, second. Here, =3600x24= 8.64x10^{4}S

Therefore,

$$Qcv = 0.00394 \times 8.4 \times 8.64 \times 10^4 = 2859 KJ/day.m^2$$

c. Heat Load of the Pool

Heat load=heat loss of evaporation + heat loss of convection=2.016 x 10^{4}KJ/day.m^2

d. The Allowable Area of the Winter Pool

$$\text{The area} = \frac{\text{heat capacity}}{\text{heat load}} = \frac{5.81 \times 10^8}{2.016 \times 10^4} = 28800 m^2$$

3. Determination of the Total Area of the Running-Water Pool

After mid-April, the running water pool is used for the running luke-warm water fishery in high density. The area of the pool is determined by the amount of exchangeable water. The designed water-changing capacity is a whole-pool water once an hour. The depth of the pool is 1m. When the water temperature in the river is 20.1°C in mid-April, the temperature in the running water pool must be required 25°C. Suppose, the flow of cold water is Gcm^3/h and the flow of hot water is Ghm^3/h, then:

$$Gh\ (36-25) = Gc(25-20.1)$$

$$Gc = \frac{Gh\ (36-25)}{25-20.1} = 721\ m^2/h$$

$$Gh + Gc = 1042 m^3/h$$

The area of the running water pool =

$$\frac{\text{flow capacity}}{\text{water depth}} = \frac{Gc + Gh}{1} = 1042 m^2$$

4. The Project Scale in the First Phase

According to the economic ability of the fishfarm, we first drilled two geothermal wells with 36°C and the flow 2000 m^3/day. Therefore, we can built a winter pool with area: $\frac{2000}{7700}$ x 28800 = 7480 m^2 and a running water pool with area : $\frac{2000}{7700}$ x 1042 -270 m^2. In order to use fully the water resources in summer, we built a running water pool with area 1040 m^2. The used area of the running water pool expands with the temperature rising in river and in the air.

THE ENGINEERING DESIGN IN THE FIRST PHASE OF PROJECT

1. Design of the Geothermal Well

According to the engineering programme in the first phase and the necessary water volume 2000 m^3/day, we planned to dril two productive wells with flowing capacities 50 m^3/h and 36 m^3/h. The location of the wells is near the abnormal geothermal area and at the across of the two rivers. The location is 300 metres far from the fishfarm. In order for the water-pump to lift and fall, the diameter of the well opening is 219 mm. The well-pipe goes down 200m to the bed rock. It is necessary to think over the interaction between the two wells.

2. Water-pump and Conveying-pipe System

As the water temperature in the well is not higher than 50°C, we first use a submergible pump which has some advantages of the uncomplication structure, steady function, light weight, low cost and so on. Each of the wells is installed with water pump from which the water is pumped through the general conveying pipes with diameter 150 mm and the biggest water velocity 1.4 m/s. in this way, we can cut down on investment. The pipes lay on ground and the way of heat preservation is simple and easy.

3. Cold Water Supply

Cold water can be pumped directly from the river, but the conveying by electricity is costly and its annual cost is US$ 12700. Therefore, we decided to channel water through 500 mm concrete pipeline 1000m far from a reservoir. Although the first investment is high in this way, we only spend little money annually. The electricity expenditure for one and half a year can pay the investment of the channeling engineering.

4. Running Luke-warm Water Pool

Thirty-two pools are built in rectangle with every bottom area 32.5m^2. Eight rows of them are in paralled connection and four grades of them are in series connection. Every grade drop is 60 cm. The soluable oxygen can increase in the water pool during water running from grade to grade, the height of pool is 1.4m, the gradient is 1.5/100 and the mean water depth is 1.0m.

5. Fishpond

Four fishponds are built to put the parent fishes in, breed fry and keep them living through winter. Their shapes and sizes are decided on the basis of the actual site. The total area of the ponds is 7000 m^2. The walls of ponds are built with stone and concrete. The depth of the ponds is 1.5-2.0 m. The geothennalwater leads to the ponds to keep water warm. In other times of a year, the ponds get the draining water from the running water pools and the supplies water flows into the river by the over-flowing holes.

CONSTRUCTION

Construction for the first phase of project began in October of 1988 and finished in April of 1989. According to the design and construction, the total built area is 9000 m^2, in which the area of the all running water pools is 1200 m^2, the area of the fish ponds is 6000 m^2 and the others are 1800 m^2. The total investment costs US$ 115,000.

BREEDING

Fry incubation, production and living through winter were made by us in the fishfarm. We adopted the densely-populated fishery of the running luke-warm water for 171 days from April 4 to October 25 in 1989. The detail of breeding is shown in Table 2. In the same year, we bred fry which lived through winter. Table 1 displays the monthly schedule of 1990 in which the production process is on the basis of a well-conceived plan. The densely-populated fishery in the running luke warm water for the first phase began in April 27 of 1990 and ended in July 30 of 1990. The results are illustrated in Table 2.

ANALYSIS OF ECONOMIC BENEFIT

According to the result and analysis of the two-year breeding and producing, the total annual income is US$ 115,000, the annual expenditure is US$94,500, the net annual income is US$20,500 and the rate of benefit to cost is 21.69% when we take T. Kilotica as an example. If we feed some expensnsive fishes, the net income & the rate will increase greatly. The annalysis of economic benefit is shown as Table 3.

SUMMARY AND DISCUSSION

Table 1: Monthly Production Schedule from November 1989 to October 1990

Date	1989		1990									
	11	12	1	2	3	4	5	6	7	8	9	10
Parent fishes and fry living through winter	------	------	------	------	------	------						
Fry breeding						------	------	------	------	------	------	------
Running water fish-breeding							fisst phase			second phase		

Table 2: The Running Water Fishfarming

Time	Area of the running water pools	Breeding				Results						Feed	
		varieties	size (g/tail)	total weight (kg)	mean density (kg/m²)	total weight (kg)	added weight (kg)	mean size (g/tail)	weight/unit area (kg/m²)	added weight/unit (kg/m²)	net non. increase (kg/m².mo)	kinds	coefficient
April 28 -Oct. 15 1989	520	T. Nilotica	17.7	2500	4.8	16100	13600	150	31.0	26.2	6.68	power mixed feed	3.2
April 27 -June 25 1990	325	T. Nilotica	150.0	4590	14.12	7810	3220	260	24.03	9.91	6.95		
April 27 -July 30 1990	585	T. Nilotica	43.0	2820	4.82	14650	11830	225	25.04	20.22	6.38	"	2.4
April 27 -July 30 1990	65	C. bracky-pomum	125	375	5.77	2200	1830	750	33.8	28.1	9.06	"	2.4
April 27 -July 30 1990	65	Ictalurus Puntatus	4	60	0.92	660	600	45	0.2	9.23	1.55	"	2.4

* The feed coefficient is calculated on average
Otherwise, 3000 T. Nilotica parrent fishes in the ponds have reproduced 500,000 their fry.

Table 3: Economic Analysis

Income			Expenditure				
Item	Amount (ton)	Amount of money (US$)	Item	Amount	Unit	Amount of money (US$)	Percentage (%)
Winter fry	22.5	38,200	Construction			9,800	10.37
Commodity fish	52.0	66.200	Feed	207.3	T	48.400	51.22
Fry	25.0	10,600	Fry	10.4	T	17,700	18.73
Total		115,000	Rent of land	0.9	Ha	2,100	2.22
Net annual income		20,500	Wages			2,800	2.96
Rate of benefit to cost		21.693	Electricity	72,000	KW·h	3,100	3.28
			Tax			4,300	4.55
			Interest of circulating fund			4,200	4.45
			Others			2,100	2.22
			Total			94,500	100.00

The utilization of lube-warm geothermal water for the running water fishfarming is an effective way for the exploration and utiization of heat resources with low enthalpy, which has some advantages with small land, high output and notable results in economy.

In order to reduce cost and increase income, it is very important to make a good programme and design. Because of limitation of the heat capacity supplied by luke-warm geothermal water, it is appropriate to adopt a two-period method with fry living through winter and fishfarming in high density in running luke-warm water. The pool scale must be decided on the basis of the largest heat capacity provided by geothermal energy and the capacity can be calculated by means of heat balance. According to the natural and the geothermal water temperatures, scale of the running water pool can be calculated by means of water-exchanging rate. In order for the full use of the natural water in summer, the area of running-water pool can be four times of the calculated area.

Feed amount is very large and its cost is 50% of the total expenditure in the running luke-warm water fishery. We should try the best to build our feed factory and fully use the local agricultural by-products to produce mixed feeds in order for reduction of total cost and increase of economic benefit.

The way of our programme and design is especially fit for the use of luke-warm geothermal water for the high-density fishfarming In this way, the net monthly increase in one cubic metre of water is 4-9kg. It has been used at three different geothermal sites in Fujian.

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