UTILISATION OF GEOTHERMAL ENERGY IN A PULP AND PAPER MILL

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ABSTRACT

The Tasman Pulp and Paper Company Ltd's Mill at Kawerau, New Zealand has been utilising geothermal energy for more than 30 years. The mill produces approximately 200,000 tonnes of kraft pulp and 400,000 tonnes of newsprint per annum. Geothermal energy produces 26% of the process steam requirements and 6% of the mill's electrical load. The management of the mill's energy sources is complex and ever changing which has resulted in unique control strategies being developed over the years to improve efficiencies in the operation of the plant. Complete utilisation of the Geothermal resource has been the aim of the Company and has led to pioneering plant and process developments.

INTRODUCTION

The siting of Tasman's Pulp and Paper Mill at Kawerau was strongly influenced by positive indications that geothermal resources were available in the locality. It was anticipated that by suitable development geothermal would provide an additional source of energy for mill operations. The process of pulp and paper production generates "fuel" in the form of wood waste from the trees and black liquor from the chemical pulping process, but there is still a considerable shortfall in the energy requirements to operate the mill. This requirement is met by importing electrical energy from ECNZ (State owned), geothermal steam, additional wood waste and fuel oil. These energy sources have to be carefully managed to give an overall stable and efficient operation of the plant.

PROCESS STEAM

Process steam is produced in two chemical recovery boilers firing black liquor, five heat exchangers utilising geothermal steam, and two power boilers burning wood waste. A small proportion of geothermal steam is used directly in process equipment but due to the non-condensible gas content its application is limited. Both types of boilers bum fuel oil for starting and extra steam production when the need arises. There is also a stand-by fuel oil fired package boiler but due to the high cost of fuel oil it is seldom used. The sources of process steam are shown in Figure 1 below.

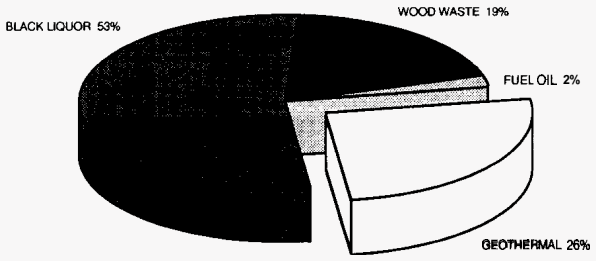

Figure 1 : Sources of Process Steam

Steam from the chemical recovery and power boilers is distributed via a common header operating at 4,500 kPa(g) and 400°C to two turbo alternators or pressure reducing stations which condition the steam for process use at 1,035 kPa(g) 190°C and 345 kPa(g) and 155°C. The geothermal heat exchangers produce steam at 345 kPa(g) saturated. The steam is then heated to 155°C with the addition of 1,035 kPa steam through temperature control stations. This helps limit the amount of condensate formed within the mill steam distribution system.

The two original Geothermal Heat Exchangers were of Italian design - (Franco Tosi) and were installed to supplement the 1,035 kPa(g)

and 345 kPa(g) process steam requirement. With further expansion of the mill two further heat exchangers designed by Whesso of England were installed with a further unit to the same design added in the early 1980's. At the present time all the heat exchangers produce process steam at 345 kPa(g) with maximum production in the order of 140 - 150 tonnes/hour.

ELECTRICAL ENERGY

The mill has three turbo alternators with a combined power output of some 39 MW. The amount of power actually developed depends entirely on the mill's process steam load at any particular time.

Two of the units operate on boiler steam at 4,500 kPa(g) and 400°C and are rated at 12.7 MW and 18.7 MW respectively. Both units have hydraulic control systems that control pass out steam at 1,035 kPa(g) and exhaust steam at 345 kPa(g). The 18.7 MW unit is in use most of the time under normal operating conditions with the 12.7 MW unit available as required. The third turbo alternator operates on geothermal steam with an inlet pressure of 700 kPa(g) exhausting to atmosphere and has a power output of 8 MW. This unit normally operates in a pressure control mode linked to the line pressure of the geothermal steam supply from the bore field. Once the turbine is fully loaded silenced vents come into operation if the bore field output still exceeds the mill's demand. The aim is to match the specific demand of the mill with the output from the bore field without venting surplus steam direct to atmosphere. This is a requirement under New Zealand's Resource Management Act. The sources of electrical energy are shown in Figure 2 below.

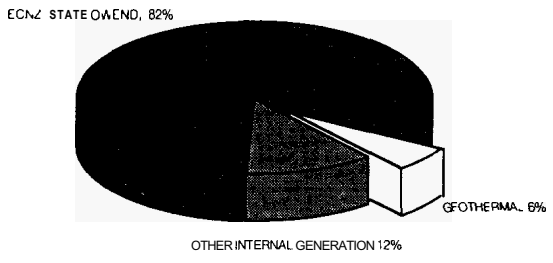

Figure 2 : Sources of Electrical Energy

ENERGY MANAGEMENT

The overall goal in energy management is to limit the use of high cost fuel oil and maximise the internally generated "energy"within the mill which includes geothermal.

The recovery boilers are operated from individual control rooms while the power boilers, heat exchangers and turbo alternators are operated from a centralised control room under a distributed control system. All the heat exchangers operate in cascade mode from the plant master pressure controller with a bias control to meet the varying load conditions.

The original hydraulic control systems on the turbines had to be converted so that they could be operated from the centralised control room. This was accomplished inhouse by using digital pressure controllers in place of the hydraulic ones. The numerous process variables and set points to operate the plant are now easily correlated and trialled by easy software changes.

Very stable operation of the plant has been achieved.

The control strategy for energy management of the mill is still being developed but the operating window is now wide open. (Ref. 1)

FURTHER UTILISATION OF GEOTHERMAL STEAM

In addition to the basic use of the geothermal steam for process steam and electrical power production a number of projects have been initiated that further utilise this valuable resource. These projects include an evaporator for pulp mill liquor, a process water heater, a geothermal condensate treatment plant, boiler feed water heaters, boiler air heaters and limited direct use of geothermal steam in the process.

The geothermal turbo alternator on full load uses some 145 tonne/hour of steam with a total heat energy potential of some 90 MW. Electrical power generated is 8 MW leaving some 80 MW of low grade heat energy still available to be utilised. The following projects have addressed the poor efficiency of using geothermal steam for electrical power generation alone as shown in Figure 3.

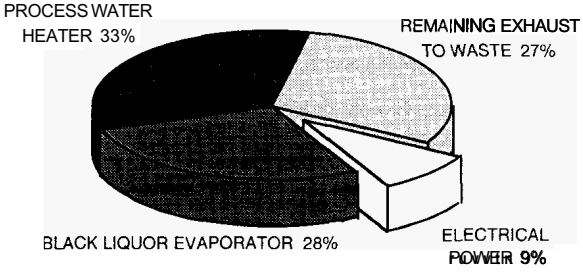

Figure 3 : Total Heat Energy Available at Full Load

WEAK BLACK LIQUOR EVAPORATOR

In the pulping process spent chemicals in the form of a weak liquor require large amounts of water to be evaporated before further processing can take place. This project utilises the exhaust steam from the geothermal turbo alternator as the heating medium. The liquor side operates at a high vacuum. The turbine exhaust is vented to atmosphere via a 50 metre high stack but with modifications to the ducting and the addition of control dampers exhaust steam **is** now diverted to the heating element of the evaporator. The unit initially suffered from a build up of non-condensable gas within the heating element curtailing heat transfer rates. This problem was solved with an eductor driven by what was in effect a geothermal waste stream from the process steam producing heat exchangers.

The condensate formed in the heating element was initially lead to waste but it is now processed in the condensate recovery plant.

PROCESS WATER HEATER

Large amounts of hot water are used in the Pulp and Paper processes. Traditionally these streams have been heated in Heat Exchangers using clean steam and some heat recovery using condensate formed from the drying process. Further modifications to the Geothermal Turbine exhaust ducting allowed for a water heater of the dimpled plate design to be installed to meet this process requirement.

GEOTHERMAL CONDENSATE TREATMENT PLANT

A significant project that has had a major impact on the mill has been the Geothermal Condensate Treatment Plant. All the condensate formed from the geothermal steam is collected and treated to produce boiler feed water suitable for use in all the steam raising equipment in the mill. The quality of the feed water produced is on a par with demineralised water but with the added advantages of already being hot and containing a controlled level of ammonia. The ammonia acts **as** a steam and condensate chemical treatment. (Ref. **2).** The plant can produce 3,600 litres/minute of boiler feed water from what was once a waste product. The comparative running costs are shown in Figure **4** below.

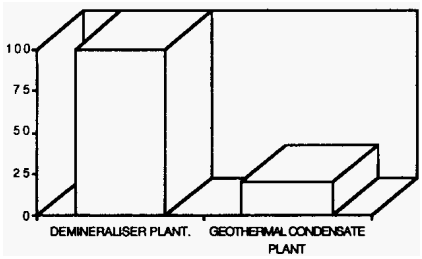

Figure **4** : Comparative Running Costs

KAWERAU BOREFIELD

Tasman is developing a process to extract silica (Ref. **3** & **4)** from bore water to be used in place of imported calcined clay **as** a filler in the production of newsprint with very good results to date.

Other parties are using the resource for electrical generation using separator water via two Ormat plants, timber drying, a horticulture project and hot pools for relaxation. Some 25% of the borefield fluid is re-injected. Further uses of the resource are being investigated within the Tasman **Pulp** & Paper Company..

CONCLUSION

A key performance indicator of the mill is the quantity of fuel oil used for the production of process steam.

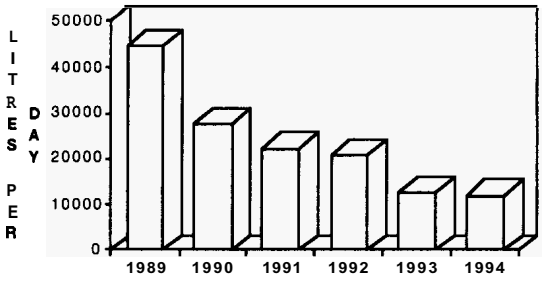

Figure **5** : Fuel Oil Used for Process Steam Production

In reality it can never be zero as both chemical recovery and power boilers require fuel oil at certain times. Continuous improvements to the way geothermal energy has been integrated into the process has played a major role in reducing the use of high cost fuel oil.

Geothermal energy is a very cost effective auxiliary "fuel" well suited to a continuous process industry like pulp and paper. Maximum utilisation of the resource will ensure its long term viability.

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