GEOTHERMAL ENERGY DIRECT APPLICATION IN INDUSTRY IN EUROPE

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Introduction

Geothermal energy was used in industry since by the ancient Etruscans of northern Italy, which made decorative enamels from the boric acid deposited by the steam and hot water at Lardarello. The acid was first extracted commercially in 1818. It quickly became quite useful, and by 1835, nine factories has been constructed in the region. These uses of the resource were restricted to areas where the hot water or steam was easily accessible, so while it was marveled at the concept, did not become widespread.

With modern technology, it is possible to use geothermal energy directly to heat living space and to provide heat for industrial processes. The harnessing of this energy requires only straightforward engineering practice, rather than some revolutionary major scientific discoveries. However, at least in Europe, this particular type of geothermal energy application is still very rare and limited in several countries.

1. POSSIBLE FIELD OF USE

Possible field of use is very wide (Fig.1). Practically, everywhere where low temperature heat is necessary it can be covered with the one extracted from geothermal brines. Depending on the technical organization of concrete industrial process, use of geothermal energy can be independent or in combination with the heat of other origin (fossil fuels, electricity, bio energy, etc.

2. BASIC INDUSTRIAL PROCESSES WITH POTENTIAL APPLICATION OF GEOTHERMAL ENERGY

In industrial applications, thermal energy in the temperature range being considered here (below 150 ºC) is used in the basic processes of: preheating, washing, peeling and blanching, evaporation and distilling, sterilising, drying and refrigeration.

2.1 Preheating and heating

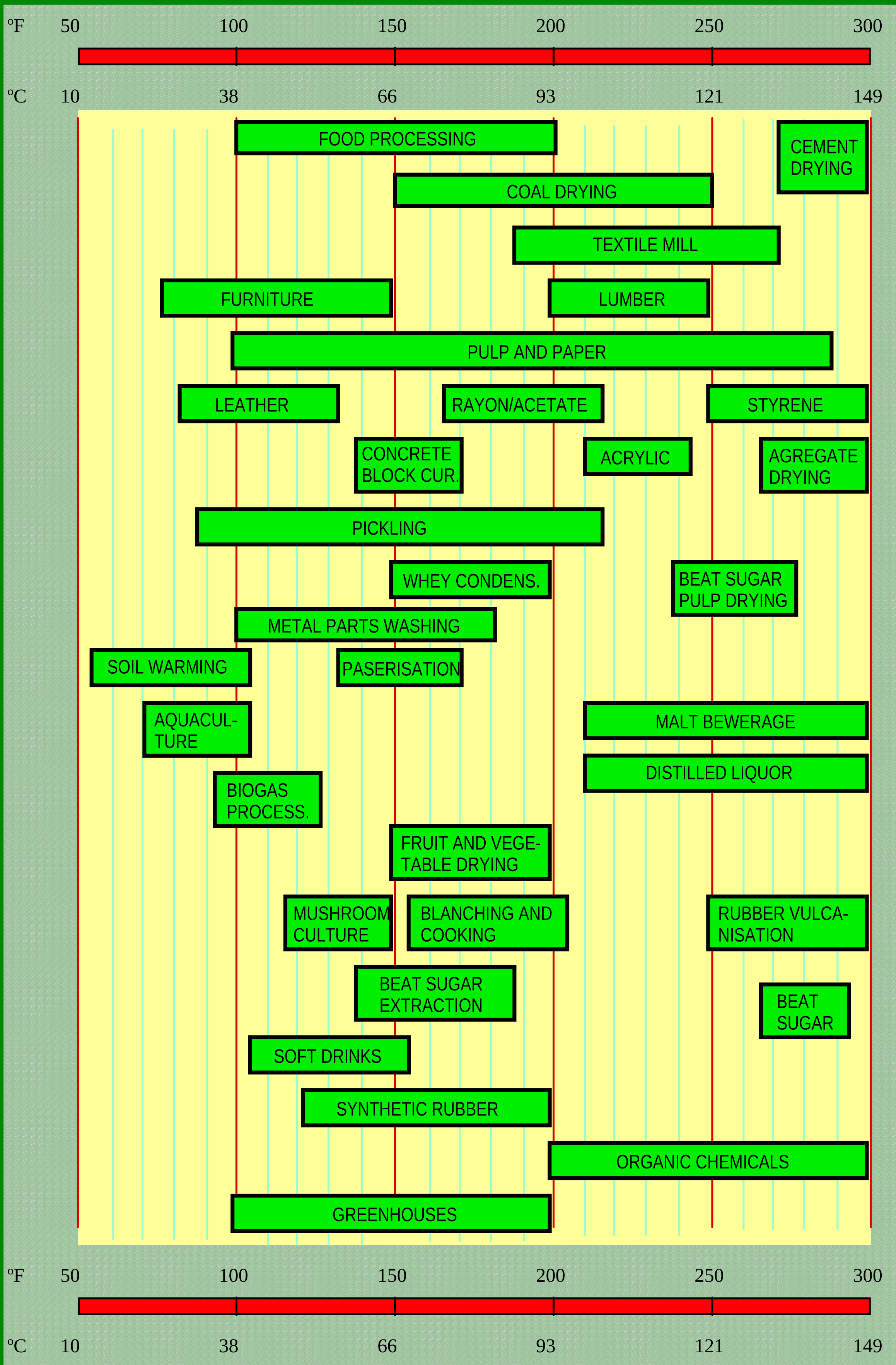
Geothermal energy can be effectively used to preheat boiler and other process-feed water in a wide range of industries. For a variety of reasons, much of the condensate is not returned. This imposes a considerable load on the boiler for feed-water heating of incoming water at typically 10-16 ºC up to the temperature at which it is introduced into the boiler, typically 93-149 ºC, depending on the system.

The geothermal resource can be used to offload the boiler of some or all of this preheating load. A wide variety of industries use for various processes, large quantities of feed water which can be preheated or heated geothermally to the use temperature.

2.2 Washing

Large amounts of low-temperature energy (35-90ºC) is consumed in several industries for washing and clean-up. One principal consumer is food processing, with major uses in meat processing for scalding; in soft drink production for container and returnable bottle washing (77ºC); in poultry dressing as well as canning and other food processes. Textile industry finishing plants are another large consumer of wash water at 90ºC. Smaller amounts are used in production of plastics (85-90ºC) and leather (50 ºC).

Sizable amounts of hot water and other hot fluids at temperatures under 90 ºC are used in several metal-fabricating industries, machinery and transportation equipment, for parts digressing, bounderizing and washing processes.



TEMPERATURE RANGE OF SOME INDUSTRIAL AND AGRICULTURAL PROCES

2.3 Peeling and blanching

In the typical peeling operation, the product is introduced into a hot bath, which may be caustic, and the skin or outer layer, after softening, is mechanically scrubbed or washed off. Peeling equipment is continuos-flow type in which the steam or hot water is applied directly to the product stream or indirectly by heating the product bath. In most instances, produce contact time is short.

Blanching operations are similar to peeling. Product is usually introduced into a blancher to inhibit enzyme action, provide produce coating, or for cooking. Blanching may be either a continuous or batch operation. Typical blanching fluids require closely controlled properties. Thus, it is unlikely that geothermal fluids could be used directly in blanchers and peelers because of the water quality. Geothermal fluids could, however, provide the energy through heat exchangers.
The temperature rang for most of the peeling and blanching systems is 77-104 ºC.

2.4 Evaporation and distillation

Evaporation and distillation are basic operations in many processing plants to aid concentrating a product or separating products by distillation. The source temperature requirements vary with the product being evaporated. However, in a majority of agri-cultural processes, water is being driven off; and in these cases, operating temperatures of 82-120 ºC are typical. In some circumstances, the evaporators operate at reduced pressures which decrease temperature needs and improve product quality.

Evaporators are commonly found in sugar processing, mint distilling and organic liquor processes. Evaporators, depending upon temperature and flow rate requirements, can be readily adapted to geothermal energy as the primary heat source. The energy can be transferred trough secondary heat exchangers to the working fluids or, in some instances, used directly at evaporator, depending upon existing plant designs or adaptations to new plant expansions.

2.5 Sterilising

Sterilisers are used extensively in a wide rang of industries and include applications such as equipment sterilisation for the canning and bottling industry. Most sterilisers operate at temperatures of 104-120ºC and would utilise geothermal energy with the use of heat exchanger potable steriliser water. Many sterilisers operate in a continuous mode. Equipment washdown and sterilisation, however, may occur periodically or at shift changes.

3. ELEMENTS OF GEOTHERMAL TECHNOLOGY FOR INDUSTRIAL APPLICATIONS

The technology composition for geothermal system function for industrial uses can be divided in two main parts.

The first part includes the general elements of geothermal systems and these are: geothermal well, connector to the geothermal well or a net of distribution, fluid transportation pipes, equipment for chemical treatment of water and apparatus of heat exchangers.

The second part is consisted of elements specific for the industrial application of geothermal energy and they are as follows:

- steam extraction system,
- system for upgrading geothermal fluids,
- equipment for adjustment of parameters (pressure, temperature and flow),
- processing apparatuses for implementation of technological processes.

3.1 General elements of geothermal systems

In this section, same stated general elements of direct application of geothermal energy are discussed, from the aspect of industrial use.

Geothermal well

There are a variety of methods of providing geothermal fluid to an above-ground system. Artesian wells provide surface water naturally and some non-artesian wells can be induced to flow without pumping.

A mechanism by which a non artesian well can be induce to flow is to reduce the density of the column of liquid in well. For instance, if the liquid is to mixed with gas, the combined fluid density may be low enough that the downhole conditions allow the liquid partially flash to steam, the reservoir maintains the low-density liquid-vapour mixture in the well.

An important advantage to pumping a self-flowing well is that pressure of the liquid is maintained, so downhole flashing and scaling are minimised. Also, by not allowing the fluid to flash, the discharge temperature can be much higher than the surface temperature of an self-flowing well. This is an important consideration when high-temperature geothermal applications are desired.

However, several factors, such as depth of the well, fluid chemistry, temperature and pressure of geothermal fluid, should be considered by the designer in choosing a geothermal well pump.

Important part of the connector to the geothermal well, is the apparatus for degassing.

Heat exchangers

The principal reason for having heat exchanger in geothermal systems is to confine the geothermal waters with their inherent impurities where corrosion or scaling can either be controlled by material selection or where cleaning will be relatively easy and economical.

It must be remembered that there will be a temperature differential between the primary and secondary fluids any time the heat exchanger is used.

Approach temperatures of less then 6ºC are often uneconomical but depend on heat-exchanger type and particular application.

The principal types of heat exchangers used in geothermal systems are the downhole heat exchangers; the shell-and tube heat exchanger; the fluidised-bed heat exchanger; the direct-contact heat exchanger; and the plastic-tube heat exchanger.

The downhole heat exchanger eliminates the problem of disposal of geothermal fluid, since only heat is taken from the well. The exchanger consists of a system of pipes or tubes suspended in the well through which clean secondary water is pumped or allowed to circulate by natural convection.

The interaction between the fluid and aquifer and that in well is not fully understood, but it appears that outputs are higher where there is a high degree of mixing, indicating that somewhat permeable formations are preferred.

3.2 Specific elements of geothermal system

In this section, stress is not given to the equipment for adjustment of parameters, and processing apparatuses for implementation of technological processes, because the geothermal system uses the same elements as the conventional one.

Steam extraction system

Multiple-temperature steam heating systems are routinely used in industrial process plants. In geothermal technologies, use of the steam flashed from geothermal fluid has many advantages because heat transfer rates with condensing steam are uniformly high, steam is less susceptible to fouling and as very important, any scaling in the flash step can be controlled by proper design of the flash vessels and by the use of scale-suppressant additives.

The design of an extraction system consists of the following parts: Geothermal fluid from each well is pumped individually to the energy extraction system. Here a scale control additive is put into the brine by a positive displacement pump and mixed in a static mixer. The fluid than flows to the first, second and third vessels where the pressure is reduced to the production requirements temperatures.

After filtration the liquid is routed to the individual reinjection well where high-pressure pumps force the liquid into the receiving strata.

System for upgrading geothermal fluids

The energy that is available initially from geothermal well is heat, usually in the form of hot water or wet steam. The higher level heat should first be extracted and a cascading use can then be accomplished to maximise energy utilisation. The industries, such as pulp and paper and chemical industries, probably will require steam at varying pressures. In most cases, the heat is extracted for process use by the following means:

1. Geothermal fluid to process fluid heat exchange;
2. Convert to steam for process heating and for electricity generation; and
3. Convert to a secondary fluid vapour (freon, isobutane, etc) for electricity generation or process heating.

Each of these means for heat transport can have some application in specific processes. Taking into account that steam is the universal process heating media, we will concentrate on designing system supply process steam at needed pressures by way of compression.

Mechanical compression, although being capital cost intensive, is used for the high grade energy upgrading the low heat and pressure.

The basic system for upgrading a geothermal fluid for various industrial process pressures has incorporated a flash vessel for the production of steam; a compressor driven by an isobutane turbine; an isobutane condenser, and a heat exchanger to heat and evaporate the condensed isobutane using the geothermal fluid.

4. PLANTS AND INSTALATION MATERIALS FOR GEOTHERMAL ENERGY APPLICATION

The change of the technological process in old plants, by applying geothermal energy, excludes discussion on plants and installation materials for the use of this energy, because the only thing necessary to be done to supply the plant with geothermal energy is to prepare the geothermal fluid chemically.

Regarding prospective or new plants projects in which geothermal energy is to be introduced, materials corresponding to the water property must be specified in order to avoid corrosion attacks.

High salinity geothermal fluids will cause high uniform corrosion as well as localised corrosion and will severely limit the use of carbon steels. The application of mild steels to geothermal environments requires that precautions be taken for deaeration, flow rate, scaling, galvanic coupling, protection of exterior surfaces and steel specifications.

By taking appropriate precautions, carbon steels can be used for thick-walled applications in contact with most geothermal fluids. Thin-walled applications will be limited by the susceptibility of these materials to localised attack, such as pitting and crevice corrosion.

5. OPTIMISATION OF INDUSTRIAL APPLICATION OF GEOTHERMAL ENERGY

Industrial application of geothermal energy shall follow two directions in development:

1. in utilisation of existing plants and equipment, and
2. in building new installation and complex technologies, adopted to the application of this sort of energy.

In the first case, optimisation should is used as an instrument for examination of economical advantages in application of geothermal energy, over some classical energy resources. This optimisation is determined both temporal and spatial. Optimisation within the system itself has an aim to examine which of the methods used in application of geothermal energy in existing technological equipment is more feasible. There are two available methods:

1. direct application of chemically treated geothermal fluid, or
2. the application of heat exchangers using the heat of geothermal fluid for feeding the secondary thermal circuit.

Optimisation plans should include certain changes in the technological process in order to enable the application of geothermal energy, utilisation of thermal pumps and determination of the maximal energy level within technological process.

Optimisation on the second level should include mathematical analysis of the great number of factors that are decisive in the development of certain industrial technology. The most important among those factors are: the geothermal fluid parameters chemical structure of the fluid, quality and price of the plant and parameters and regimes of the technological process itself. The equipment for environmental protection is to be mentioned as well.

6. CONCLUSION

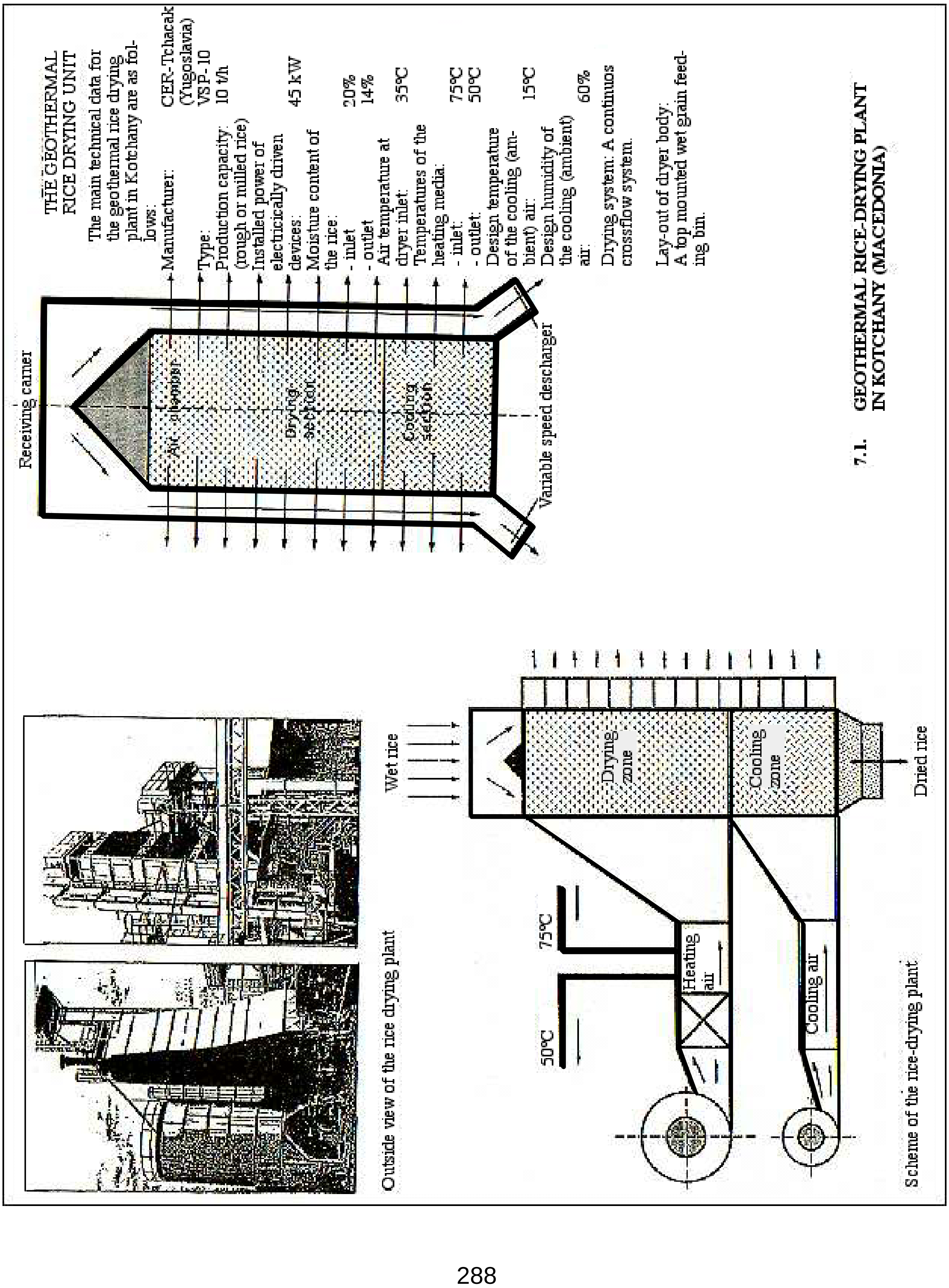
In the world-wide practice, the application of geothermal energy, as an alternative energy resource, can be of a great importance. This is especially the case in the countries where exceptional natural geothermal potentials exist.

The major contribution in development of the special technological equipment, required for the utilisation of this kind of energy, (e.g. pumps, transportation equipment, chemical treatment of fluid, heat exchangers, etc.), is realised in technologically developed countries, i.e. U.S. and Western European ones.

The industrial application of geothermal energy is at the beginning in Europe. However, the existence of geothermal fields as well as the insufficient resources of conventional energy represents the challenge for further investigations in this field. Quality of geothermal resources that are available in Europe, dictates the use of this type of energy within the low-temperature technological processes. These processes are significantly engaged in different groups of processing industries. Therefore, the expectations for broader engagement of professional and scientific potentials in various disciplines, is quite legitimate.

7. EXAMPLES OF INDUSTRIAL APPLICATIONS IN EUROPE

There are not many examples of direct application of geothermal energy in Europe. One of them is as follows:



7.1. GEOTHERMAL RICE-DRYING PLANT IN KOTCHANY (MACEDONIA)

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