REPORT

DEVELOPMENT OF GEOTHERMAL BINARY-
CYCLE WORKING-FLUID PROPERTIES;
INFORMATION AND ANALYSIS OF CYCLES

Final Report

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ABSTRACT

The research discussed in this report was performed at the University of Oklahoma during the period January 1, 1980 through September 30, 1981. Efforts were directed principally to the following tasks: (1) comparisons of mixture and pure fluid cascade cycles, (2) development of guidelines for working fluid selection for single boiler cycles, (3) continued evaluation of mixtures as working fluids, (4) working fluid thermophysical property correlation and presentation of properties information, (5) support to the INEL Conversion Technology Program.

1. INTRODUCTION AND OVERALL SUMMARY

The majority of the work discussed in this report was performed at the University of Oklahoma during the period January 1, 1980 through September 30, 1981. Efforts were directed to the following tasks:

- (1) Comparisons of Mixture and Pure Fluid Cascade Cycles
- (2) Development of Guidelines for Working Fluid Selection for Single Boiler Cycles
- (3) Continued Evaluation of Mixtures as Working Fluids
- (4) Identification of Working Fluid Thermophysical Property Data Needs
- (5) Working Fluid Thermophysical Property Correlation and Presentation of Properties Information
- (6) Support as requested to the INEL Conversion Technology Program

The initial comparisons of mixtures and pure fluids in cascade cycles (task 1) were summarized in a report to DOE-Idaho project personnel in October, 1978. This work indicated that for low temperature georesources such as Raft River, dual boiler mixture cycles may achieve resource utilization levels as great as triple boiler pure fluid cycles. This area of study has been further addressed in the M.S. thesis research of C.T. Chu (Reference 1) and was discussed in some detail in Report OU/ID-1719-3 (Reference 2).

The subject of development of guidelines for working fluid selection for single boiler cycles (task 2) was addressed in a

paper presented at the Thirteenth Intersociety Energy Conversion Conference in San Diego in August, 1978 (Reference 3). This work indicated there may be numerous fluids as good or better than isobutane in geothermal binary cycles. A total of 100 fluids were considered in more recent research. This work was addressed in the M.S. thesis research of S. Ramaswamy (Reference 4) and was summarized in Report OU/ID-1719-3 (Reference 2).

The evaluation of mixtures as working fluids in geothermal binary cycles (task 3), has been a continuing study at the University of Oklahoma since 1973. This work has indicated that if countercurrent flow can be achieved in heat exchangers, mixtures have definite advantages over pure fluids in subcritical binary cycles. Discussion of thermodynamic, economic and equipment considerations has been presented by K.Z. Iqbal in his Ph.D. thesis (Reference 5); portions of this work was reproduced in Report OU/ID-1719-3 (Reference 2).

Task 4 is the continuation of an effort initiated in 1976 to identify working fluid thermophysical property data needs. A cooperative effort among different geothermal research groups led to an identification of isobutane thermodynamic properties data needs which in turn led to an experimental data procurement program at the National Bureau of Standards, in 1978. Efforts were also directed to identifying isopentane thermodynamic data needs and identifying viscosity and thermal conductivity data

needs for isobutane and isopentane. Also, thermodynamic property data needs were considered for the isobutane-isopentane mixture originally considered for the proposed Heber plant.

Task 5 involved the determination of correlation parameters for the MBWR equation of state for isobutane and isopentane and parameters in correlations of viscosity and thermal conductivity for isobutane and viscosity for isopentane. Because thermal conductivity data for isopentane in the region of cycle operating conditions are not available, a generalized correlation was used to provide a reasonable means for estimating isopentane thermal conductivity. The data judged to be the best available were correlated for isobutane and isopentane. The results of the efforts on the determination of data needs and correlation of working fluid thermophysical properties were delayed so that pressure-enthalpy thermodynamic properties diagrams in SI units for a number of hydrocarbon working fluids could be prepared and included in Report OU/ID-1719-4 (Reference 6).

Task 6 involved direct interaction of University of Oklahoma personnel with INEL personnel in support of the INEL Conversion Technology Program. Support was provided in several areas, including (1) suggestions of temperature, pressure and property measurement points for the Raft River 5 MW plant, (2) suggestion of the experimental program for analysis of plant performance for

the Raft River plant, (3) cooperative efforts on evaluations of mixtures as geothermal binary cycle working fluids (4) analysis of the effects of using mixtures as the working fluid in a geothermal binary cycle plant designed for use of a pure working fluid, (5) transmittal of computer codes for geothermal binary cycle simulations using mixture working fluids including consultation regarding use of these codes.

2. CONCLUSIONS

It is hoped that the work performed in this project has been of general value to the developing geothermal industry and of specific value to the INEL Conversion Technology Program, especially the 60KW test program and the Raft River 5MW program.

3. REFERENCES

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