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INDUSTRIAL APPLICATIONS OF GEOTHERMAL RESOURCES

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ABSTRACT

Industrial applications are considered to constitute a huge potential for direct geothermal uses as they often require a source of heat in a range similar to the low to medium temperature geothermal fields. This paper proposes an overview of industrial applications that may resort to geothermal resources instead of other sources. It, however, has to be borne in mind that, due to the nature of the geothermal resources, the industrial application may require a minimum of engineering to avoid potential operational troubleshooting. The paper provides insight on projects in this field.

1. INTRODUCTION

Industrial applications of low and medium geothermal resources encompass a broad scope of uses and there is a huge potential of activities whose energy needs could be matched with medium to low temperature geothermal resources.

For instance, about 25% of US energy use occurs at temperatures < 120°C and most of it comes from burning natural gas and oil (Tester et al., 2013). A large part of this energy is used for industrial applications and such uses should not be neglected when scoping potential exploitation activities for a geothermal field.

2. INDUSTRIAL APPLICATIONS

Industrial applications encompass a rather wide range of industrial activities requiring fluid at low to medium temperature, for instance:

- Process heating;
- Industrial space air conditioning;
- Food processing;
- Food drying;
- Fish drying;
- Pulp and paper processing;
- Washing and dyeing of textiles;
- Leather and fur treatment;
- Fuel production and oil enhancing;

- Chemical production;
- Mineral production: sulphur, gases, salts or other precious metals;
- …and many more.

Typical applications and their temperature range are presented in Figure 1.

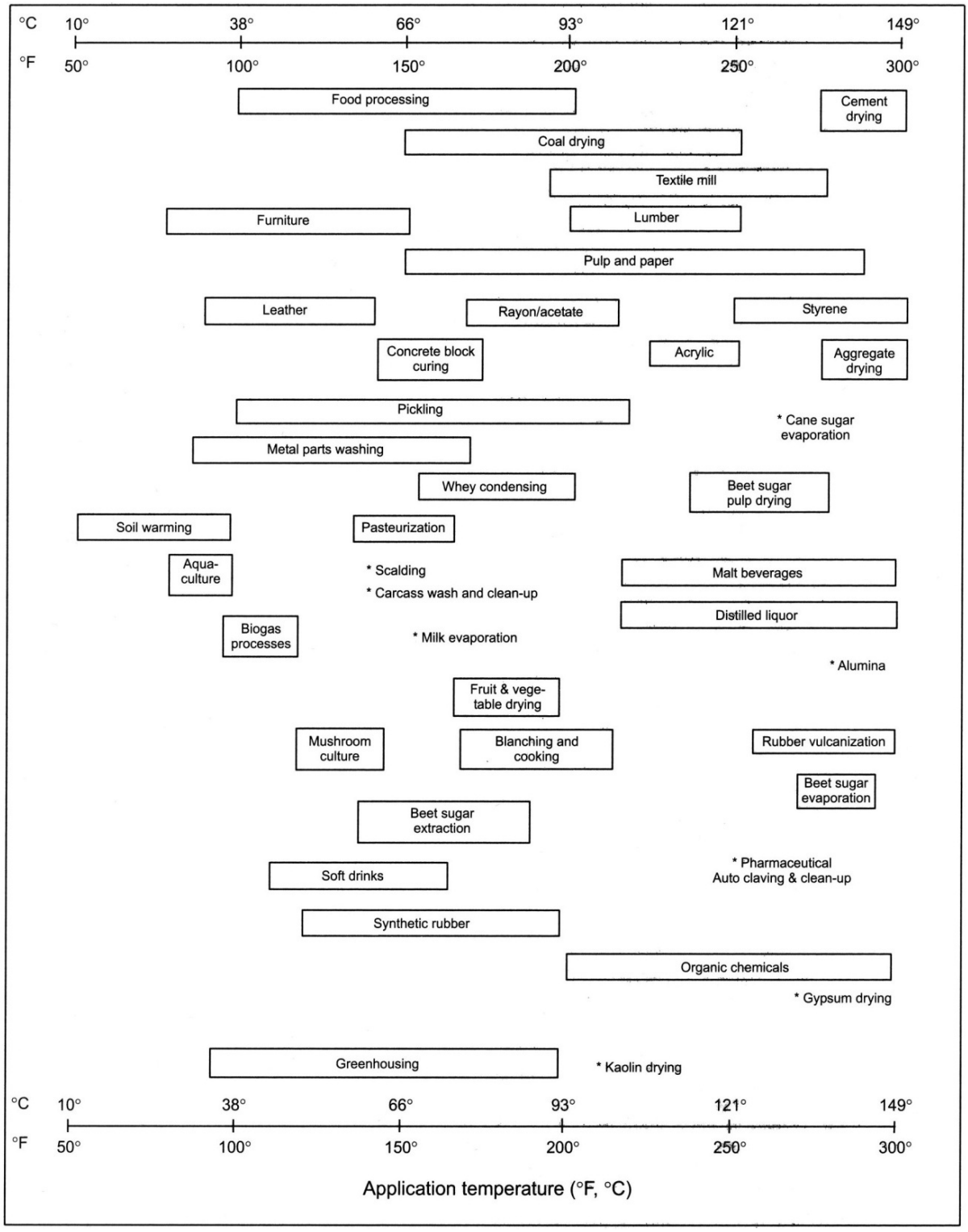

FIGURE 1: Temperature range for some industrial processes and agricultural applications

Conventional industrial processes that utilize fossil fuelled heat can in many cases be transferred to geothermal heat with a minor adaptation, in a technically efficient and economically feasible way.

Typical processes involved in industrial uses of geothermal resources are (Líndal, 1992):

- Drying: Drying can be realised by using air preheated by the geothermal fluid via a heat exchanger or by direct contact. Such a process is commonly used for drying crops or fish.
- Evaporation: The evaporation process is used to concentrate solutions. It is used for instance to obtain salt. The process is also used for water desalination or in any process requiring the vaporization of a solute.
- Distillation: Distillation is the process of separating mixtures based on differences in volatility of components in a boiling liquid mixture. Distillation is a commonly known process in the liquor and hydrocarbon industry.
- Refrigeration: Adsorption heat pumps, using a lithium bromide solution, are well known equipment suitable for realisation of industrial cooling or freezing with geothermal heat.
- Process heating: The process heating can be achieved by pre-heating water in a boiler or with direct heating.
- Industrial space air conditioning might be part of the industrial process in a specific plant where given temperatures are required for the process.
- Other processes such as: extraction, washing and dying, baking, etc.

The use of geothermal resources in industrial applications might, however, not go without challenges due to the peculiar characteristics of geothermal resources that may be richer in minerals than cold groundwater. The equipment selection might be affected by components such as: silica, oxygen, chlorides, calcium, magnesium, hydrogen sulphide and the pH of the fluid. Deposition is not expected to be a major problem in low-temperature utilization compared to high-temperature utilization (calcite, sulphides, silica). For these reasons, industrial projects using geothermal resources will not be able to fully duplicate an already existing solution. The process concept always has to be adapted and engineered to some extent to fit to the specific geothermal resource characteristics.

Depending on the geothermal field characteristics and the industrial application, the benefits of using such a source of energy may be higher than the adaptations that are required to utilize the resource.

3. SHOWCASES

3.1 Nordursalt – a means to process salt

The salt factory Nordursalt (Figure 2) was built in 2012 to 2013 and was officially inaugurated on 17 September, 2013.

The factory uses 36 l/s of 70°C hot waste water from a seaweed factory nearby, which was until then discarded. This water, together with 115°C water from a geothermal well that is useful for regulating the heat, is used to boil the sea into brine and dry down in a salt brine.

FIGURE 2: Salt produced at Nordursalt (Nordursalt, 2014)

A boiling tank and condenser are used to boil the sea and let the water evaporate at 50°C, at sub atmospheric pressure. Pressure is maintained by the injection of cold sea water into the steam in the separator standing by the plant. The salt originates from the sea. The sea is boiled in the boiling tank with titanium tubes where the hot heating water flows. Low pressure superheated sea water is placed in contact with the titanium tube, not directly with the geothermal fluid.

Hot water from the boiling tank is used for drying the salt brine and flakes. Brine is dried in salt pans and the salt is finally dried in the dry chamber, from which the salt passes into the packing containers. The energy that drives the processing plant is thus obtained almost entirely from waste water that was unused until the salt factory was taken into operation, and 115°C geothermal water. Electricity is only used to power pumps, the air blower in ventilation spaces, wrapping and for general use. No pollution is emitted from the factory. The use of the waste water is on the contrary seen as positive as the temperature of the waste water from the seaweed factory decreases considerably from what it was previously.

Figure 3 shows a simplified process concept of the pilot salt factory.

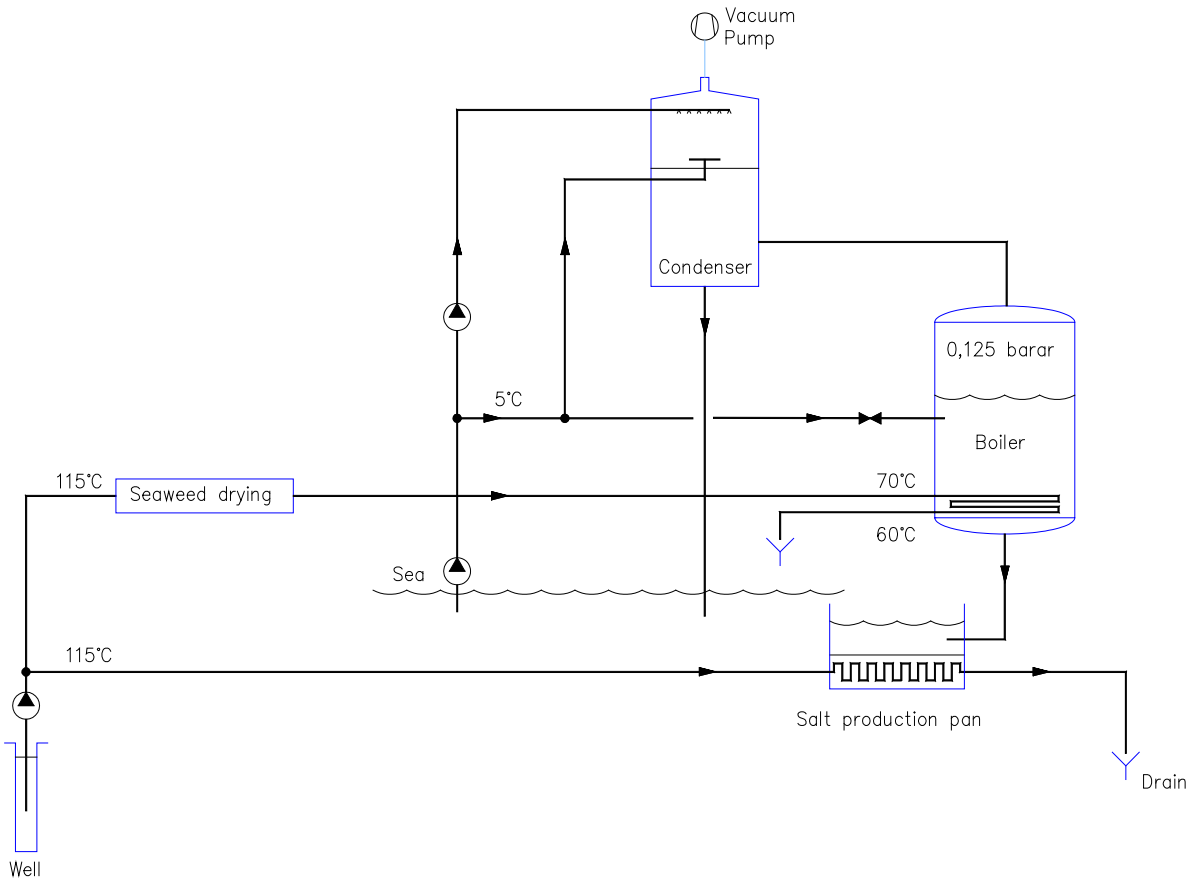

FIGURE 3: Simplified process concept – Pilot salt factory

3.2 Geothermal laundry in Hveragerdi – cleaning and drying

The retirement home Ás in Hveragerdi, Iceland, was founded in 1952 and currently has about 150 residents. In addition, the laundry also provides services to a local health clinic. The laundry, see Figure 4, uses geothermal steam for washing and drying purposes. The energy cost of this "geothermal" laundry is only a fraction of what it would cost to use electricity.

The geothermal laundry was installed in 2006-2007. It uses 150°C geothermal steam from a borehole located nearby. The geothermal steam is directly used to heat up the laundry dryers. Rather important savings in the use of electricity result from the use of the geothermal steam, easily available in the neighbourhood.

FIGURE 4: Laundry dryer

Part of the geothermal steam goes through a heat exchanger used to heat cold water up to 90°C for use in the washing machines. Return water from the dryers, the heat exchanger and from the washing machines is then directed to a cooling tank before it is released back to nature. When at maximum load, the laundry requires about 0.2-0.3 kg/s of geothermal steam. This use of steam for heating enables the laundry to save the electricity normally required for heating and drying.

In addition to using geothermal steam, the laundry also only uses environmentally friendly detergents in the laundry, thus minimising the effects on the environment.

Technical information:

- Geothermal two phase flow from the borehole:
  - 150°C;
  - 0.2-0.3 kg/s at peak load.
- Utilization:
  - Washing machines;
  - Dryers.

Figure 5 presents a simplified process concept for the laundry.

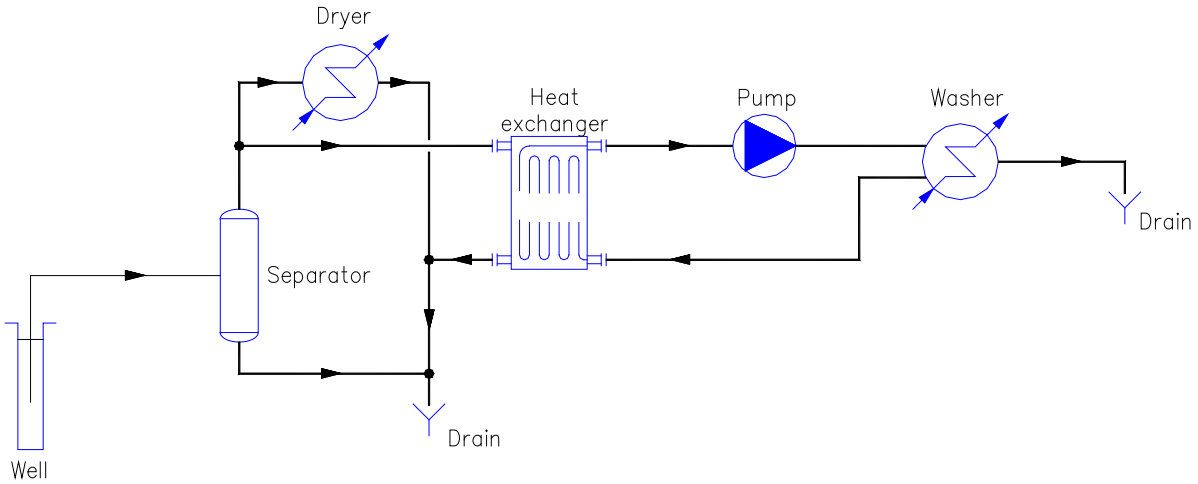

FIGURE 5: Simplified process concept–Laundry in Hveragerdi, Iceland

4. Fish drying in Reykjanes

One of the most successful uses of geothermal resources in an industrial application in Iceland is the fish (head) drying in Reykjanes. The process is rather simple, utilizing high pressure geothermal steam to heat up a closed low temperature (80°C/40°C) water cycle driving the fish drying heater. A low temperature geothermal resources could easily be utilized instead of the steam.

The drying process is done in 2 stages. The first stage is done in a rack cabinet of the conveyor belt drying. The air temperature should be about 18-25°C, relative humidity 20-50% and air velocity 3 m/s.

The duration is about 24–40 h and after that process the water content has gone from 82% down to 55% (Figures 6-8).

The second stage is done with 22-26°C air in a drying container, located on top of an air tunnel. The relative humidity 20-50% and the air velocity 0.5–1 m/s through the drying container. The duration is some 72 h. The water content after drying is lower than 15%.

The total drying time of fish products is in the range of 100–140 h depending on their size and initial water content.

100 kg of fish (heads), with 82% water ends as 21.2 kg of dried fish (heads).

FIGURE 6: Fish products in batch dryer in Reykjanes

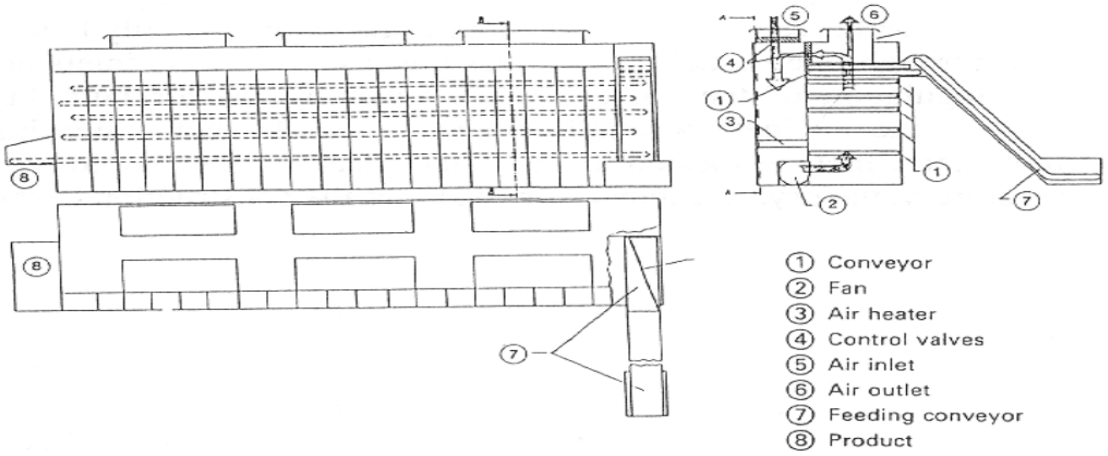

FIGURE 7: Continuous conveyor drying for primary drying

Energy consumption for fish drying is based on the latent heat vaporization for water which is 2,450 kJ/kg, but the design of drying cabinets are normally based on 3,500–5,000 kJ/kg due to heat loss and various other issues.

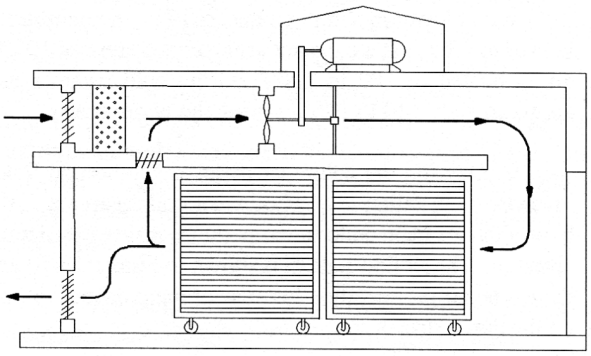

FIGURE 8: Batch dryer for fish drying

5. CONCLUSION

The typical processes involved in industrial uses of geothermal resources require in most cases the use of conventional industrial solutions with minor adaptation taking into account the characteristics of the geothermal fluid and how it may be handled.

Geothermal resources may therefore be directly used for industrial applications in a technically efficient and economically feasible way. Considering the huge potential for industrial applications requiring heat below 120°C, industrial application should systematically be taken into account when scoping potential exploitation activities for a given geothermal field.

The potential value of geothermal resources for direct industrial use is still underestimated. The authors of the paper are convinced that it could be utilised in more situations, should the project developers be more aware of the potential applications and should the industry be less afraid of making the adjustment necessary to be able to use geothermal resources.

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