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Title: USING A HOT DRY ROCK GEOTHERMAL RESERVOIR FOR LOAD FOLLOWING

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USING A HOT DRY ROCK GEOTHERMAL RESERVOIR FOR LOAD FOLLOWING

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ABSTRACT

Field measurements and modeling have shown the potential for using a Hot Dry Rock (HDR) geothermal reservoir for electric ***load following***: either with Power-Peaking from a base-load operating condition, or for Pumped Storage of off-peak electric energy with a very significant thermal augmentation of the stored mechanical energy during periods of power production. For the base-load with power-peaking mode of operation, an HDR reservoir appears capable of producing over twice its nominal power output for short -- 2 to 4 hour -- periods of time. In this mode of operation, the reservoir normally would be produced under a high-backpressure condition with the HDR reservoir region near the production well highly inflated. Upon demand, the production backpressure would be sharply reduced, surging the production flow.

Alternatively, for Pumped Storage, the reservoir would be operated in a cyclic mode, with production shut-in during off-peak hours. When the produced thermal energy of such a pumped-storage system is considered, an HDR reservoir would be capable of returning considerably more energy to the surface during the production phase than would have been consumed in inflating the reservoir during the off-peak storage phase. Pumped Storage reservoir operation was actually demonstrated experimentally during a brief series of cyclic reservoir tests at the end of the Long-Term Flow Test (LTFT) of the HDR reservoir at Fenton Hill, NM in May 1993.

The analytical tool used in these investigations has been the transient finite element model of the an HDR reservoir called GEOCRACK, which is being developed by Professor Dan Swenson and his students at Kansas State University. This discrete-element representation of a jointed rock mass has recently been validated for transient operations using the set of cyclic reservoir operating data obtained at the end of the LTFT.

INTRODUCTION

The subjects of Power Peaking and Pumped Storage Energy Production, which would offer electric utilities flexibility in load management when using engineered Hot Dry Rock (HDR) geothermal systems, are very timely as concerns the commercialization of HDR geothermal technology. This is because one or the other of these load following concepts may provide an initial "niche" market application which would allow HDR geothermal energy to become economically competitive earlier in the commercial demonstration phase, before HDR technology would have had sufficient time for the anticipated engineering refinements that will be necessary to make HDR power generation an accepted option in the presently very competitive electric power marketplace. In both of these applications, one would use the large fluid capacitance of a highly pressurized HDR reservoir to store and then rapidly produce energy. The resulting flexibility offered by these engineered HDR systems may be the ultimate key to the development of HDR geothermal energy as a commercial reality.

The first concept is that of on-demand power peaking using an HDR geothermal system. In this concept, the HDR reservoir would be continuously produced in a high-backpressure base-load operating mode with the ability -- and flexibility -- to almost instantaneously double the power output by dropping the production backpressure to a much lower level. In practice, this might be accomplished by reducing the backpressure from a base-load level of 3000 psi to 700 psi in less than a minute, effecting a very significant increase in the production flow rate, as well as an increase in the produced geofluid temperature, as the inflated portion of the reservoir surrounding the production wellbore is rapidly vented.

The second concept is that of using an HDR reservoir for pumped storage and power peaking as follows: The reservoir would be shut-in and pressurized with an electrically driven pump during off-peak hours, inflating the reservoir with fluid and storing mechanical energy through the elastic compression of the rock comprising the HDR reservoir region. Then, the reservoir would be partially vented during the subsequent period of peak power demand, returning the previously stored mechanical energy in the form of a much larger amount of thermal energy. This augmented energy production, with the mechanical energy being returned as thermal energy, obviously results from the increase in the enthalpy of the injected fluid as heat is extracted from the HDR reservoir during the storage phase of the cycle. This recovered thermal energy, during the production phase of the cycle, would then be converted to electrical energy in a conventional geothermal power plant.

In this "pumped-storage" mode of operation, an HDR reservoir is capable of returning to the surface significantly more thermal energy than was stored as mechanical energy during the hours of off-peak pressurization. This behavior is not unlike that of a heat pump, which is capable of providing several times its electric power input as space heat during winter months.

This study represents only a first analysis of these two HDR load-following concepts. A more definitive study must await a comprehensive experimental data set supported by further numerical modeling. The presently available data is from a 3-day sequence of cyclic flow experiments performed in May 1993, at the end of the Long-Term Flow Test (LTFT) of the Fenton Hill HDR reservoir. The modeling results presented here will allow us to better define and plan the sequence of HDR production flow experiments planned for the summer of 1995.

Hopefully, questions regarding how best to operate an HDR reservoir in a base-load mode with extended power surges will be answered experimentally during the reservoir flow testing planned for the summer of 1995.

DISCUSSION AND CONCLUSIONS

These preliminary experimental and modeling results suggest that load-following methods of HDR reservoir operation could be very attractive from a commercial power-production standpoint.

The HDR load-following concept which maintains the system in a high-backpressure base-load operating condition except for periods of peak demand, when the reservoir is produced in a rapid venting mode with at least twice the power output for 4-hour intervals, appears to offer the most attractive method of load following.

However, positive-gain pumped storage using an HDR reservoir appears to offer several advantages over conventional pumped storage concepts now being used by the electric utility industry -- the principal one being an energy output several times greater than the off-peak energy storage.

As now planned, the initial results obtained from this study will be confirmed during the summer of 1995 when a sequence of cyclic flow tests will be performed in association with additional numerical modeling using a model with a more detailed representation of the jointed rock region in the vicinity of the production wellbore. This region of the model is the most important for modeling cyclic reservoir production, since a significant fraction of the produced fluid will have been stored in the pressure-dilated region within 100 m or so of the production wellbore prior to each low-backpressure production interval.

References

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