Advanced Low-Temperature Geothermal Technology

Delbert D. Thomas ME – Trimodal Group, Corp.

ABSTRACT

The LTPC engine is a positive displacement device that does not depend on high-pressure steam to create energy. While the LTPC engine can be used very effectively with steam, it was primarily designed to use a refrigerant as the working fluid, which enables it to create energy from fluid temperatures as low as 150F. Having the ability to create energy at these low temperatures opens up global markets for waste heat recovery, low temperature geothermal, and cost effective solar with longer lasting storage.

Keywords: geothermal, solar, waste heat, power generation, green power

1 RANKINE CYCLE ENGINES

The "Rankine Cycle" has been recognized for well over 100 years as an excellent method of converting heat into mechanical energy. Perhaps the best-known applications were the steam locomotives that pulled trains across the continent in the 1800s.

Even today most power plants, including nuclear, use the Rankine Cycle to generate power, using turbines where the energy source is steam. Whether the fuel is coal, gas, oil, or nuclear; the heat generated by the combustion of these fuels is used to generate steam. This steam, at a pressure of approximately 600 psig to 1000 psig, which spins a turbine, converts the heat to mechanical energy.

2 ORGANIC RANKINE CYCLE ENGINES

The LTPC engine is a positive displacement device that does not depend on high-pressure steam to rotate a multistage turbine wheel and it is capable of using a heat source as low as 150 F, whereas a steam turbine requires a heat source of over 600 F to be efficient. Because the turbine is essentially a "fan" there is a "slippage" as the steam passes through the turbine wheel, whereas a positive displacement device is far more efficient than and therefore capable of producing mechanical energy at a much lower pressure. The LTPC engine efficiency obtained is in the area of 55% compared to 25% to 35% efficiency for a turbine using comparable steam.

Although the LTPC engine can be used very effectively with steam, it was primarily designed to use a refrigerant as the working fluid, in lieu of water as does a steam engine, and is termed as an "Organic Rankine Cycle" engine. The Organic Rankine cycle engine has become very popular for the generation of power from geothermal energy sources.

There are many such geothermal installations throughout the world of these phase change engines. California has over 24 such plants in operation with Nevada over 40. These plants all use turbines and therefore cannot operate at temperatures lower than 200 F and actually operate most efficiently at temperatures between 400F and 600F.

Currently, there are no positive displacement prime movers (engines) in the low-grade geothermal industry. State of the art equipment is still based on turbine and screw compressor prime mover geometry. The Trimodal LTPC utilizes positive displacement technology with several innovations that will significantly increase overall thermal efficiency, particularly with low-grade, below temperature geothermal brine.

2.1 Liquid Refrigerant vs. Water

The working fluid in the LTPC engine does not use water like a steam turbine, but rather, it uses a refrigerant. This refrigerant generates far more pressure at a lower temperature than water / steam.

The patent pending LTPC engine system pumps high pressure liquid refrigerant into an evaporator where the low value heat is added to the vapor and the resultant high pressure vapor, approximately 300-575 psig, is used to drive double acting pistons within cylinders. A conventional automotive type engine derives its energy from expanding gasses working against the head of a piston every other rotation of the crankshaft.

2.2 Double Acting Pistons

A double acting piston uses the high-pressure gas to drive the piston downward as well as upward. This means twice the energy is produced per cycle; and compounding the cylinders further increases the efficiency. This means that the unused energy leaving the first or high-pressure cylinder enters the second stage or low-pressure cylinder to extract added work energy. In a breakthrough, which was designed to minimize internal friction losses, piston rings are eliminated and "deliberate blow-by" is used to entrap a fluid boundary layer seal.

The piston diameter of the second stage piston is approximately twice that of the first stage piston (four times the surface area) so as to produce equivalent power as the

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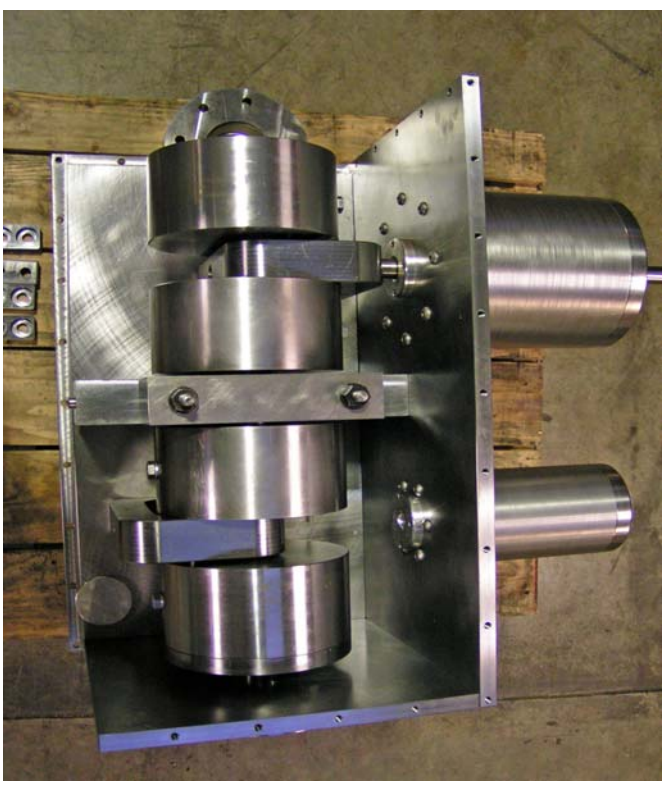
smaller higher-pressure first stage piston. The vapor leaving the low-pressure cylinder passes through a heat exchanger and then to a condenser where the vapor is returned to the process as a liquid. The heat exchanger mentioned reclaims some of the heat and transfers this energy into the refrigerant liquid before it enters the evaporator and the cycle is repeated.

The cylinders of the LTPC engine are arranged in an "opposed" or "pancake" configuration. In an original design move, alignment rods extend beyond the cylinder heads (via bushings) to maintain perpendicularity of the connecting rods to the crank, eliminating side loads and maintaining piston alignment within the cylinders without contact.

2.3 Scotch Yoke

There is a "Scotch Yoke" arrangement in lieu of a conventional crankshaft. This arrangement, along with a rotational speed of approximately 650 RPM allows a smooth almost vibration free operation. There is a close tolerance, but no contact between the pistons and the cylinder walls. The design uses an electronic-solenoid valve, eliminating camshafts and valve lifters, thus creating an engine with minimum friction and parasitic load.

The LTPC engine is quite simple to construct. Most of the engine can be injection molded from reinforced thermosetting plastic with metal use being reserved for the output shaft, connecting rod and fasteners.



Cut-away of the LTPC

3 MARKET OPPORTUNITIES

There are many sources of low value heat that can be used to operate the LTPC engine. Trimodal Group has targeted low-grade geothermal, large scale solar and coal fired utility plant waste conversion to enhance plant efficiencies. In most cases, the system will operate cost effectively with below steam temperature regimes.

A partial list follows:

- Low Temperature Geothermal Sources (hot springs and shallow wells);
- Low Cost Solar Collectors, as pre-heat to focused systems;
- Proprietary low cost, low tech "timed" reflecting solar arrays that can deliver competitive power (<10 cents/KwH) when coupled to the LTPC array in large solar desert arrays.
- Boiler and Industrial Furnace Stacks.
- Low Pressure Steam at Condensers of Conventional Power Plants
- Gas Turbine HRSG Discharges
- Refrigeration Plant De-Super heaters
- Hot Natural Gas in some Oil Fields
- Waste Heat from Steel and Aluminum Rolling Mills
- Waste Hot Water and Low Pressure Steam from Industrial Processes.

There are countless low temperature worldwide geothermal sources that can be used to power the LTPC engine to generate electrical power or to operate pumps or other such rotating devises. These shallow geothermal brines are concentrated around the Pacific Rim nations, the East Africa rift and through central Europe. Estimates are that 300,000 megawatts are readily available throughout these regions with wells less than 1,500 feet (500 meters) in depth.

4 ADDITIONAL APPLICATIONS

The LTPC engine has a definite, targeted application within existing coal-fired power plants. The use of waste heat from such plants allows less coal to be burned to produce the same amount of electrical energy therefore reducing carbon emissions. The recovery and conversion of heat currently absorbed at the condensers immediately at the steam turbine discharge ports will move the thermal cycle efficiency of single stage coal plants from 33% to plus 50%.