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INDUSTRY DIRECTION™

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Geothermal plants: a brief state of the art

Geothermal power plants were in commercial operation in Italy since 1914 and in New Zealand since 1958. The first geothermal power plant in the Americas was inaugurated at Pathé in Mexico on November 20, 1959. The United States joined this exclusive club the next year when it inaugurated the PG&E Geysers Unit 1 in Northern California in September 1960.

Most of the geothermal wells produce hot water and steam, but long term flowability is a lingering issue. Most wells fail to maintain flow for very long. Only the productive and long-lived wells are candidate enough for the installation of small power plant, often of the size of between 25 MW-110 MW power plant. However, with time many active wells begin to lack permeability, bring low-to-moderate temperature steam, or die shortly after producing.

The reason for the brief operation of wells is not well explained or deciphered. They encounter small, limited steam caps, or suffer from wellbore scaling. The latter would lead to a narrowing of the wellbore, essentially a throttling process, with progressive and accelerating reduction of flow. Some such problems are managed with downhole injection of chemical scale inhibitors, as is routinely conducted.

Fig.1: A geothermal plant

Types of geothermal power plants

There are three basic types of geothermal power plants:

Dry steam plants use steam directly from a geothermal reservoir to turn generator turbines. The first geothermal power plant was built in 1904 in Tuscany, Italy, where natural steam erupted from the earth.

Flash steam plants take high-pressure hot water from deep inside the earth and convert it to steam to drive generator turbines. When the steam cools, it condenses to water and is injected back into the ground to be used again. Most geothermal power plants are flash steam plants.

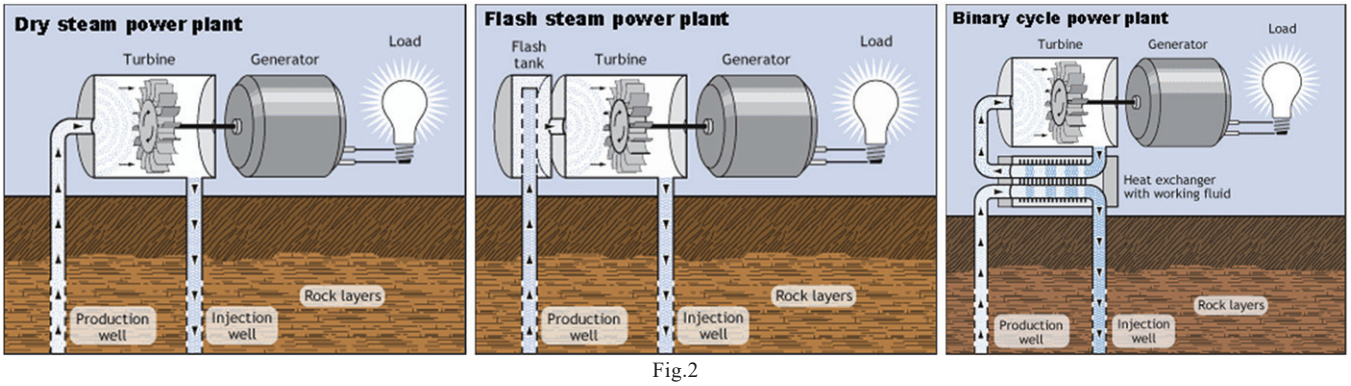

Fig.2

Binary cycle power plants transfer the heat from geothermal hot water to another liquid. The heat causes the second liquid to turn to steam, which is used to drive a generator turbine. The differences between dry steam, flash steam, and binary cycle power plants are shown in the diagrams (Fig.2).

Turbine

A typical turbine of a geothermal plant consists of 12 stages of blades: the first stage comprises impulse-reaction blades (low-reaction, ~"10–20% degree of reaction, DOR), while the last 11 stages were ~"50% DOR blades (Fig.3). The unit is fitted for bottom inlet and bottom exhaust in some cases where the turbine-generator sits on an elevated platform, with the inlet and outlet steam piping passing through a cellar.

The unit in the figure is rated at 3500 kW with inlet steam pressures between 4 and 8 ata (roughly 400–800 kPa) and an inlet steam temperature of about 200°C. The turbine-generator package is "semi-moveable" in that it is mounted on a platform that could be separated, allowing the turbine and the generator to be moved independently, thereby reducing the weight to be borne by individual transporters.

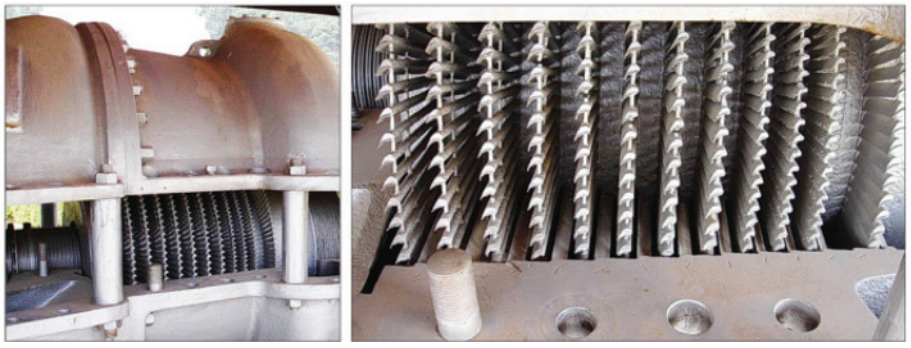

Fig.3: (left) a typical turbine of a 3.5 MW plant; (right) detail of the blades; steam flows from right to left.

Modern turbines

One of the major suppliers of geothermal turbines is Mitsubishi Power has supplied more than 100 units (totalling more than 3,000 MW) of steam turbines for geothermal power plants, ranging from small output to large output units to meet various operational requirements.

1. SC1F – Single casing for 1 exhaust flow direction

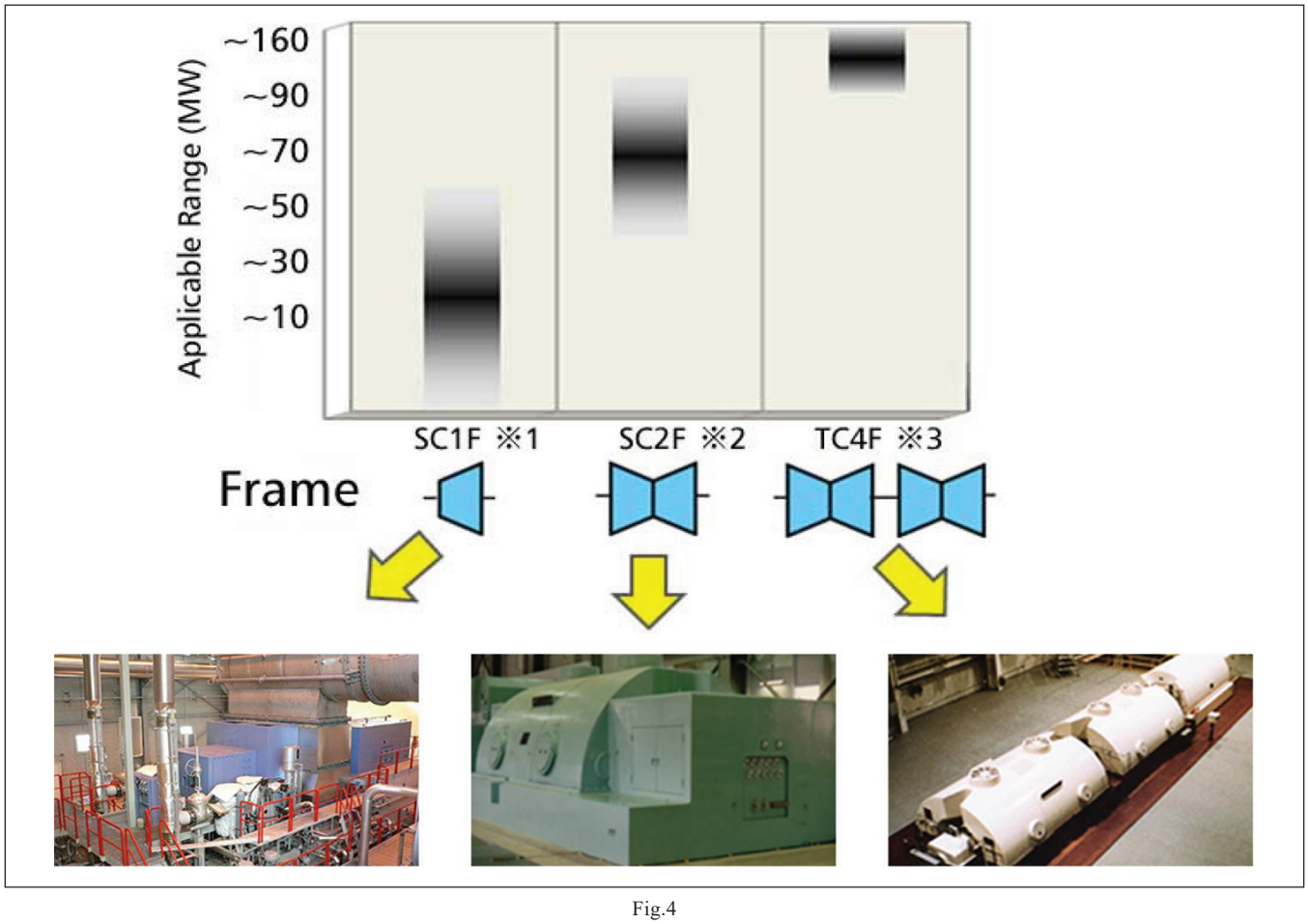

Fig.4

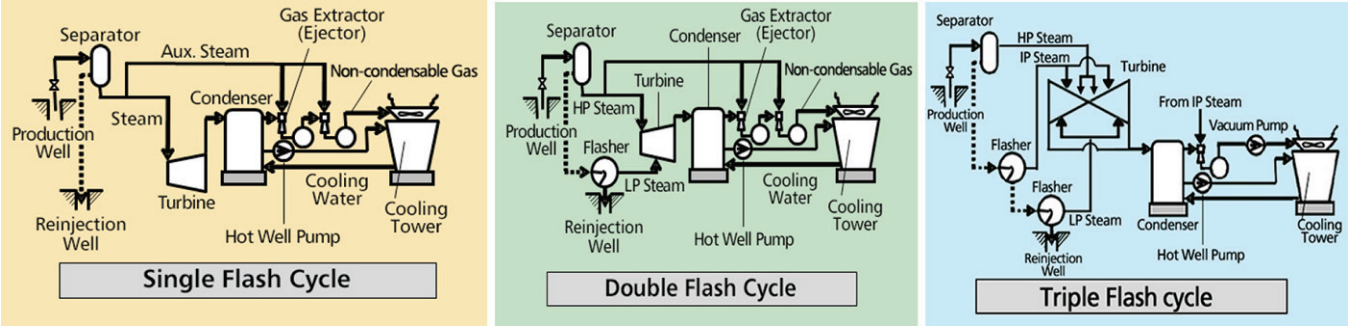

Fig.5

2. SC2F – Single casing for 2 exhaust flow directions
3. TC4F – Tandem compound (double casing) for 4 exhaust flow directions

Mitsubishi have steam turbine lineups for single flash, double flash and triple flash cycles to meet the requirements of different geothermal steam conditions.

Geothermal heat pumps

Although air temperatures above ground change throughout the day and with the seasons, temperatures of the earth 3m below ground are consistently between 10°C and 16°C. For most areas of the United States, this means soil temperatures are usually warmer than the air in winter and cooler than the air in summer. Geothermal heat pumps use the earth's constant temperature to heat and cool buildings. Geothermal heat pumps transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer. According to the U.S. Environmental Protection Agency (EPA), geothermal heat pumps are the most energy-efficient, environmentally clean, and cost-effective systems for heating and cooling buildings. All types of buildings, including homes, office buildings, schools, and hospitals, can use geothermal heat pumps.

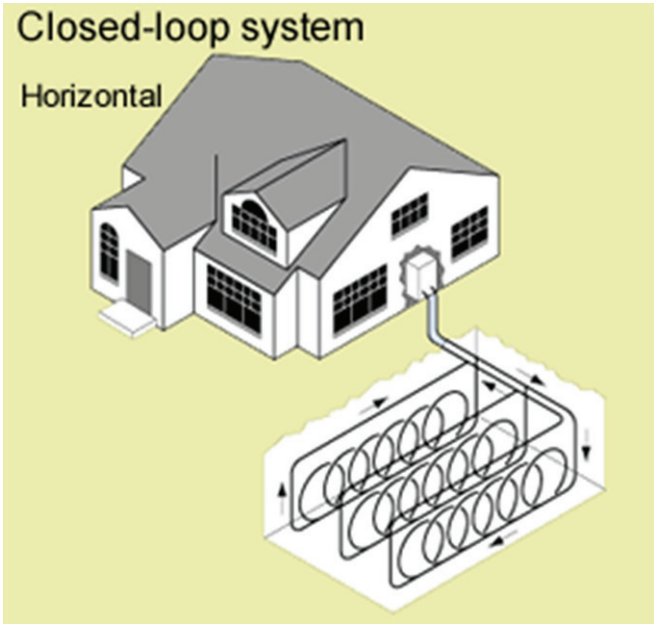

Fig.6: A typical geothermal heat pump system

Acknowledgement

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