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PACKAGE REFRIGERATION UNITS OPERATED WITH GEOTHERMAL FLUIDS

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ABSTRACT

The coupling of two helical rotary screw expanders, one being used as a screw type compressor, and the other one as a prime mover, can be utilized as a portable refrigeration unit, capable of being operated with the total flow of a geothermal well of an intermediate to high temperature water geothermal system.

INTRODUCTION

The use of the screw compressor, also known as the Lysholm engine, for the gas and process industries has been known since its invention, but it was not until the late 1950's when it was introduced to the refrigeration industry, for compressing refrigerant vapors. On the other hand, the helical rotary screw expander, now in its experimental stage as a total flow geothermal prime mover for electric power generation, has demonstrated its reliability and high efficiency. The coupling of these two units has not been attempted, but this combination seems to be an attractive application of the geothermal energy in areas where cooling, rather than heating, is required, without the need of going through the electricity generation stage.

The Lysholm Engine

The Lysholm Engine invented in 1934 by the Swede Alf Lysholm, was primarily designed for gas compression and its rugged construction is responsible for its excellent reliability. Its use as an engine, was first reported by H.R. Nilsson in 1952.

The Lysholm engine (Fig. 1) consists of two intermeshing rotor shafts. One of the rotors is male, and the other female. The male rotor is usually driven by the motor and has four lobes. The female rotor is driven directly or through gears by the male rotor and has six interlobe spaces.

Both rotors are contained in a stationary housing, with inlet and outlet gas ports. The flow of gas in the rotors is both radial and axial.

With a four-lobe rotor and a six lobe female rotor the male rotor rotating at 3600 RPM, the fe-
The helical rotary compressor makes the unit very attractive wherever a high pressure differential is required in a geothermal field. The idea of connecting the surface as the hydrostatic pressure diminishes, obtaining at the well-head a steam-water mixture. Normally an orifice is installed in the line, which produces a pressure drop resulting in a mixture with a higher steam water ratio, which can be separated into its components, using the steam for power generation in a steam turbine and sending the water to waste.

The use of the Lysholm engine in a geothermal field was first attempted at Cerro Prieto in wells M-7 and M-10 in 1971 and 1972, by Sprankle, with a small unit of 62.5 KVA. Its successful operation made the promoter of the application build a much larger unit, which later was tested in the U.S., Italy, once more in Cerro Prieto at well M-11 and in New Zealand.

Efficiencies well in excess of 70% can be obtained, but most of all, the idea of connecting the unit directly to the well-head, without any separator makes the unit very attractive wherever power is required in a geothermal field.

As a geothermal prime mover, the screw expander under the auspices of Hydrothermal Power Co. has undergone several modifications in the configuration, the method of construction and the shaft-seals. The configuration modifications were the following: The expander exhaust in the original design was pointing vertically upward, which allowed liquid to accumulate in the exhaust section, blocking it and causing unnecessary back pressure. This disadvantage was corrected in the revised configuration where the exhaust flows downward from the expander. In both of these configurations, the rotors must sweep unflashed liquid the entire length of the machine, resulting in pumping losses. In addition, the exhaust porting provided passages unswept by the rotors where the scale could accumulate (Fig. 2). The opening of a discharge port in the lower part of the casing provided unrestricted exhaust porting and minimum pumping losses.

The Geothermal Package Refrigeration Unit

As in any refrigeration cycle of the compression type, the expanded refrigerant gas enters the compressor through the suction inlet. The compressor...
or raises its pressure and is delivered through the discharge outlet. During the process the gas temperature raises, because of the compression work that is added to it.

Because of being this compressor of the oil rejection type, the refrigerant gas delivered by the compressor carries over large amounts of lubricating oil, therefore an oil separator has to be installed downstream the compressor (Fig. 3).

The high pressure refrigerant vapor is discharged into the condenser where it gives up its latent heat of vaporization and is cooled and returns to a liquid.

The condenser can be air cooled, water cooled in a shell and tube heat exchanger or cooled in an evaporative cooler.

The liquid is collected in the lower part of the condenser or in a liquid receiver. From here it flows through the expansion valve where its pressure is reduced. The low pressure liquid vaporizes in the evaporator absorbing the heat of the surrounding media.

In this package refrigeration unit the direct expansion is preferred. In an air conditioning system of this type, the refrigerant liquid at high pressure is sent to the air handlers, where the cooling coils or evaporator are located, downstream the expansion valve. The air to be cooled is circulated through the cooling coils by means of the air handlers and sent through ducts to the air conditioned rooms. (Fig. 3).

For industrial processes brine is chilled in the evaporator and then sent to process for cooling purposes.

Big savings have been achieved, in maintenance and power costs, with screw compressors replacing reciprocating units. The use of helical rotary screw expanders actuated with geothermal fluids as prime movers, besides increasing these savings, by using the geothermal energy more efficiently, make the package refrigeration unit more independent, since no electricity is needed for running it and so power lines are not necessary, which permits installing these units in remote areas where there is nothing but a geothermal well.

REFERENCES


Fig. 3. Direct Expansion Air Conditioning with screw compressor actuated by helical rotary screw expander.