Thermophysical Properties of Geothermal Energy and Mineral Water Resources of Azerbaijan, Germany, Russia and Turkey

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Geothermal energy harnesses the heat energy present underneath the Earth and is generated in many places, where heat from the earth's core rises to the surface, for example where volcanoes and hot springs are present. Geothermal energy is considered as renewable because of the heat emanating from the interior of the Earth is essentially limitless and continuously regenerates through natural geologic processes. Azerbaijan possesses rich geothermal energy and mineral water resources. More than 50 million m\textsuperscript{3} of geothermal energy resources are available in Azerbaijan with maximum temperatures of up to \(\sim\)140 °C. Geothermal water resources of Germany are rich, which already use for the various purposes: in medicine, alternative energy etc. These resources have a low concentration of the major ions Na, Ca, Mg, and Cl, SO\textsubscript{4}, HCO\textsubscript{3}, which are thermal waters that have been in contact with rocks containing little or no soluble components. In Russia about 300 mineral water sources have been developed as spas and health resorts. More than 150 of them produce bottled mineral water. Pyatigorsk is located in the South of Stavropol region in the middle of the Caucasian Mineral Waters area. This place is a famous Russian mineral water resort. Turkey has more than 600 hot water springs, with surface temperatures ranging from 40-140 °C. Those hot springs are mainly situated along the major grabens at the Western Anatolia, along the Northern Anatolian Fault Zone, Central and Eastern Anatolia volcanic regions. The geothermal resources of these countries have been extensively studied. But, most of these research investigations were of geological, geographical and chemical properties. The main thermophysical properties, such as density, viscosity, vapor pressure etc. have only had limited studies. To use the geothermal energy resources as an alternative energy source requires the investigation of the thermophysical properties of a wide range of parameters. In many cases, the temperature of the geothermal water remains high, but pressure quickly becomes equal to ambient pressure. If we will use the geothermal resources for power generation directly at the source, they can be generating the energy. Using the experience in Iceland and other developed countries, we can maximise the use of geothermal energy as an alternative energy resource. In this presentation, we will inform the thermophysical properties analysis of geothermal resources of Azerbaijan (Astara and Lenkeran), Germany (Murquelle and Fettquelle in Baden-Baden), Russia (Pyatigorsk) and Turkey (Keklik Magara and Afyon) over the parameter range of interest: \((p,\rho,T)\) behaviour at \(T=(278.15\text{ to } 413.15)\text{ K}\) and \(p=(0.101\text{ to } 100)\text{ MPa}\) using the DMA HPM vibrating tube densimeter; density measurements at \(T=(278.15\text{ to } 363.15)\text{ K}\) and \(p=0.101\text{ MPa}\) using the DMA 5000 vibrating tube densimeter; vapor pressure measurements at \(T=(283.15\text{ to } 323.15)\text{ K}\) using the static method; viscosity measurements at \(T=(278.15\text{ to } 343.15)\text{ K}\) using the SVM 3000 Stabinger viscometer and the chemical compounds analysis using the IRIS Intrepid II Optical Emission Spectrometer. These investigations have been examined for the first time. Using the \((p,\rho,T)\) data, the comprehensive and accurate thermodynamic equation of state over a well specified range of parameters which are of interest in renewable energy research was constructed. An empirical correlation for the vapour pressure and viscosity results has been developed. These equations are used to calculate thermodynamic properties of these resources. An empirical correlation for the density of the geothermal resources as a function of pressure and temperature has been developed. Two different equations of state were used to calculate the various thermal and volumetric properties.