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ONE YEAR EXPERIENCE WITH PORTABLE BACK-PRESSURE TURBINES IN LOS AZUFRES

Gerardo Hiriart L.

Comisión Federal de Electricidad
Dr. Salvador González Herrejón No. 52
Morelia, MEXICO 58020

ABSTRACT

This paper contains the experience gained after one year operating five 5 MW portable, back-pressure, geothermal power plants at Los Azufres. A brief description of the field and the equipment is given. Cost figures of the whole installation and a list of what we believe are the advantanges and disadvantages is also presented. The main conclusion is that the use of this type of turbogenerators is quite atractive in new undeveloped fields and also in countries with financial problems where initial capital cost investments must be kept as low as possible at the expenses of long term steam consumption.

INTRODUCTION

At the Los Azufres geothermal field, five wellhead turbogenerators were installed one year ago. The reasons in choosing back-pressure turbines were to have portable units in order to test this new field and to have the ability to move then to an other well in case of severe changes in the well conditions. The economical analysis showed that the investment (in turbogenerators only) could be completly recovered after three years of generation. That is, if one looks at the turbogenerators as tools for field testing, they pay off in three years. One should keep in mind that Los Azufres is 2,800 m over sea level, wich implies an atmospheric pressure of 0.7 atm.

In this paper the main characteristics of the field and of the equipment are presented; some idea about the cost and our opinion regarding the pros and counter of this type of installations is given. Finally a brief description of some of the problemas found at Los Azufres is presented.

THE FIELD

The Los Azufres geothermal field is located in central México over the Neovolcanic belt, one hour drive from the city of Morelia (Fig. 1) - so far, 40 wells have been drilled. It is dificult to split them in exploratory and production wells. Enough is to say that ten have zero production or were abandoned during construction because of drilling problems. Six are very good inyection wells (more than 150 Ton/h acceptance) and the rest can be considered as " Producing wells " with an average of 50 (Ton/h) of steam at a separation pressure of 1 MPa. In the northern part of the field the mixture at separation conditions is half steam-half water, with 1 to 2 % of gas by weight and the wells are 1,500 m deep on the average. In the southern part, known as Tejamaniles, most of the wells produce dry (even superheated) steam with a gas content that goes fron 1 up to 25 % by weight; they are 800 m deep on the average.

Three of the 5 MW portable power plants are located (see Fig. 2) in the northern part, using saturated steam and two in the south-zone using superheated steam.

THE PLANTS

Each group is composed, as shown in Fig. 3, of a Weber-type steam water separator (soft in the superheated zone), one spherical valve, one spherical valve one chevron-type deshumidificator, a steam filter, two control valves, the Mitsubishi turbogenerator, a silencer on -

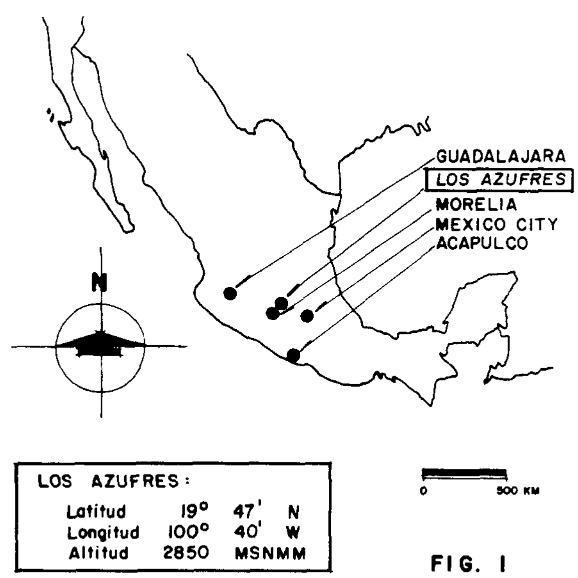

FIG. I

top of the power house and a transformer.

The turbine is a five impulse stages, 3,600 -- rpm directly coupled to a 4,160 v syncronous - generator. The oil and the generator are air cooled. Inlet steam pressure 0.8 MPa, exhaust to the atmosphere at 70 KPa. Total saturated steam comsuption 60 Ton/h.

To start up the turbine no external source of electricity nor water is needed. For lubrication, an auxiliary Geothermal small turbine - is used. During operation no personnel is -- needed, in case of tripping a bell rings at a central station located at the headquarters - at Los Azufres.

Then main equipment is mounted over squids, - the time for setup in the field is about 10 - days. The teaviest piece is about 60 tons. - No alignement in the field is needed.

The five units are running since August 1982. In this particular case the time from the day the order was placed to the day of delivery - was 9 month. Parallel to that it took three month to prepare the platforms and to build - the foundations and the electrical ground --- grid. The time for instalation, tests and -- startup was 1 month per engine.

THE COST

In a country like México there is a great difference between import and domestic equip--- ment and labor wich makes the economical analysis difficult to extrapolate to other coun-- tries. Any way, translating the figures to - 1983, those prices and its percentual weight become as shown in the following table:

COST OF THE 5 MW PLANT

Turbogenerator	61.0 %
Transformer	3.8 %
Mechanical Equipment ...	8.0 %
Electrical Equipment ...	6.3 %
Civil works	2.4 %
Egineering & design	2.5 %
Assembly	16.0 %
T O T A L	100. 00 %

Cost (1983 prices) 350 U$/KW

COST OF THE WELLS (1500 M AVE)

Drilling	44.3 %
Platform	1.3 %
Accesories	7.0 %
Cementation	6.3 %
Casing	41.1 %
T O T A L	100. %

Average production per well 70 (Ton/h) (*)

well cost (1983) U$ 1 850 000
Specific cost of the well 370 U$/KW

TOTAL COST AT LOS AZUFRES 720 U$/KW
* not including wells that didnot produce

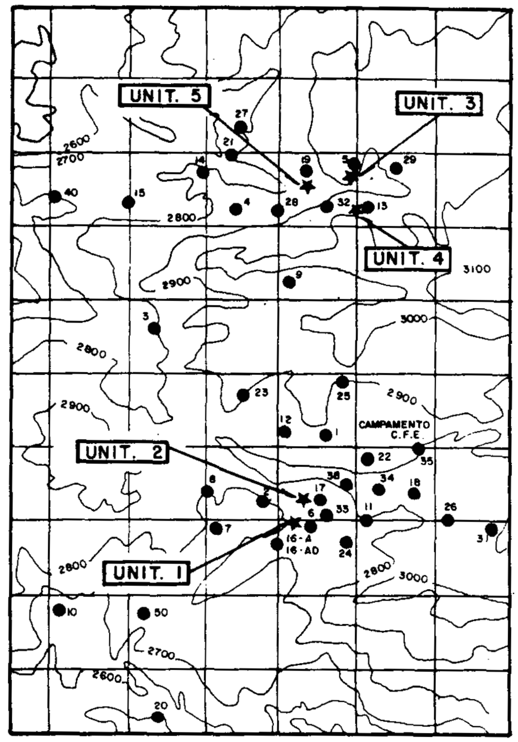

FIG. 2 WELLS AND PLANTS LOCATION AT LOS AZUFRES

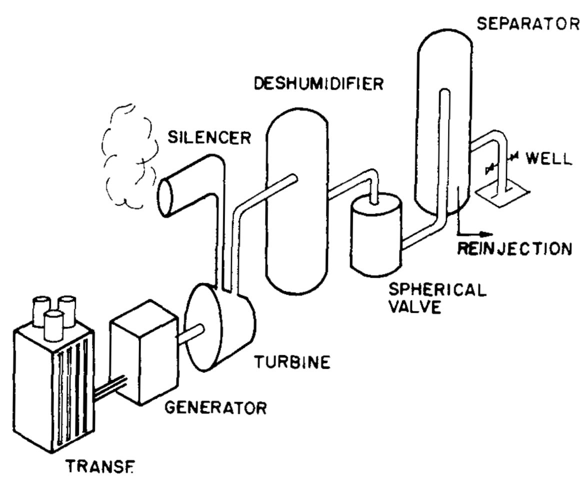

FIG. 3 GENERAL ARRANGEMENT OF THE 5 MW WELL-HEAD TURBINE.

PROS AND CONS

The use of back-pressure, well-head, 5 MW Geothermal power plants has some pros and some -- contras. According to our short experience -- they can be listed as follows.

DISADVANTAGES:- Steam consumption per kwh is - high. (12 kg/kwh in Los Azufres).

- The steam that enters the turbine is " Fresh flashed ", that is, it doesnt travel in long pipes where a small amount of condensation, drained later at the entrance of the turbine, helps to remove all the solids that were -- carried in the steam.

- It is practically impossible to use all the energy that the well produces or all the -- power that the turbine can deliver. In --- other words, if the turbine is for 5 MW, -- usually the well will deliver more steam -- than necessary (underuse of the well) or less than necessary (underuse of the turbine).

- Too many electrical transmission lines that increases the vulnerability to lightnigs -- and failiures.

- There is no control on the gases associated to the steam. They are discharged directly to the atmosphere, even though in this case the discharges are spreaded across the ---- field giving less concentration at each --- point.

ADVANTAGES:- Low capital investment in the -- equipment (specially atractive for the countries with financial problems due to high interest rates).

- Each well can begin production several --- years before than what would be,using a -- big central power plant.

- They can be installed in new wells, even - though the uncertainty about the evolution of their production characteristics.

- Specially atractive in fields with high gas content. If gas decreases with time, they leave a best well to be integrated latter - to a big central power plant.

- Because of the short distance from the --- well to the turbine, the heat losses are -- smaller (In a central power plant, heat -- and drainage losses in steam pipes represent 5 % of the total power produced).

- A new Geothermal field can be evaluated --- with enough confidence by extracting steam for months or years from several strategically located wells.

- Reliability of eleven 5 MW units is higher than one 55 MW power plant.

- Construction and engineering work is drastically simplified.

OUR EXPERIENCE

After more than one year experience operating those turbogenerators we have found that the equipment is highly reliable. The reasons that have occasionaly caused tripping of the turbines can be grouped in

Mechanical trouble (mainly lubrication)	35 %
Precautorious inspection	7 %
Electrical transmission lines trouble	58 %

the power factor of the plants, having enough steam, is over 90 %. Unit 1 an 5 were generating less than 5 MW because the corresponding wells were not producing the 60 Ton/h of steam; recently, a second back up well was added to - each one to complete the 5 MW.

The main problems found have been, (appart --- from those in the electrical transmission lines), of silica scaling in nozzles and blades. The origen can be explained as follows: In -- well 17, at the bottom of the well the steam - is not completly dry, it contains 1 % of water with all the impurities, such as silica and -- sodium. As it flows up, pressure decreases -- and the small amount of water evaporates leaving the impurities suspended in the steam. - When this superheated steam passes through the deshumidifier, no silica is remove.

When the isoentropic expansion takes place in - the first row of nozzles, inside the turbine, - some water appears. Because of solubility differences, all the imipurities go to the water, -- oversaturating it and producind scaling at the leaving edge of the nozzles.

In well 5, where a half water half steam mixture is produced,scaling problems found have a - similar explanation. In this case the " Fresh-separated " steam that contains a certain ----- amount of water in suspension, because the -- friction losses (In the spherical valve for -- example) it decreases isoenthalpically its --- pressure allowing the droplets to flash, leaving the salts in suspension, and repeating --- again the malfunctioning of the deshumidifier. In well 13 where we also have water and steam - mixture this problem does not appear because -- the distance from the separator to the deshumidifier is 300 m, inclined some 10° downward. - The pipe permits some cooling that produces a small amount of condensation. The condensated water flows in the stratified mode of the two-phase flow problem due to the 10° positive --- slope and this is easely removed by drainage - at the end of the pipe and also by the deshumidifier itself.

FIG. 4 Panoramic view of the Northern part of Los Azufres, Michoácan

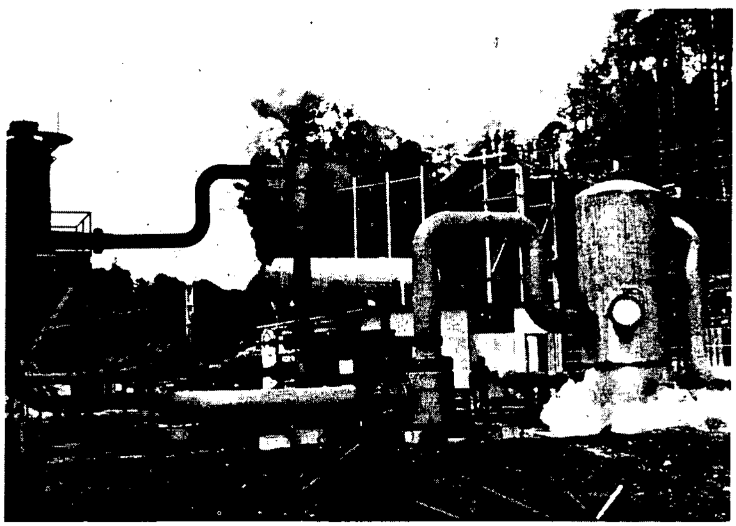

FIG. 5 Unit 2 at well 17, spherical valve and deshumidifier in -- first plane

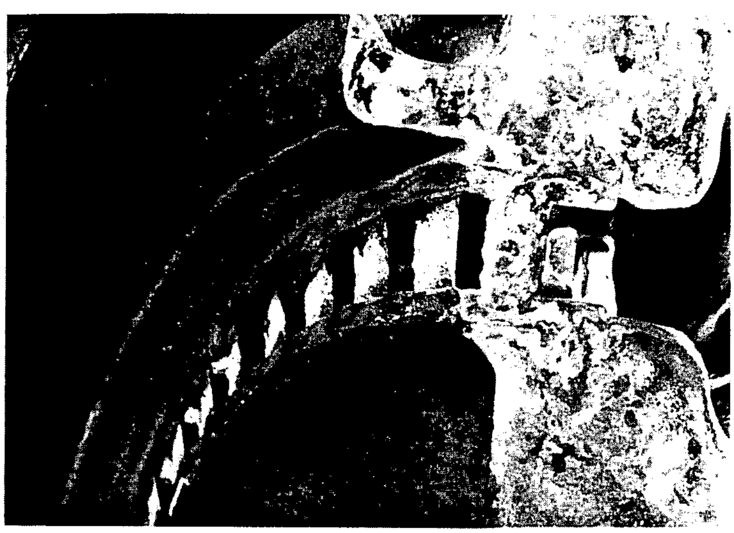

FIG. 6 Silica deposition in the second nozzle row of Unit 2 at well 17