

THE LONG TERM USE OF GEOTHERMAL RESOURCES AT THE TASMAN PULP & PAPER CO LTD'S MILL, KAWERAU, NEW ZEALAND

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ABSTRACT - The Tasman Pulp & Paper Company Ltd's mill at Kawerau has been utilising the geothermal resource available in the area surrounding the mill for more than 30 years. This resource was just one of the many factors considered for the final siting of the mill although it wasn't till much later that the potential of the geothermal field was fully appreciated. The original concept was to deliver "steam only" to the mill with the water separation as close as practical to the well heads. Over the years the resource has been developed to give a very reliable supply of steam to meet the requirements of the mill. The mill produces per annum approximately 200,000 tonnes of kraft pulp and 400,000 tonnes of newsprint. Geothermal resources make up approximately 30% of the process steam and 5% of the electrical load required by the mill and without this resource other forms of energy such as oil, gas or coal would be required. "Clean" process steam is produced in Heat Exchangers because of the non-condensable gases associated with geothermal steam it has not been practical to use it direct in the pulp and paper drying process. However it is used direct in heating combustion air and shatter sprays in the Chemical Recovery Boilers, black liquor heating, boiler feedwater heating and timber drying kilns used by an associated company. Electrical energy is produced in a 8MW Turbo Alternator exhausting to atmosphere via a water evaporation plant in the liquor cycle of the pulp mill and a water heater that supplies hot process water at 70°C to both the pulp and paper mills. All the condensate produced from the use of geothermal steam in the mill is collected and processed to provide high quality make up feedwater for use in the Heat Exchangers, Power and Recovery Boilers in place of high cost demineralised water. Separated water at the borefield instead of being discharged directly to the local river as in the early days has been further utilised for electrical generation (three Ormat type units), a pilot plant to recover silica to be used as a newsprint additive and reinjection in selected wells. Only then is the remaining water discarded.

Introduction: From the start of the first newsprint being produced in 1950's, Tasman Pulp and Paper Co. Ltd has expanded and developed its production facilities at Kawerau until today, the Mill produces some 200,000 tonnes per annum of market kraft pulp and 400,000 tonnes per annum of newsprint. 75% of the total production is exported to markets worldwide and has a sales value of US \$300,000 million. Large amounts of energy both electrical and heat (steam) are required in the production of pulp and paper being in the order of 800,000 MWh and 4,000,000 tonnes of steam per annum. Geothermal resources account for approximately 5% of the electrical energy and 30% of the process steam requirements of the Mill. The remaining process steam is produced in two power boilers fuelled by wood waste and two chemical recovery boilers burning black liquor produced in the pulping process. Fuel oil can be used as an additional energy source but only when there is a shortfall from woodwaste, black liquor or geothermal energy sources. The Geothermal Borefield has been developed to achieve a very reliable source of energy which is of the utmost importance to a continuous process industry. At the end of the 1970's Tasman sold its borefield assets to the Crown who have administered it through various ways since then, in return Tasman pay Royalties for the supply of Geothermal steam.

Geothermal Steam Supply: The Geothermal steam-supply to the Mill is by two pipelines traditionally referred to as the H.P. and L.P. The H.P. line was originally designed for 1400 kPa and the L.P. 700 kPa. The size of the former has recently been increased to allow for the supply of steam to timber drying kilns operated by an associated company and for future Tasman requirements. The two lines are cross-connected at the Mill by means of a pressure control valve so that the H.P. line pressure can be controlled by dumping steam to the L.P. line. Take-offs from the H.P. line supplies Geothermal steam to the two Chemical Recovery Boilers and one of the five process steam generators. The L.P. line supplies Geothermal steam to the other four process steam generators and a 8 MW turbo alternator. Pressure control of the L.P. line is achieved by a control device on the turbo alternator or by silenced relief valves at the mill and also at the borefield. The supply pipelines have been relatively maintenance free and have only been down during the Christmas Shut when pulp and paper production ceases for two days. Problems with safety valves due to steam leakage have been eliminated by the use of rupture discs before the valves.

Process Steam Generators: It is not practical to use Geothermal steam direct in the paper machine driers due to the non-condensable gas concentration (3% by mass) so therefore the Geothermal steam is used in five heat exchangers to produce "clean" process steam at 345 kPag. The first two heat exchangers installed at the Mill were to a design by Franco Toshi of Italy.

Two more heat exchangers were installed in the 1970's to a design by Wbesoe of England and the last one to the same design in the 1980's.

Both designs has the Geothermal steam on the inside of the tubes with the "clean" steam being produced on the shell side.

The "clean" steam output from the heat exchangers was originally controlled by the amount of geothermal steam entering the heat exchanger. The condensate produced was collected in a separator vessel before being discharged under level control to waste. Venting to atmosphere from the top of the separator vessel ensured the required amount of steam "blow through" the heat exchanger to prevent the non-condensable gases building up within the tubes restricting heat transfer rates. The amount of venting or "gas-off" ended up being manually controlled in the two original heat exchangers and vapour pressure controllers used with some success in the later heat exchangers. The "clean" steam output from two of the heat exchangers was automatically controlled by a tie-in with the 4500 kPag Mill steam header control, the remaining three outputs were controlled manually by an operator.

A new centralised control room incorporating a distributed control system has recently been installed in the plant. This gave the opportunity to develop and try new operating and control strategies by quick and easy software changes. It has resulted in all the heat exchanger outputs now being controlled by the 4500 kPag header controller by the amount of venting or "gas-off" at the individual separator vessels. This control strategy makes use of and clearly demonstrates that non-condensable gas has a major effect on heat transfer rates. It also gives extremely fast and accurate control over the entire range of the heat exchanger "clean" steam output. The stability of the total Mill steam system has benefited from this strategy beyond expectations. Further development to a higher level of control using fuzzy logic techniques is envisaged when control systems resources can be made available.

A major problem with the heat exchangers until **recently was** the severe scaling on the "clean steam" **side** due to the indifferent quality of the feedwater. The feedwater consisted of a mixture of hot process softened water, raw water and when available a limited quantity of demineralised water. It was believed that chemical treatment could control scaling but the varying quantities of raw water made it extremely difficult. High continuous blowdowns were required and acid cleaning of the heat exchangers on the "clean" steam side were required at regular intervals to maintain a reasonable clean steam production. **All** the associated problems with the quality **of** the feedwater were solved when the innovative geothermal condensate recovery plant **was** installed.

Geothermal Condensate Recovery Plant: During the 1980's experiments indicated that the geothermal condensate produced in the Mill could be processed **by** using steam stripping to remove the non-condensable gases and then utilised **as** feedwater for the heat exchangers to produce process steam. From indepth analysis of the condensate. The main contaminants that had to be removed were Hydrogen Sulphide and Carbon Dioxide. Ammonia was also found to be present and thought to be a contaminate until it was realised that if the level of ammonia could be controlled it would **be** a unique "built in" corrosion inhibitor for the whole Mill steam/condensate system. Further experiments and trials revealed that allowing the condensate to "flash" first before steam stripping would improve the efficiency of the **process**. The final plant design consisted of a flash vessel and a stripping vessel. The flash vessel serves **as a** collection/storage vessel and a separation device where most of the non-condensable gases **are** removed.

The stripper vessel consists of a packed column containing 10.5 m³ of stainless steel "LEVAPAK" rings where the remaining non-condensable gases are removed and at the same time the level of ammonia to give maximum hydroxide alkalinity in the treated condensate **is** controlled.

All the available geothermal condensate is processed in this plant. The quality **of** the water **is** comparable to demineralised water and it supplies all the feedwater for the heat exchangers plus most of the makeup feedwater for the **power** and chemical recovery boilers.

Geothermal Turbo-Alternator: In the late 1950's a G.E.C. turbo alternator **was** installed. It was rated at 10 **MVA** and exhausted to atmosphere via a 50 metre high stack. **A** hydraulic pressure controller incorporated in the governing system stabilised the pressure in the L.P. geothermal steam main.

The advent of the centralised control room required the turbine control system to be able to **be** operated remotely. This was accomplished "in house" by retaining some of the old hydraulic system and replacing other with electronic communication and pressure transmitting equipment. The machine has given good service but does suffer from the geothermal steam conditions i.e. gland leakage and erosion of the turbine blading.

Two projects since the turbine installation have been undertaken to utilise the exhaust steam. The first in the late 1960's to increase the evaporation of water from black liquor in the pulping process. The second in the late 1980's to heat filtered process water replacing the use of "clean" steam in heat exchangers.

Black Liquor Pre Evaporator: The unit is a single body, rising film heat exchanger with a direct contact condensor. Design evaporation was 45 tonnes/hour but has always been difficult to achieve due to the problems with the non-condensable gas building up within the calandria and the steam flow configuration.

A central baffle directs the geothermal steam entering at the bottom to flow up one side of the tube bundle and down the other to the vent. Without a very positive flow through the calandria pockets of non-condensable gas can accumulate indicated by lower temperatures measured at the vent. Various ideas have been put forward with little or no success sometimes being masked by evaporation that takes place due to the liquor inlet temperature and the pressure in the vapour head. The problem has been solved by an eductor driven by the venting stream of carrier steam and non-condensable gases from the heat exchanger separators which was previously vented to atmosphere at the top of the turbine exhaust stack.

Filtered Process Water Heater: During the late 1980's a new continuous digester and fibre line was built to replace the original batch digesters. A process water heater on the turbine exhaust was a further opportunity to utilise the available heat energy.

Hot water is used mill wide and the project design targeted areas where significant savings could be made. Problems with the heater have been material selection and the heating element attachment to the inlet and outlet water headers. The elements are of the dimple plate design. A replacement heater was required due to excessive leakage caused by fatigue induced stress corrosion cracking. The material specification was changed from 304 to 316 stainless at the same time the attachment of the envelopes to the headers was redesigned. Leakage from the heater has to be viewed with concern as this leakage enters the geothermal condensate system for processing as boiler feedwater. The unit still suffers from pinhole leaks which are extremely difficult to repair.

When the turbine is shut down for maintenance etc. both the Pre Evaporator and Water Heater are able to run on geothermal steam direct. The steam is reduced in pressure through conditioning valves to below 6 kPag from 690 kPag. Pipework has also been modified so that the Pre Evaporator can operate as the Water Heater in breakdown situations.

Chemical Recovery Boilers: Geothermal steam has been able to be used direct in this area heating combustion air for the boilers, black liquor heaters and shatter sprays and with few problems being associated with its use.

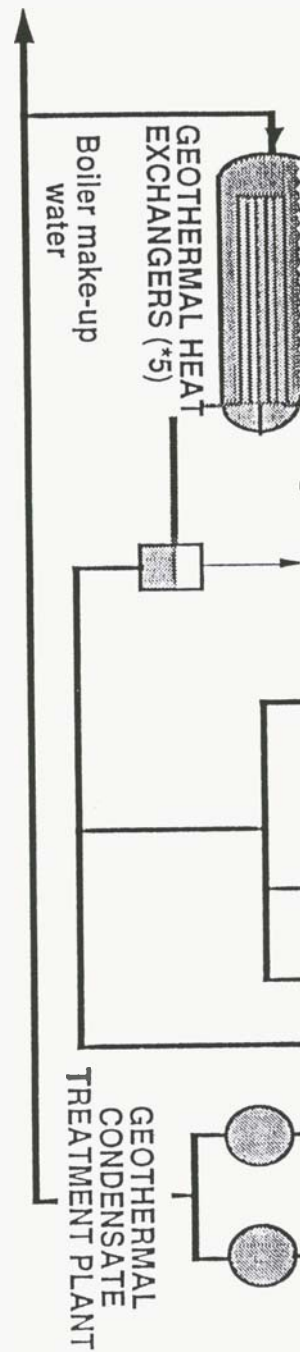
Boiler Feed Water Heaters: Power and Chemical Recovery Boiler feedwater heaters have two clean steam and two geothermally heated units. Originally the geothermally heated feedwater heaters were designed to operate in parallel with the 345 kPag clean steam heaters. Further studies indicated that by altering the piping configuration to allow the units to be operated in series a significant increase in the final feedwater temperature could be achieved. The piping modifications were carried out successfully and the plant has benefited from the increased feedwater temperature.

Geothermal Silica Precipitation Plant: A very promising process utilising separated borefield water is being developed at Tasman. A pilot plant has been built and operating for some time extracting silica. In the form of a slurry precipitated silica can replace imported calcined clays as a filler in newsprint and at the same time greatly improving the quality of the product. Full scale trials have been run on the machines with excellent results and with more trials planned in the print rooms the project has met all the Company's expectations.

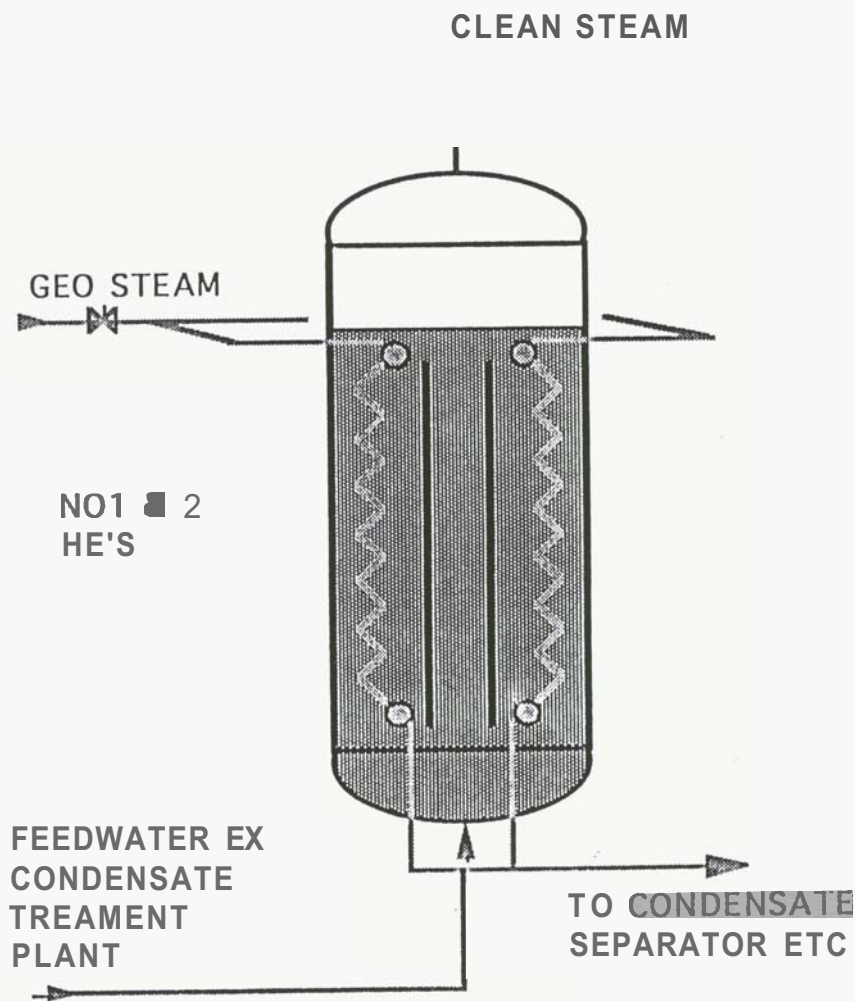
Conclusion: Geothermal Resources play a **very** important part in Tasman's energy **needs**. It is ideally suited to the pulp and paper industry or in fact any other venture where large quantities of low grade process heat is required. There are also opportunities to utilise the resource even further than just the steam output. Separated borewater is being used to generate electricity in two Ormat plants for the local electricity board, a horticulture project growing out of season vegetables for domestic consumption and hot pools to relax in. Once out of the ground the resource **has** few disadvantages and is economical **compared** with other purchased fossil fuels.

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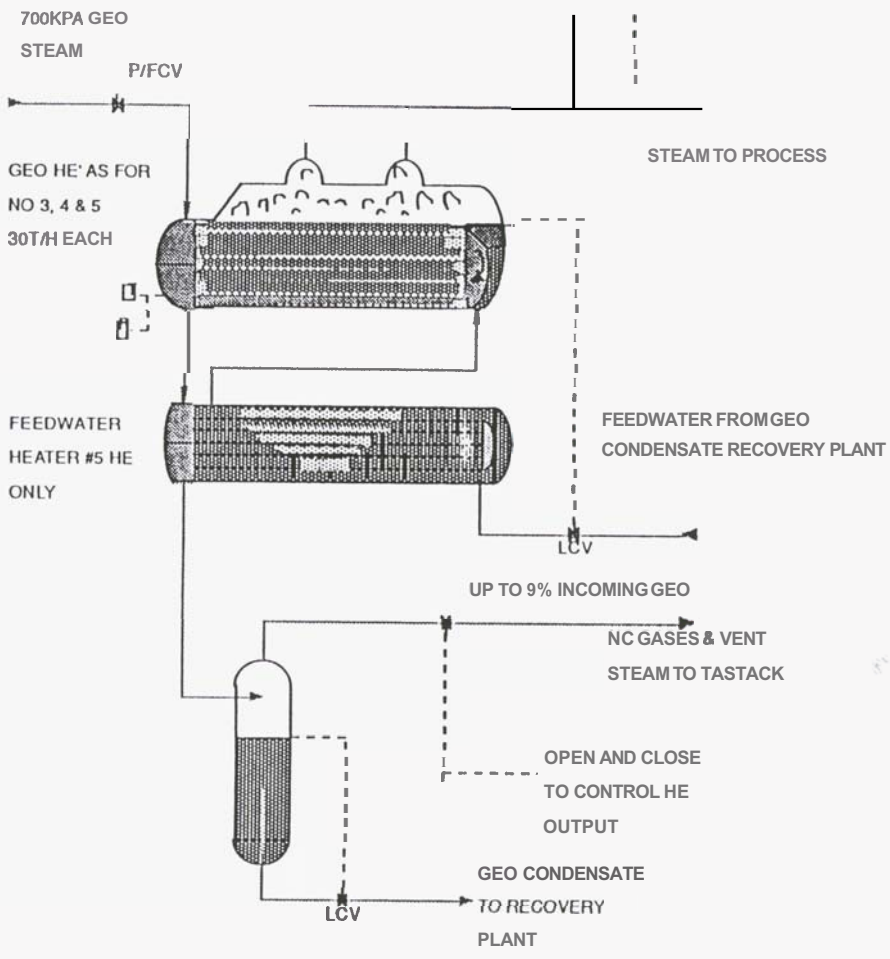
OVERVIEW GEOTHERMAL SYSTEM

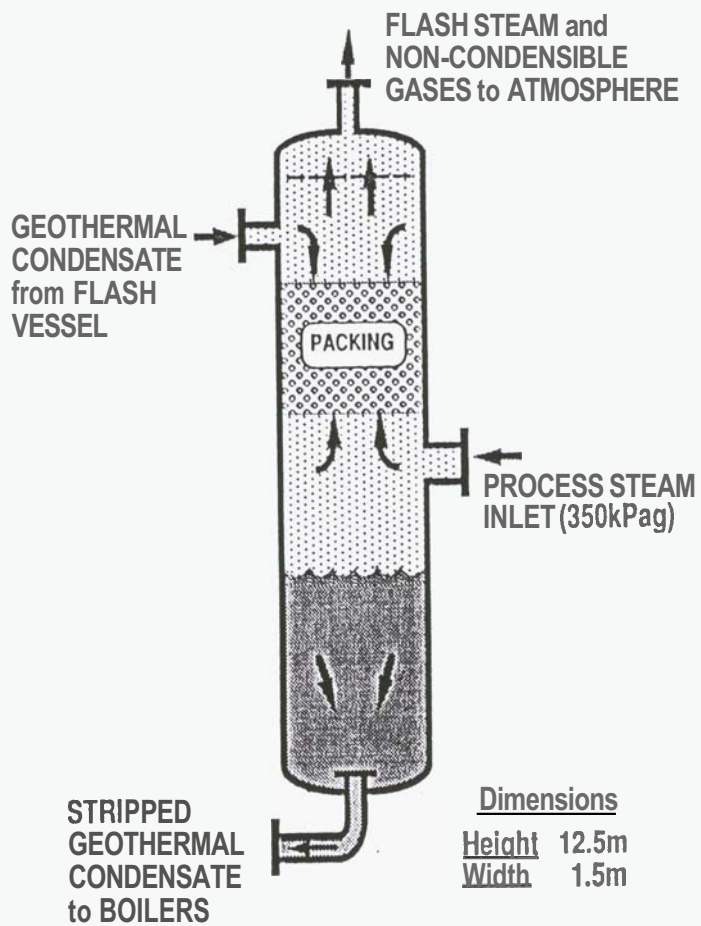


RAW GEOTHERMAL
CONDENSATE

"FLASHED"
CONDENSATE TO
STRIPPER

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STEAM STRIPPER

| COMPONENT | RAW CONDENSATE |
|------------------------|----------------|
| CO ₂ mg/kg | 65 |
| HCO ₃ mg/kg | 345 |
| H ₂ S mg/kg | 24.2 |
| NH ₃ mg/kg | 26.8 |
| O ₂ mg/kg | nil |
| pH | 6.0 |
| Alkalinity | P nil |
| mg/kg | m 36 |
| (CaCO ₃) | 2p-m nil |
| Conductivity uSm/cm | 200 |
| SiO ₂ mg/kg | <0.1 |
| Ca mg/kg | 0.2 |
| Mg mg/kg | 0.02 |
| Fe mg/kg | 0.1 |

CONDENSATE