Title: Optimization of the Energy Conversion Starting from Low-Temperature Heat

Phd:
Daniel Walraven

Promotor:
Prof. dr. ir. William D'haeseleer

Co-promotor:
Dr. Ben Laenen
Ir. Johan Van Bael

Problem statement

Low-temperature geothermal heat sources can be found in many regions in the world, but despite their huge energetic potential, only a limited amount of these sources are used. These heat sources are in most cases not free and wells have to be drilled to access the geothermal heat. One injection well and one or more production wells are usually used and depths down to several kilometers are needed to obtain a temperature high enough to be useful. These deep geothermal wells are very expensive, so, the obtained geothermal heat should be used very efficiently for electricity generation and or for heating purposes. Due to the low temperature, the conversion efficiency of the geothermal heat into electric power is low (Carnot). The effect of this low efficiency is in fact twofold. First, relatively large amounts of heat, and thus large equipment, are needed to generate a unit of electricity. Second, most of the heat which is added to the power plant has to be dumped into the environment. This results in a relatively large and expensive cooling system and a relatively large water and or electricity consumption in this cooling system. The consequence is that the investment cost of geothermal power plants per installed capacity is high.

Objectives of the research

The goal of this work is to develop a model and algorithm which can find the optimal economic design of low-temperature geothermal power plants, with a focus on the electricity-generating system. Different types of binary power cycles, which are typically used for electricity generation from low-temperature heat, like the organic Rankine cycle (ORC) and the Kalina cycle are implemented. Detailed models for two types of heat exchangers, of an axial turbine and of both wet and dry cooling are added. A system optimization is performed by optimizing the configuration of the binary cycle and all the components together, resulting in components which are optimal to be used together and to be used in the obtained cycle. It is shown from a *thermodynamic* point of view that well-optimized ORCs perform better than Kalina cycles and that multi-pressure, subcritical ORCs and single-pressure, transcritical ORCs are the most promising ones. ORCs with plate heat exchangers perform usually better than ORCs with shell-andtube heat exchangers, while not taking fouling and corrosion into account. The advantage of shell-and-tube heat exchangers is that the geometry of the hot-fluid side and the cold-fluid side are different and can vary almost independently from each other.
Cooling with water, which is cooled in a mechanical-draft wet cooling tower, results in better economics than cooling with an air-cooled condenser in the investigated case. This is especially due to the high investment cost of the air-cooled condenser, but also due to the high electricity consumption of this type of cooling. Only when water is expensive, cooling with air can be the better choice. These results are valid for the moderate climate in Belgium. For other climates these conclusions do not necessarily hold.

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