NOTICE CONCERNING COPYRIGHT RESTRICTIONS

Error

An error occurred while processing this page. See the system log for more details.

Error

An error occurred while processing this page. See the system log for more details.

Error

An error occurred while processing this page. See the system log for more details.

TABLE I

PLANT	HRS OPERATION 1993	PLANT AVAILABIL. %
Los Humeros 1	8317.5	94.95
Los Humeros 2	8298.8	94.73
Los Humeros 3	8137.3	92.89
Los Humeros 4	8187.5	93.46
Los Humeros 5	7675.4*	95.75
Los Humeros 6	**	**
Los Humeros 7	2808.6***	95.90

* Commercial Operation : 1.Feb.1993
** Not in commercial operation in 1993
*** Commercial Operation : 1.Sep.1993

The major problem encountered during the units initial operation was a repeated clogging of the steam path for the first units installed in the new developed field of Los Humeros. Within one week of operation, the unit output reduced to a quarter of the nominal output. Fig. 5 shows the appearance of the first stage diaphragm as it was found after only 60 hours of operation in 1990 in the Los Humeros 2 unit.

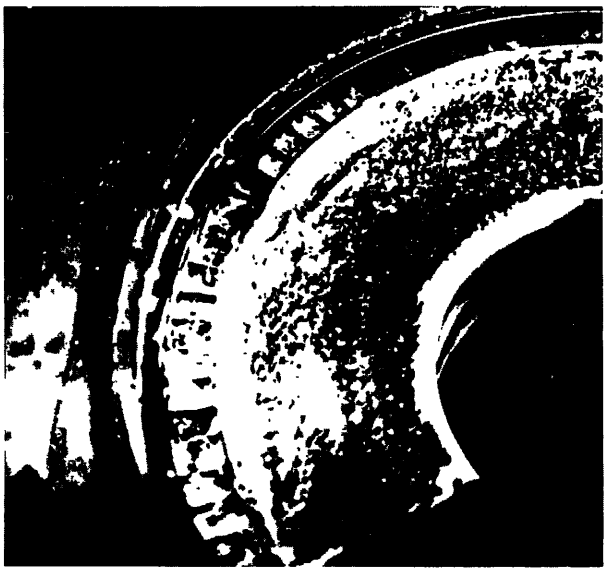

Figure 5
First stage diaphragm clogging of Los Humeros 1 after only 60 hours of operation

The deposits resulted to be SiO2 (92%), Iron Sulfides and Iron Oxides (6.3%), Na (0.72%), Chlorides (0.32%), B (0.24%). The problem has been solved by injecting water in the steam. The injection is carried out continuously at a rate of 0.6% maximum just upstream the turbine stop valve. After then the units could be left in operation regularly without any appreciable reduction of capacity. The injection of water is applied on all the 7 units of Los Humeros. The three units installed in Los Azufres never suffered clogging problems in the steam path and are running without any water injection.

Another problem encountered during the commissioning of the first units has been related to the clogging of the drains connected to a common header. This problem was solved, according to Ansaldo practice applied on the geothermal units in Italy, by making independent each drain /1/.

In reference to maintenance, the first two units in Los Azufres have been operating for 32 months with only minor overhauls and no opening of the steam turbines for the above mentioned period. The Los Humeros units are operating, after solving of the clogging problem with scheduled main overhaul, including opening of the steam turbine, at every 12-14 months.

Opening of the steam turbine requires no more than half a day and the removal of rotor and diaphragms can be completed in another half a day.

FUTURE DEVELOPMENTS

The original project developed by CFE for the ten small power plants was focused on simplicity, low erection costs and short cycle for erection. This led to units with atmospheric discharge that obviously have inherent penalties from the point of view of efficiency. In fact, in spite of these units are all located at an elevation of about 3,000 m, only about 60% of the available enthalpy drop (with reference to an usual exhaust pressure of 0.1 bar for a condensing unit) is utilized giving a relatively high consumption of steam per kW generated. Therefore in order to increase the efficiency of the plants and to reduce the damages caused to the surrounding environment by the discharge by the geothermal steam, Ansaldo upon request of CFE has studied the transformation of the units and of the whole plants into condensing ones.

Two different design modifications have been proposed: the first one is based on the modification of the existing steam turbine in order to make it suitable for the new operating conditions. The second alternative considers the possibility of adding a low pressure turbine with its own generator to the existing one.

For both cases several new components are required for the plant modification to condensation, mainly a condenser, a cooling tower and the vacuum system. In the case of the second alternative, an extension of the existing building housing the turbogenerator is required as well.

In the case of the first alternative, the existing back pressure steam turbine is modified replacing the second last stages with new ones. In order to handle the increased volumetric flow, a longer and stronger blade is used. To accomplish that, the last stage wheel is cut and a new last stage shrunk on wheel is used. Also the casing is slightly modified in the discharge section to give more passing area. Discharge to the condenser is still upward with a cross over pipe. No changes are projected for the other parts of the turbogenerator including the reduction gear and the generator. The condensing pressure in this case is of 0.3 bar with a little decrease of inlet flow (both the relatively high condensing pressure and the reduced inlet flow are due to limitation imposed by the existing hardware) : the output in this first case is increased about 13% while the steam consumption per kW generated is about 85% of the original design.

A better result in terms of increase of output and reduction of steam consumption can be achieved with the second solution that includes a second turbine of the condensing type, fed with the steam discharging: in this case no changes are required to the old existing turbines that still operates at original design conditions. In this case condensing pressure can be selected with no limitations due to the existing hardware and no reduction in inlet flow is required. With a condensing pressure of 0.1 bar, the increase in terms of net generated kWs is about 74% and the steam consumption results about 58% of the original design figure.

Fig. 6 shows the study of the modified turbine for the first alternative. Fig. 7 shows the scheme for the second option.

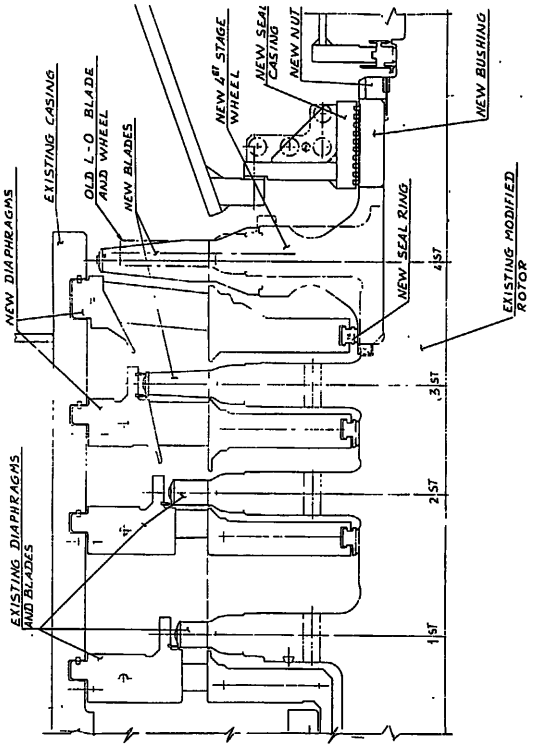

Figure 6 Modification of the 5 MW geothermal steam turbine for transformation from atmospheric discharge to condensing.

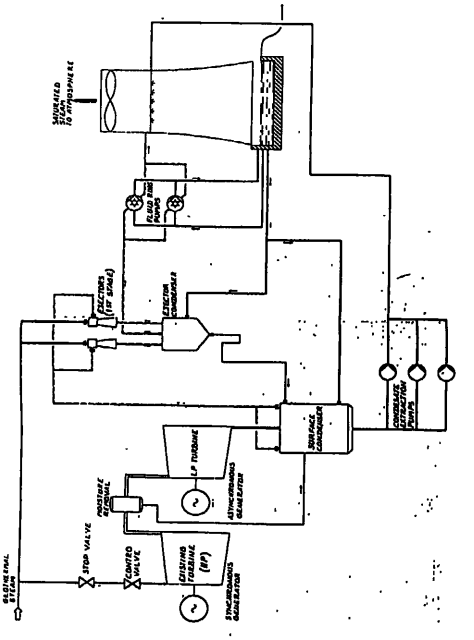

Figure 7 Scheme for transformation of the existing plant to a condensing plant by adding a low pressure turbine downstream the exhaust of the existing back pressure turbine.

Note that there are neither intercept nor control valves between the "old" back pressure turbine and the new low pressure turbine, therefore it has no control system. Starting and loading can be accomplished with the control system and the control valve of the HP turbine as well as emergency operation, such as load rejection which can be managed using the existing control and trip system. Another feature of this second solution considered in order to keep costs as low as possible and easy plant operation, is the use of an asynchronous generator for the low pressure unit. Another possibility is the installation of some of the units in new geothermal fields when in the field where they are actually operating larger condensing units will be installed. The move of the small turbine-generator sets to a new site is not a problem having designed as portable sets.

CONCLUSIONS

The ten 5 MW turbine-generator sets designed by Ansaldo for CFE are typical small units for well head installation particularly suitable for new fields or when low cost and short cycle installation are required. Operating experience gained with them shows that the project targets, such availability, easy of operation, maintenance and flexibility have been obtained.

REFERENCES CITED

/1/ Siena, Sergio, 1986 Small - medium size geothermal power plants for electricity generation Geothermics, Vol. 15, No. 5/6 pp 821-837.

/2/ Falavigna, Loris, 1990 Aspectos tecnico-economicos de los centrales geotermelectricos de pequena potencia Geotermia y desanella e Venezuela, pp 190-197.