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THE STUDY AND BENEFIT ANALYSIS ON THE WAY OF ANTICORROSION/SCALING OF THE GEOTHERMAL WATER OF A MEDIUM OR LOW TEMPERATURE

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ABSTRACT

This paper reports the research result of a national key project. The geothermal water is a water resource with relatively high temperature and hence with very high utilization value. But its high salinity and complicated composition causes corrosion and scaling in the utilization system to a varying extent, that obstructs exploitation and utilization of the geothermal resource. This paper expounds the character of the geothermal water, analyses the mechanism of corrosion and scaling, and describes the experimental research carried out for prevention of corrosion and scaling caused by the geothermal water of a medium or low temperature. The experimental results show that with an anti-corrosion/scaling water treatment procedure the geothermal water can be directly introduced into the utilization system for a very high utilization rate of the geothermal energy. The average corrosion rate of carbon steel by the treated geothermal water is only 0.02mm/a compared with 0.78mm/a by the untreated water. No scaling is found in the system. The treatment procedure is simple. Neither environmental pollution nor heat loss is caused. The cost of the treatment is lower than that for the city tap water. This treatment method is proven to be effective on eliminating both corrosion and scaling resulted from the geothermal water.

INTRODUCTION

Geothermal water is a special resources with multifunction which combines heat, water and mineral resources. It has a very high benefit and is watched attentively by the world. The same as many countries in the world, China possesses with very abundant geothermal water resources. Except that Xizang and Yunnan have high temperature geothermal reservoirs, at present most of them developed and utilized by most part of our country are low or medium temperature geothermal resources under 150°C. For example, according to the situation of exploration, there are six layers of low or medium temperature geothermal reservoirs underneath the city Tianjin P.R. China, which are quite considerable reserve, with a water temperature of 50-98°C. Cover strata thermal reservoir of 500 meters depth geothermal water had been extracted in Tianjin in the sixties with a temperature of 30-50°C. The type of water chemical compound is HCO_3^{-}-Cl^{-}-Na^{+}, its hardness<2 Germany hardness. The water is used directly as process water of textile, printing and dyeing, carpet production, so to substitute the normal energy and water sources, to improve the environment, and raise the quality of products.

In order to raise the level of resources utilization and according to the nature state of geothermal water, the requirements for heat consumption temperature zone and water qualities are different for the heat consumers, China composed a flow sheet of comprehensive utilization of geothermal water since seventies which is between the outlet of geothermal well to the water discharge. The required temperature of the first heat consumption zone is 60-98°C, it can be used as space heating of residence rooms or green house of the farmers, geothermal heating and ventilation, tea drying, drying of agricultural by-products. According to the requirement of water quality, geothermal water of first heat consumption zone can be used for hot spring recuperation, and/or making drinkable mineral water. Its tail water can be flowed into the second heat consumption zone with a temperature of 20-60°C, it can be used as process water for textile, printing and dyeing, paper making, leather, timber processing, plating etc. productions. And it can be used also for the cultivation of edible bacteria, seed drying, hatch chickens, fry survive the winter, aquaculture, agricultural cultivation etc. Thus it can reach the aim of comprehensive utilization of geothermal water. Besides, from the point of view of economics, due to the cost of the well drilling exploitation is expensive, in the exploitation of low or medium temperature geothermal water it should develop as much as possible the benefit of it's heat, water and mineral resources. It can be widely applied only when it is more competitive than normal energy. Evidently, the prerequisite of realizing this aim is letting the geothermal water flows directly into utilization system, so to raise the rate of comprehensive utilization of geothermal water as heat, water and mineral resources.

But because of the nature of geothermal water itself, in course of utilization it will produce corrosion and scaling problems, how to clear away these obstacles will be the key problem of whether the geothermal water can be utilized and developed reasonably or not. After three years of field experimental studies, the paper provides an ideal approach not only economic reasonable but also satisfying the environmental requirements to solve this problem.

THE OBSTACLES OF DEVELOPMENT AND UTILIZATION OF GEOTHERMAL WATER AND THE ANALYSIS OF THE APPROACH OF SOLUTION

The formation of geothermal water determines that it has high temperature, contains of many chemical compositions and considerably high in TDS, such as the TDS of thermal well 28 of ordovician geothermal reservoir in Tianjin even high up to 4710ppm. The major compositions of water qualities are shown in Table 1.

Table 1 Major chemical compositions of some geothermal water in Tianjin (mg/kg)

	thermal 3	thermal 28	Gand 6
Temp. °C	59.0	57.0	64.0
pH	8.12	7.87	8.35
Cl^-	849.0	895.1	568.4
SO_4^{2-}	2071.5	2101.3	134.5
CO_2^{2-}	16.2	15.4	14.8
HCO_3^-	192.2	201.4	532.7
Na^+	760.0	780.0	620.0
Ca^{2+}	50.6	560.0	12.2
Mg^{2+}	88.2	101.0	0.6
SiO_2	32.1	31.2	40.0
TDS (ppm)	4536.0	4710.0	1936.0
Total Hardness German Degree	91.13	101.73	1.82

If that geothermal water enters directly into the utilization system without treatment, the system will cause serious corrosion and scaling problems by the corrosive ion and scaling ion in the water. For example, utilization system of Tianjin thermal well 28 has appeared erosion-corrosion on the water transmission steel pipe after one year of service, the gate plate of valve has been broken and unusable after 9 months of operation, and white foam scales appeared on the leakage points of the pipeline.

Geothermal water in different geothermal reservoir, the state and level of damage in the system are totally different as the chemical compositions and thermal physic properties of them and the characters of utilization systems are different etc.. For example, Zhen well No.4 in Sinian period geothermal reservoir in Tianjin, its one inch geothermal water transmission pipes have been totally blocked only after two years of operation etc.. These problems are the serious obstacles in the development and utilization of geothermal resources. In the design of geothermal utilization system, in order to reach the aim of directly utilizing the geothermal water, the obstacles must be cleared away. Of course, there are many ways of treating the fluids which corrode and scale the vessels or systems. But how to take appropriate steps according to existing circumstances that the covering area of geothermal utilization system is large, no heat lose and no pressure drop in the course of treatment is required, keeping the functions of heat-transfer, mass-transfer and energy-transfer of the system, to satisfy the requirement of technically and economically reasonable and measures of anticorrsion and antiscaling meeting the requirement of environmental protection etc. are the crux of the matter. This is a complex technical research involving engineering thermophysics and utilization of energy resources, material sciences, geological sciences, chemical engineering and water treatment etc.

Tianjin Tanggu district belongs to Guantao formation geothermal reservoir, its water temperature is 74°C, capacity of single well is $160m^3/hr$ of water, total heat supply area of 4 wells is $240,000m^3$, 8 sets of titanium plate type heat exchanger is adopted in the system, the utilization system process chart is shown in figure 1, although the comprehensive utilization process is adopted in that process it is comparatively reasonable, but because of the price of titanium plate is expensive, it is difficult to compensate the investment benefit getting from low or medium temperature geothermal water, hence from the economic point of view, it has no competitive power. Based upon the above mentioned knowledges, using modern water treatment technology to inhibit corrosion and scaling of geothermal water at the same time is a most ideal and realistic approach, it is the view point of this paper, thus, not only it can satisfy the above requirements but also the geothermal water is treated by that way, so any equipments, valves and instruments of the whole system when contact with the geothermal medium are protected. This is the point that is beyond comparision by any other anti-corrosion and

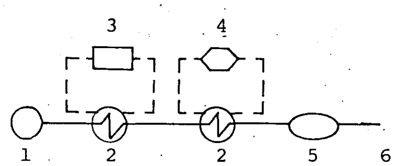

Figure 1. Comprehensive utilization system of Tianjin Tanggu living district

1. geothermal well; 2. titanium plate type heat exchanger; 3. space heating system; 4. indoor hot water supply system; 5. bathroom; 6. discharge into sewer.

antiscaling measures. This approach that acts as the pretreatment measure of comprechenive utilization of low or medium temperature geothermal resources is extremely ideal.

EXPERIMENTAL STUDIES OF GEOTHERMAL WATER SCALING AND SCALING INHIBITION BY MAGNETIZATION

The informations of the quality of water show that geothermal water contains several tens elements, they exist mainly in ionic compound state, either in ion state or in complex ion state, as a result of complex compound may increase greatly the solubility and stability of elements in geothermal liquid, therefore raising their moving ability. All of the geothermal utilization system can be looked upon as a chemical equilibrium system, in this system, the internal factors of scale formation of geothermal water are its complicated chemical compositions and its saturation state under the conditions of geothermal reservoir, but in the course of operation of geothermal fluid, temperature, pressure, its chemical compositions and concentration, pH value and the change of fluidization etc. are the external conditions of its scale formation, consequently, control of the external conditions is the basic point of searching the ways of antiscaling.

All substances in the world possess magnet but different in magnitude. It is well known that magnetic effect has been utilized in production and living such as electrcity, electronic, energy, message etc. modern industries, in some water treatment system, it appears a good magnetic anti-scaling effect too, according to the reports of literatures, authors consider that magnetic antiscaling is a result of internal energy change in water solution due to magnetic effect. In consideration of that strong and weak magnetic substances are uniform distributed in geothermal water, and under the action of external magnetic-field, they produce the action of strengthened magnetic-field due to magnetization, so the better magnetic anti-scaling can be gotten in the geothermal water. In order to prove the above-mentioned facts, an agricultural green house geothermal water indirect space heating system of thermal well 3 which belongs to Tianjin ordovician geothermal reservoir was selected to carry out a parallel contrast test for the effect of productive magnetization action. The scheme of the system is shown in Figure 2.

The capacity of thermal 3 well water is 38m³/hr., water temperature of well head is 59°C, heat supply area is 4500m², compositions of geothermal water are shown in Table 1, space heating hours per year is 2,880. In the experimental system, 4 sets of Austenite stainless steel plate type heat exchanger acted also as monitorial system for corrosion and scaling monitoring. An external magnetic antiscaler was installed at geothermal water inlet of heat exchanger 3C, as shown in Figure 2, the other three sets of heat exchanger 3A, 3B, 3D weren't installed with antiscaler. Experiment was started

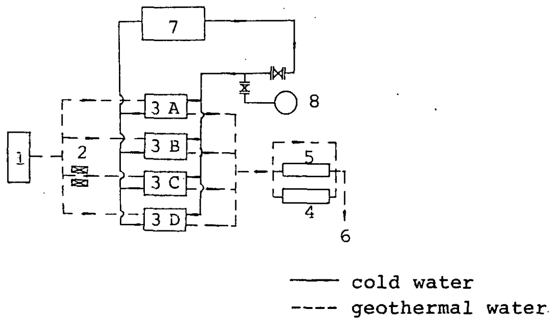

Figure 2. Thermal well 3 geothermal green house indirect heat supply system scheme

1. geothermal well; 2. magnetization equipment; 3. stainless steel plate type heat exchanger; 4. bath room; 5. fish pond; 6. discharge into sewer; 7. geothermal green house; 8. cold well.

in November 1984, heat exchanger was dismounted for measurement after 190 days of testing, only a very thin layer of soft scale was found at the surface of plates of heat exchanger 3C, the scales were rubbed off easily by soft cloth, the brightness of plate surface still remained; plate surface scales of the other three heat exchangers are hard, the colour of scale layer are brown-red, it attach closely on the surface of plates, the thickness of scale layer various from 0.35 to 0.66mm, it can be removed only by using scale removal clean-up agent, it is found by test, the major composition of its scale is Carbonate. The comparative figure of magnetic scale removal effects of heat exchanger plates is shown in Figure 3. The scale removal effects were stable after continuous operation of the system. By observations, it is no matter whether the Austenite stainless steel type heat exchanger installed with magnetic scale inhibitor or not, all plate surfaces were corrosive perporated. State of point corrosion of Austenite stainless steel in the medium of high chloride ions content is shown in Figure 4.

Conclusions of experiment are:

1. Magnetic scale removal effect is evident when the scale compositions of geothermal water contains mainly Carbonate.

2. Magnetic-field has no anti-corrosion effect to geothermal water.

3. The chemical compositions of geothermal water have no evident changes through magnetic-field.

4. Magnetic scale removal equipment is simple, its primary investment is small, the treatment cost is only 0.015yuan/ton of water (price in 1984).

5. There are no heat loss, no pressure drop, no environmental pollution in the course of magnetic scale removal.

Evidently, for scaling type geothermal water, if the compositions of scale are suitable, a selection of magnetization treatment process for water quality treatment is the best approach, and so the geothermal water can be entered directly into the utilization system and its comprehensive benefit should be very high.

CORROSION BEHAVIOR OF METAL IN GEOTHERMAL MEDIUM AND RESEARCH ON COMPREHENSIVE TREATMENT FOR ANTI-CORROSION/SCALING BY WAY OF CHEMICAL INHIBITION

Both corrosion and scaling geothermal water are often found in low or medium temperature geothermal water, how to select a technical and economic feasible way to eliminate both corrosion and scaling is very important.

According to the observation in practical application, the course of corrosion of metallic materials in geothermal medium belongs to the mechanism of electrochemical corrosion, the state of damage is appeared as totally uniform corrosion.

Following the development of water treatment technology and the appearance of various kinds of new type water treatment agents in recent years, and according to the water qualities, water temperature and the situation of thermal energy utilization requirements of low or medium geothermal water, the adoption of chemical inhibition process has been decided. A layer of adhesive protective film has been formed on the metallic surface and the velocity of metallic corrosion has been reduced after adding the corrosion delay agent into the gothermal water, in order to maintain the scaling substance in water into dispersive state or forming chelate ions, scale inhibilitor was added into water so to stabilize the scaling substance not to scale. Thus, not only the aim of direct utilization of geothermal water can be reached but also the superiority of comprehensive treatment of both anticorrosion/scaling of geothermal water can be embodied. The crux of the matter is that whether a formalation which is not only technical and economic reasonable but also satisfying the environmental requirement, can be selected or not, hence, a field test was taken at thermal well 28, which belongs to Tianjin Ordovician system geothermal reservoir whose water quality compositions see Table 1, to study the feasibilitiy of the chemical inhibition process.

Carbon steel is selected as testing material. The test divides into three stages, the first stage is the static simulating test which aims at selecting a formulation. Its facilities are shown in Figure 5. Second stage is the field dynamic simulating test aimed at checking and adjusting formulation. Figure 6 is the facilities schematic diagram. Third stage is the formal commission test, in the parallel contrast test, it involves with and without chemical adding, and repeatability test is adopted, to measure separately the uniform corrosion rate and the thickness of scale layer of carbon steel test pieces so to evaluate the level of corrosion and scaling.

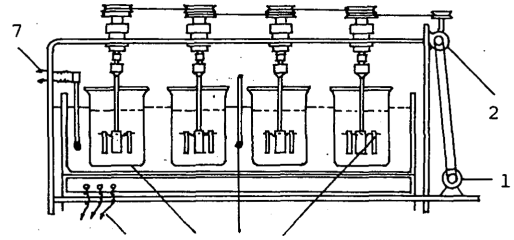

Figure 5 Static simulating test facilities scheme

1. motor; 2. speed reducer; 3. carbon steel test piece; 4. test cup; 5. thermalmeter; 6. input for power supply; 7. thermostat.

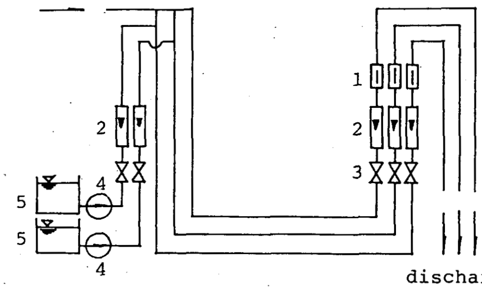

Figure 6 Field dynamic simulating test facilities scheme

1. the tube with test piece; 2. rotameter; 3. regulating valve; 4. metering pump; 5. chemicals melting box.

In the test, a complex formulation, which was a compound of cathodic type corrosion delay agent and anti-scaling agent which was able to disperse chelation, was selected, and in the test, attention was paid to fully utilize the action of cooperation and raise the efficiency of chemicals, therefore, an ideal effect through of comprehensive treatment on anticorrosion/scaling of low or medium temperature geothermal water has been obtained.

According to the static simulation test, a formulation named "31A6C" was selected from 300 more formulations. Testing data of test round 282 are shown in Table 2. No scale, no corrosion products and a metallic brightness yellow plating film appeared on the surface of test piece no.22 which corresponding to formulation "31A6C". Its uniform corrosion rate CR=0.0327mm/a. While in the same test round, test piece no.25 is the one without chemicals adding, the test piece increases a thickness of 0.12mm by its surface scaling and corrosion products. Uniform corrosion rate of its CR=0.7267mm/a. The appearance of test pieces of that round are shown in figure 7.

In order to check the reliability of formulation "31A6C", a static simulating repeatable test, test round 302 was carried out. Its testing data are shown in Table 3. The corresponding test pieces of formulation "31A6C" are 39#, 40#, 41#. No scale and no corrosion products on the surface of these test pieces and with metallic brightness yellow film appeared on it. Their average uniform corrosion rate CR=0.0318±0.0018mm/a. Test piece 42# is the one without chemicals adding, its uniform corrosion rate CR=0.6088mm/a. The appearance of test pieces in that test round are shown in figure 8. The effect of several repeatable tests following are very stable.

Table 2 Formulation selecting test, test round 282

No. of test piece	formulation	W_1 (g)	W_2 (g)	W (g)	CR mm/a
20	31A2C	20.0242	20.0085	0.0157	0.0857
21	31A4C	19.9959	19.9863	0.0096	0.0524
22	31A6C	20.0149	20.0089	0.0060	0.0327
23	31A8C	20.1060	20.0979	0.0081	0.0442
24	31H2C	19.9769	19.9125	0.0614	0.3516
25	without adding	19.9982	19.8651	0.1331	0.7267

Table 3 Repeatable test test round 302

No. of test piece	formulation	W_1 (g)	W_2 (g)	W (g)	CR mm/a
31	3BA2C	20.1996	20.1689	0.0307	0.1682
32	3BA2C	19.8302	19.7994	0.0308	0.1687
33	3BA2C	20.1349	20.1039	0.0310	0.1699
34	31Ab	20.0234	20.0100	0.0134	0.0734
35	31Ab	20.1537	20.1413	0.0124	0.0679
36	31Ab	19.8732	19.8615	0.0117	0.0641
37	31H2C	20.0115	19.9870	0.0245	0.1343
38	31H2C	19.6901	19.6556	0.0345	0.1891
39	31A6C	20.2422	20.2361	0.0061	0.0334
40	31A6C	20.2029	20.1974	0.0005	0.0302
41	31A6C	20.1338	20.1280	0.0058	0.0318
42	without	20.0304	19.9193	0.1111	0.6088
1091	adding	13.2190	13.1324	0.1166	0.6755
25	"	19.9982	19.9128	0.1331	0.7267

Note: W_1: weight before test;
W_2: weight after removal of scaling;
W: weight loss $W = W_1 - W_2$;
CR = C x [W?(A·t·d)]mm/a;
C : calculating constant $C = 8.76 \times 10^4$;
t : test time t = 71hr;
A : surface area of test piece $A = 28.59cm^2$;
d : density of carbon steel $d = 7.86g/cm^3$.

Therefore, field dynamic smulating test was carried out for formulation "31A6C". Testing facilities scheme is shown in figure 6. Through field adjustment of formulations, the test results were: after adding chemicals, the surface of carbon steel test pieces were clean with no scale, no corrosive products, it appeared a yellow metallic brightness film which protected the metallic materials and lowered the velocity of corrosion. The corrosion rate is 0.02mm/a, but without chemicals adding under the same conditions is 0.78mm/a, and the surface of test pieces increase a thickness of 1.8mm by the mixture of scale and corrosive products. By field dynamic simulating test, it proves that the effect of formulation "31A6C" is excellent and stable. The cost of chemicals was 0.109 yuan/ton water, while the industrial water commodity price was 0.35 yuan/ton water. This treatment procedure is simple, no pressure drop and no temperature loss, and Evironmental Sanitation and Sanitation Engineering Research Center of China Preventive Medical Academy of Science authenticated that this chemical formulation as no texic and no environmental pollution by a toxic test. It showed that this is a feasible and ideal approach to solve the anticorrosion and antiscaling problems of low or medium temperature geothermal water.

Using this research result, an anticorrosion/scaling comprechensive treatment technology promoted application test was carried out at Gang 6 well gesthermal water space heating system of Tianjin Dagang district which blongs to Tianjin Basis Rock Lung-Shan Formation geothermal reservior in October 1989. The major compositions of the water were shown in Table 1. There are two geothermal wells in the system, total water output $140m^3/hr$, water temperature 64°C.

Corrosion to the system by that geothermal water were very serious. Valves and indoor water tap of the system started to leak only after one month of operation without treatment, and erosive corrosion appeared on the steel pipes. In order to solve this problem, three rounds of test pieces hanging parallel contrast test were carried out, from October to December 1989 in the field production system, and the chemical formulation named "G6-2" was determined. The experimental facilities scheme is shown in Figure 6. The hanging test pieces tube with rotameter installed under it in Figure 6 are shown in Figure 9. In Figure 9, there are three parallel operated branch pipes, the flow of geothermal water of each branchpipe is controled by rotameter. The chemical adding of this is continuous. In these three branch pipes: on the right side-1, formulation"G6-2" is added in, the hanging test piece is 1#, in the middle-2, the amount of chemical adding is half of the formulation "G6-2", whose hanging test piece is 2#. On the left side-3, whose hanging test piece is 3#, without chemical adding. After test, the appearence of test pieces 1, 2, 3 are shown in figure 10. The operational results of Gang 6 second round are: test piece 1#: after adding chemicals, the surface of carbon steel test piece is clean, no scale, no corrosive products, and appears with blue mettalic brightness plating film, tight and bright, CR=0.0090mm/a, its tube walls are clear and transparent, the test pieces and float in it are distinctly visible. Test piece 2#: after adding chemicals, the surface of test piece is clean, no scale, no corrosion products, and appears with blue mettalic brightness plating film, but thinner film CR=0.0145mm/a ,its tube wall cover with balck thin film, the test pieces and float in it are indistinctly visible. Test piece 3#: without adding, surface cover with red scale and corrosion product CR=0.5920mm/a, its tube wall cover with thicker brown red scale and corrosive products, no way to see the test pieces and float in it. Test piece 0 in figure 10, without adding and exposed to the leakage point of space heating system, its corrosion state becomes more and more serious.

This experimental research is successful. Formal commission has been started now. As a result of the space heating system utilizing geothermal water, coal consumption per annum decreases from 15,000 tons to 7,000 tons, i.e. coal saving per year is nearly half the total consumption.

Summarising the aforesaid points and through the field test and production practice it proves that this approach is technically and economiclly reasonable and meeting the requirements of environmental protection. It is the best approach to reach the aim of comprehensive utilization of low enthalpy geothermal energy by comprehensive treatment of corrosion and scaling problems of low of medium temperature geothermal water.

ECONOMIC ANALYSIS

A comparison of two schemes which are either with chemicals adding (scheme A) or without chemicals adding treatment (scheme B) to solve the corrosion and scaling problems for a space heating system using geothermal water of geothermal well 28. The common deman of both schemes A & B are ensuring the safety operation of the system. The expenses of scheme A include chemicals cost and operational cost for chemical adding besides the construction investment.The increasing of expenses will prolong the service life of the system. In comparison with scheme B and on the common counting period, it decreases relatively the total construction investment. Owing to this space heating system is the utility service system, no products producing from the system, so the sppraisal of the economic effect of these two schemes considers only the investment of the project and normal operation cost. Because of the service life of these two schemes are different, and in order that there is a common time base for schemes comparation, therefore, it takes the maximum service life of these two schemes as the common counting base.

1. According to the calculation formula of pipe wall thickness, and a consideration of negative deviation and corrosion allowance of pipe wall thickness, the additional allowance of pipe wall thickness is 1mm, and according to the system adding with chemicals, the corrosion rate of steel pipe CR=0.02mm/a, then the service life of this system is 1/0.02=50 years, without chemical adding, corrosion rate of steel pipe CR=0.78mm/a, the service life of the system is 1/0.78=1.282 years, taking 50 years as the common calculation base.

2. According to the price in 1984, total construction investment of the space heating system was 140,000 yuan. Hence, the total construction investment of scheme B in the counting period was

140,000 x 50/1.282 = 5,460,000yuan

while scheme A was 140,000 yuan.

3. The water outlet of single geothermal well of the system is 50m^3/hr, space heating hours per year is 2,880 hours, chemical cost of formulation "31A6C" was 0.109 yuan/ton water (1984 price). So the total expenses of chemical cost in the counting period was 0.109x50x2880x50 = 784,800 yuan.

4. The primary investment of chemical adding facilities of the system is 10,000 yuan. Taking ten years as service life of chemical adding equipment, maintenance expenses of chemical adding is 10% of the primary investment, regular operation expenses is 10% of primary investment, then, in the counting period. Total expenses of chemical adding equipment primary investment, maintenance and normal regular operation are

10,000 x 1.2 x 50/10 = 60,000yuan

Finally, the economic comparison of schemes A & B of this space heating system are shown in Table 4.

In the counting period, the cost of scheme B is 5460.0-984.8=4475.2x10^3 yuan more than scheme A. In 50 years, the fund can be used

Table 4 Economic comparison of schemes with and without chemical adding of thermal well 28 geothermal space heating system

Item	Service life (year)	Total investment in the counting period (1,000 yuan)			
		construction investment	chemical cost	chemical adding operational expenses	Total investment
Scheme A	50	140	784.8	60.0	984.8
Scheme B	1.282	5,460	/	/	5,460

to build a same system which greenhouse space heating including chemical adding facilities and operational cost 4475.2/984.8=4.6 sets. It means that one more set of agricultural greenhouse space heating system can be built in about 11 years, as well as decreases the maintenance work and steel consumption in the system of scheme B. It shows that scheme A with chemical adding to protect the system is the feasble scheme.

CONCLUSION

1. Geothermal water resources is a special mineral resources with multifunctions. The goethermal water comprehensive direct utilization program shall be arranged according to the zone of heat consumption and the requirements of water quality, so to develop fully the special functions of thermal, water and mineral resources, especially for low or medium temperature geothermal field, only in this way, it might have more competitive power than the utilization of other energy sources.

2. Due to its formation, geothermal water possess not only high temperature but also many chemical compositions and higher total dissolved solids, corrosive ions and scaling ions in them, they very often produce serious corrosion and scaling problems to the system and becoming serious obstruction for the deveopment and utilization of geothermal resources. In the design of geothermal utilization system, these obstruction must be removed, then it might reach the aim of direct utilization.

3. In accordance with the formation of geothermal water and the properties of the utilization system, crucial technology of this experimental research lies on the ways of inhibition of corrosion and scaling of geothermal water in the system by modern water treatment technologies including physical and chemical processes, the geothermal water can be entered into the system after treatment. It proves that the effects of this anti-corrosion and antiscaling process are evident by large amount of experiments and production practices. In the course of treatment, heat loss is small, no toxicity, no environmental pollution, low in primary investment and operation cost. It is the best way of controlling anti-corosion, antiscaling for low or medium temperature geothermal water, and to raise the level of geothermal resources utilization is of great promotive values.

4. For the geothermal water whose scale substances contains mainly carbonate, magnetic antiscaling process is the most ideal process. Its treatment cost is much lower than the price of city water supply.

5. Using chemical inhibition process to treat geothermal water which produces corrosion and scaling, it can obtain the ideal effect of comprehensive treatment for anti-corrosion and antiscaling of geothermal water, uniform corrosion rate of carbon steel is less than 0.02mm/a. Treatment cost is lower than the price of city water supply.

6. Due to the water chemical type of geothermal water and its corrosion and scaling harmful type and level to the system in various geothermal well are different, the treatment countermeasure are different too. This paper considers that base upon the above mentioned researches and through large amount of experiments to search for common charater, the regularity research for corrosion and scaling and its control countermeasure shall be carring out, and according to the crucial indexes, the obstruction control countermeasure program of low or medium temperature geothermal water shall be compiling to instruct the development and utilization of it.

7. The research demonstructes that the method of parallel contrust test adopted for static simulating test, dynamic simulating test and formul commission test is feasible, and its treatment results can be promptly and quntitively evaluated. This paper holds that this method of test can be used in anticorrosion and antiscaling treatment for geothermal water with low temperature.

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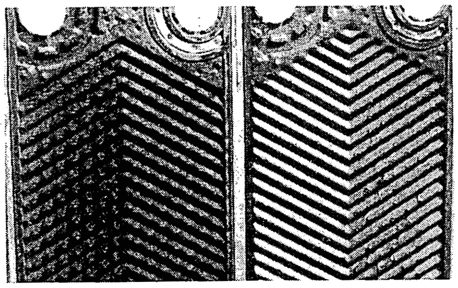


Figure 3 Heat exchanger plate sheet magnetization anti-scaling effect contrast figure
Left: without magnetization scale-inhibitor
Right: with magnetization scale-inhibitor

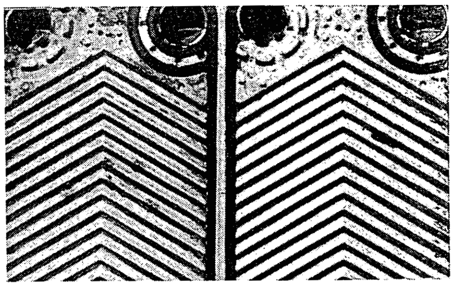
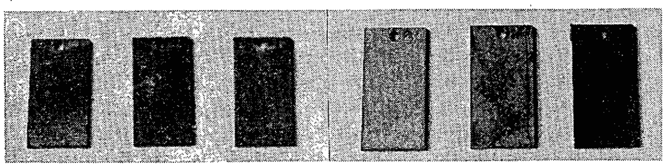
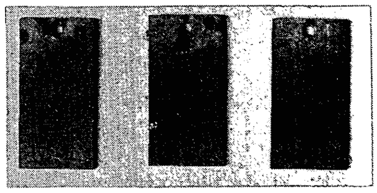


Figure 4 The state of plate sheet corrosive perforated after 4 months of operation for Austenite stainless steel type heat exchanger

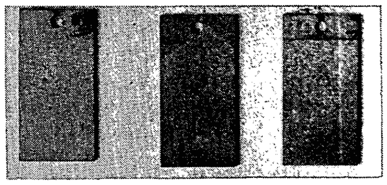


20 21 22 23 24 25

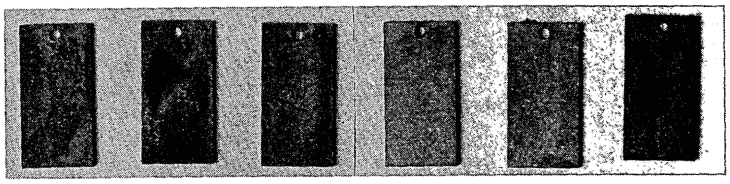
Figure 7 Appearance of test pieces in test round 282. Static simulating formulation selecting test



31 32 33

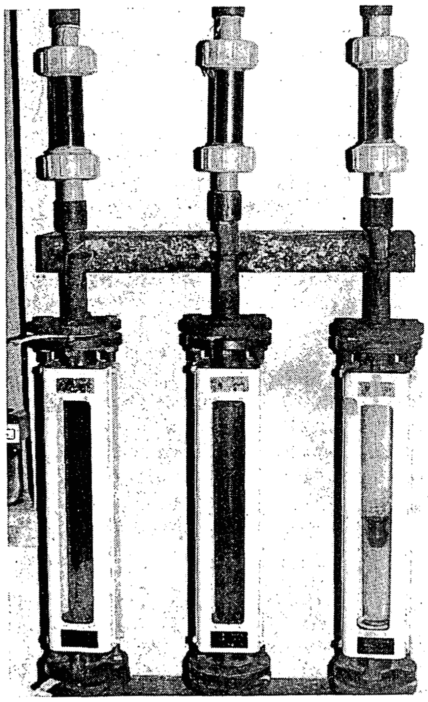


34 35 36



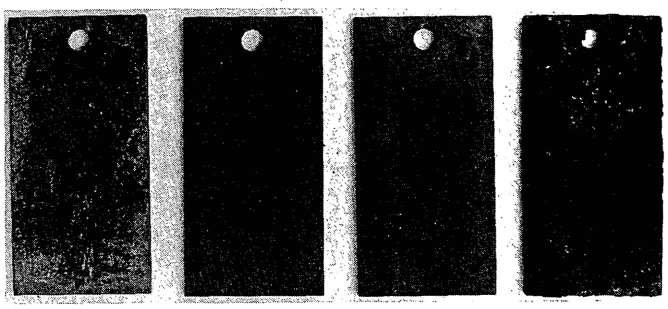
37 38 39 40 41 42

Figure 8 Appearance of test pieces in test round 302. Static simulating repeatability test



3 2 1

Figure 9 Testing facilities picture of Gang 6 well anticorrosion/scaling test



3 2 1 0

Figure 10 Appearance of test pieces in Gang 6 geothermal well dynamic simulating parallel contrast test