Research of Thermal Properties of Hot Water in Masalli District of Azerbaijan

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Abstract—This publication was prepared with the financial support of the Small and Medium Business Development Agency of the Republic of Azerbaijan. The agency is not responsible for the content of the publication. **Using a heat pump in low-temperature geothermal waters is an effective way to extract heat for heating, hot water supply and other needs. Low-temperature geothermal sources (up to 30–60 °C) provide an excellent opportunity for the use of heat pumps. A heat pump operates on the principle of extracting heat from low-temperature sources and converting it to a higher temperature suitable for heating. A heat pump system uses a refrigerant that circulates through a closed system, going through several phases:evaporation, compression, condensation and expansion. In the case of geothermal waters, the pump extracts heat from low-temperature water and transfers it to the heating or hot water supply system.**

Keywords—geothermal energy, geothermal waters, thermophysical proportion, density,

I. Introduction

Traditionally, district heating systems have been designed to operate at high temperatures to meet the high heat demand of poorly insulated buildings. In most cases, fossil fuels must be used to achieve the required high temperatures. However, technological innovation, digitalization, and current trends towards more energy-efficient buildings may enable the increased use of green energy technologies such as low-temperature geothermal energy, solar thermal energy, and water bodies, as well as low-temperature waste heat sources in next-generation district energy systems. These sources are widely available locally in many regions. However, they remain largely untapped because they are not immediately compatible with the existing district energy infrastructure and building stock. The use of low-temperature renewable energy sources and sustainable waste heat in district energy systems is often hampered by factors such as lack of data, high upfront costs, budget constraints at the municipal level, inadequate regulation, and lengthy

Heating is the largest single form of energy use worldwide, accounting for more than half of final energy demand.

II. Ease of Use

Heating buildings and producing domestic hot water account for approximately half of all heat generated. Much of this energy is produced by burning fossil fuels, making the residential and commercial building sector a significant contributor to greenhouse gas emissions, air pollution and the associated negative health impacts that are of great concern in many cities around the world. District energy systems offer the potential to expand the use of renewable energy, improve energy efficiency, prevent energy poverty, reduce fossil fuel use and reduce CO_2 and hydrofluorocarbon emissions from the heating and cooling sector. Technological innovations and current trends towards more energy-efficient buildings, as well as the development of a new generation of district energy networks, may enable the increased use of low-temperature renewable energy sources such as geothermal and solar thermal energy, as well as waste heat from industrial or commercial sources. These sources are more widely available locally in many regions, but remain largely untapped because they are perceived as incompatible with the district energy infrastructure and much of the existing building stock.

II1.Low- and medium-temperature geothermal resources.

Unlike traditional heating systems running on fossil fuels, heat pumps reduce the carbon footprint, as they use renewable energy sources. But along with the advantage, the use of heat pumps is complicated depending on some factors. For the heat pump to operate with geothermal waters, it is necessary to ensure a stable and sufficient water flow, otherwise the system will not work efficiently. In some regions, geothermal waters contain a significant amount of minerals, which can cause clogging of the system. To solve this problem, filtration and dehydration systems are used.

Therefore, their careful monitoring is necessary. Until now, studies of the thermophysical properties of geothermal and mineral waters of Azerbaijan were carried out in a very limited range. Basically, the geological and chemical properties of these waters were studied [2-3]. To use geothermal waters in various energy plants, it is necessary to know their thermophysical properties. This article presents experimental data on the "Istisu" geothermal water of the Masalli region of Azerbaijan (Figure 2).

Figure 2. Istisu deposit, Masalli region, Azerbaijan.

The measured sample was taken directly from the source. To measure the thermophysical properties (except for chemical analysis), it was prepared for measurements after filtration, removal of dissolved gases and air using a vacuum pump. Thus, the study of the thermophysical properties of geothermal waters not only allows to increase the efficiency of their use, but also promotes sustainable and environmentally friendly use of geothermal energy.

II.Theoretical description of experimental results.

A high-precision experimental setup implementing the method of a density meter with a vibration tube [3] was used to measure the density of the "Istisu" geothermal water of the Masalli region at high pressures and temperatures (pρT data). This method in modern experimental thermal physics is characterized by high measurement accuracy, simplicity, insignificant time and economic costs, as well as the possibility of automating the measurement process. The operating principle of the experimental setup is given in [7-9]. The main element of the experimental setup of the Anton-Paar DMA HPM vibrating tube densitometer is a measuring cell containing a Hastelloy C-276 vibrating tube made of nickel-based stainless-steel alloys with high corrosion resistance. The measuring cell is designed to measure temperatures in the range of T=263.15÷473.15 K and pressures p=0.1÷140 MPa. The temperature in the measuring cell, where the U-shaped tube is located, is maintained using an external thermostat F32-ME (Julabo, Germany) with an error of 0.01 K. The temperature is measured using a platinum resistance thermometer (ITS-90) Pt100 (Type 2141) with an error of ±15 mK. The pressure is generated by a HIP pump (No. 37-6-30, USA) and measured by pressure sensors (WIKA Alexander Wiegand GmbH & Co., Germany) P-10 accuracy class 0.1% and HP-1 accuracy class 0.5% of the maximum measured value. The signals from the pressure gauges are also transmitted to the computer control system. The error in measuring the density under these conditions was Δρ/ρ = ±(0.01 - 0.03)%. The measurements of the (p,ρ,T) dependencies were carried out using isotherms from the minimum possible pressure for a given temperature, and then increasing it with a step of approximately 10 MPa.

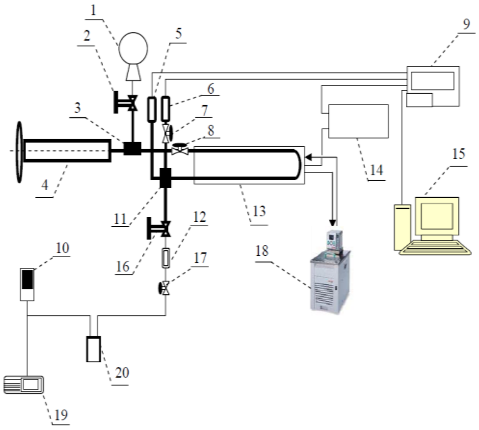

Figure 3- Installation of the DMA HPM vibration tube densimeter: 1 - sample flask; 2,7,8,16,17 - high pressure valves, 3 - tee, 4 - HIP pressure gauge; 5 - HP-1 pressure sensor; 6 - P-10 pressure sensor; 9 - mPDS2000V3 temperature, pressure and oscillation period monitoring system; 10 - vacuum gauge; 11 - tetrahedron, 12 - viewing window; 13 - vibration tube; 14 - interferometer; 15 - computer; 18 - F32-ME thermostat; 19 - vacuum pump; 20 - liquid nitrogen thermos.

The studies were conducted at temperatures in the range of T = (273.15 to 393.15) K and pressures up to p = 100 MPa. At atmospheric pressure, the obtained density values were compared with the density values measured on the DSA 5000M installation. The data obtained by different methods are in good agreement with each other within Δρ/ρ = ± 0.02%. The obtained results of the density of the geothermal water "Istisu" of the Masalli district are given in the table

Table 1 - Experimental values of pressure p, density ρ, temperature T, as well as the calculated values of the isothermal compressibility coefficient κ_T, isobaric coefficient of thermal expansion α_p, differences in isobaric and isochoric heat capacities (c_p-c_v), thermal pressure coefficient γ and internal pressure pi of the geothermal water "Istisu" of the Masalli district.

p/ MPa	*ρ*/ kg·m^{-3}	*T*/ K	$k_T\cdot10^6$/ MPa^{-1}	$\alpha_p\cdot10^6$/ K^{-1}	(c_p-c_v)/ J·kg^{-1}K^{-1}	γ/ MPa·K^{-1}	p_i/ MPa
0.101	1000.22	273.15	483.3	-21.4	0.27	-0.0450	-13.6
5.022	1003.20	273.15	481.0	-13.1	0.09	-0.0261	-12.1
10.005	1005.61	273.15	473.9	-0.4	0.00	-0.0089	-10.2
19.974	1010.40	273.15	463.1	24.3	0.33	0.0421	-5.5
29.934	1015.11	273.15	451.0	48.9	1.44	0.1187	-0.10
40.003	1019.72	273.15	4412	74.9	3.41	0.1786	6.5
49.943	1024.20	273.15	434.5	101.0	6.31	0.2320	13.8
60.098	1029.41	273.15	426.3	128.1	10.27	0.2910	22.7
70.005	1033.48	273.15	418.3	156.28	15.40	0.3625	32.01
80.135	1037.10	273.15	411.1	185.3	21.87	0.4387	42.8
90.135	1041.10	273.15	410.2	214.5	29.76	0.5172	54.5
100.064	1045.05	273.15	400.1	245.4	39.23	0.6107	67.6
0.101	1001.12	278.12	477.8	32.3	0.5961	0.0665	18.4
5.133	1003.20	278.11	471.1	42.1	1.05	0.0895	19.7
10.124	1006.14	278.11	465.6	53.5	1.65	0.1132	21.4
20.101	1010.20	278.11	453.1	74.3	3.30	0.1628	25.2
30.043	1014.74	278.12	443.2	95.1	6.32	0.2152	29.8
40.041	1019.22	278.12	433.5	117.1	9.54	0.2705	35.2
50.120	1024.12	278.12	424.4	140.1	12.54	0.3343	42.0
60.112	1028.55	278.12	415.3	161.3	17.22	0.4008	49.3
70.467	1032.20	278.10	410.0	185.1	22.73	0.4541	55.9
80.065	1036.32	278.13	401.3	210.2	29.41	0.5234	65.4
90.021	1040.41	278.15	394.4	235.1	37.31	0.595	74.4
100.345	1044.44	278.14	389.3	260.3	46.21	0.6740	85.9
0.101	1001.01	283.21	468.0	97.4	5.84	0.2113	58.9

5.261	1003.04	283.22	460.2	106.2	7.02	0.2304	60.0
10.142	1005.31	283.21	455.1	114.3	8.89	0.2512	61.0
20.233	1009.80	283.21	443.3	132.3	11.26	0.2971	64.3
29.814	1014.10	283.21	433.5	150.1	14.23	0.3424	67.1
40.528	1018.72	283.21	422.2	170.1	18.44	0.3953	72.1
50.135	1022.70	283.25	413.4	185.3	22.79	0.4513	77.1
60.069	1026.71	283.27	405.8	203.1	28.19	0.5011	82.6
70.051	1031.24	283.21	397.1	220.9	34.29	0.5574	88.5
79.955	1035.31	283.20	390.8	240.1	40.42	0.6233	94.1
89.970	1040.33	283.15	381.2	260.2	48.31	0.6837	102.3
100.253	1042.33	283.16	377.5	281.6	56.30	0.7421	110.1
0.101	999.27	293.18	455.4	209.2	28.51	0.4622	135.5
5.023	1001.04	293.18	448.1	215.3	30.32	0.4800	135.5
10.019	1002.61	293.18	442.3	219.3	32.10	0.5185	136.1
20.169	1008.39	293.18	430.1	229.7	36.02	0.5429	136.9
30.215	1012.35	293.18	419.3	240.3	40.31	0.5832	140.2
40.220	1016.12	293.18	411.3	252.5	45.32	0.6175	141.5
50.160	1020.32	293.18	400.1	263.3	50.01	0.6605	143.2
59.912	1024.17	293.18	390.4	274.2	55.47	0.7019	146.6
69.940	1028.19	293.19	381.2	284.9	61.12	0.7460	149.3
79.925	1032.01	293.18	375.5	297.3	67.01	0.7921	152.3
90.002	1036.4	293.15	370.3	309.2	73.35	0.8427	156.2
99.985	1010.35	293.14	361.4	319.7	80.40	0.8892	161.3
0.101	998.12	298.15	449,8	259.5	45.01	0.5923	172.3
5.011	1000.10	298.16	444.3	263.1	46.93	0.6021	172.4
10.019	1002.21	298.15	438.2	268.4	48.71	0.6121	172.4
20.029	1007.32	298.14	426.3	274.9	52.73	0.6472	173.2
30.013	1011.34	298.15	414.3	283.3	57.04	0.6833	173.5
40.485	1015.38	298.13	403.1	291.4	61.44	0.7191	174.3
50.152	1019.15	298.15	395.1	299.0	66.16	0.7631	176.3
60.324	1023.45	298.16	386.2	306.9	71.24	0.8062	178.4
70.042	1027.34	298.15	376.9	316.4	76.62	0.8415	180.4
80.334	1031.45	298.14	370.1	323.9	82.22	0.8831	182.1
90.168	1034.59	298.15	361.9	332.8	88.30	0.9238	182.3
99.241	1038.09	298.14	356.3	342.4	94.19	0.9590	186.8
0.101	993.06	313.15	445.3	395.7	111.15	0.8917	279.3
5.143	995.21	313.15	441.0	396.1	112.70	0.9042	278.3
10.014	997.28	313.15	431.0	396.3	114.22	0.9237	277.3
19.986	1001.45	313.15	420.1	396.7	117.43	0.9511	276.4
29.935	1005.54	313.15	410.2	398.4	121.35	0.9753	275.3
39.947	1009.59	313.15	396.3	399.0	129.12	1.0040	274.4
50.004	1013.59	313.15	386.4	400.4	127.83	1.0314	274.3
59.924	1017.46	313.15	378.2	402.1	132.02	1.0632	273.3
70.024	1021.34	313.15	369.5	404.0	134.81	1.1032	272.4
80.050	1025.10	313.15	361.3	405.8	140.41	1.1237	271.8
89.924	1028.76	313.15	353.9	408.4	143.53	1.1540	272.4
99.935	1032.39	313.15	346.7	411.0	147.82	1.1853	271.3
0.101	983.66	333.15	452.3	550.4	226.91	1.2260	407.8
5.193	985.87	333.12	444.8	546.8	227.20	1.2315	404.3
10.175	988.00	333.14	437.8	543.9	227.85	1.2393	404.1
20.093	992.20	333.13	424.7	538.1	229.51	1.2751	401.8
30.074	996.33	333.15	412.5	533.0	230.33	1.3022	400.3
40.067	1000.39	333.14	401.1	528.1	231.56	1.3167	398.6
50.072	1004.41	333.15	391.3	524.0	233.12	1.3423	397.5
60.132	1008.23	333.17	379.7	519.8	234.71	1.3662	394.9
70.143	1012.92	333.15	370.9	515.9	236.19	1.4001	391.9
80.231	1015.81	333.16	363.6	512.9	238.32	1.4140	390.1
90.435	101943	333.15	355.3	510.1	239.72	1.4381	389.1

99.951	1023.06	333.14	346.8	506.8	241.39	1.4611	387.3
0.101	972.40	353.15	471.7	677.8	357.91	1.4400	508.3
5.000	973.72	353.15	463.1	673.1	354.43	1.4532	508.1
10.024	976.49	353.15	454.8	666.9	354.33	1.4662	508.4
19.956	980.19	353.15	440.5	656.7	352.70	1.4908	507.3
30.054	984.34	353.15	426.9	647.1	351.91	1.5163	505.3
40.031	989.29	353.15	414.4	637.9	351.28	1.5409	504.3
49.963	993.14	353.15	403.1	629.9	350.932	1.5635	503.4
59.994	997.31	353.15	391.9	623.6	350.66	1.5891	503.8
69.904	1000.50	353.15	382.6	616.3	350.62	1.6133	499.4
80.165	1004.32	353.15	373.2	610.4	350.58	1.6452	498.3
89.940	1007.91	353.15	364.3	603.3	350.82	1.6634	496.0
99.982	1011.53	353.15	355.2	598.3	351.11	1.6833	494.1
0.101	957.23	373.15	498.9	777.1	471.50	1.5569	581.2
5.181	959.76	373.20	488.6	769.3	469.69	1.5789	581.1
10.130	962.09	373.15	481.3	761.2	468.31	1.5814	581.0
20.140	966.50	373.15	464.3	747.0	464.59	1.6110	581.0
30.159	971.15	373.15	447.6	733.9	461.80	1.6373	580.9
40.113	975.21	373.17	434.0	722.1	459.76	1.6641	580.6
49.992	979.45	373.14	421.0	711.2	457.73	1.6893	580.2
59.973	983.43	373.17	408.8	701.3	456.43	1.7152	580.1
70.040	987.59	373.15	397.6	692.1	455.16	1.7409	579.8
80.015	991.36	373.19	387.0	683.6	454.56	1.7665	579.4
89.975	994.16	373.15	377.0	675.5	453.88	1.7917	578.5
99.973	998.81	373.14	368.2	669.3	454.48	1.8172	578.1
0.201	941.89	393.15	537.5	845.3	557.58	1.5773	619.8
5.039	944.31	393.15	526.0	836.7	553.91	1.5902	620.1
9.991	946.80	393.15	515.2	826.3	550.41	1.6042	620.4
19.963	951.55	393.14	495.3	807.6	544.06	1.6306	621.0
29.961	956.23	393.15	477.1	790.7	538.80	1.6581	621.6
40.049	960.80	393.13	460.0	774.8	534.52	1.6853	622.3
49.988	965.33	393.15	444.9	761.5	530.80	1.7120	622.8
59.923	969.53	393.16	430.7	748.4	528.82	1.7385	623.5
69.978	973.67	393.15	417.5	737.3	525.71	1.7659	624.2
80.039	977.77	393.17	405.2	726.5	524.18	1.7943	625.1
89.963	981.45	393.15	393.9	717.3	523.09	1.8211	625.7
99.933	985.31	393.15	383.3	709.3	522.89	1.8492	626.9

Thefollowingequation of statewasusedtodescribetheresultsobtained

$$p = A\rho^2 + B\rho^8 + C\rho^{12} \quad (1)$$

Thecoefficients A(T), B(T) and C(T) depend on thetemperatureinpolynomialform:

$$A(T) = 4\sum_{i=1}^{3} a_i T^i, B(T) = \sum_{i=0}^{3} b_i T^i, C(T) = \sum_{i=0}^{3} c_i T^i \quad (2)$$

Thevalues of thecoefficientsa$_{ij}$, b$_{ij}$ and c$_{ij}$inequations (1-2) aregiveninTable 2.

Table 2. Values of the coefficientsa$_{ij}$, b$_{ij}$and c$_{ij}$of the equation of state (6).

a_i	b_i	c_i
$a_1 = -3.77\cdot10^{-6}$ $a_2 = 0.01\cdot10^{-8}$ $a_3 = -0.18\cdot10^{-9}$ $a_4 = 0.23\cdot10^{-13}$	$b_0 = 8810.37\cdot10^{-4}$ $b_1 = -72.51\cdot10^{-7}$ $b_2 = 0.21\cdot10^{-8}$ $b_3 = -0.21\cdot10^{-8}$	$c_0 = -6721.43\cdot10^{-9}$ $c_1 = 57.0003\cdot10^{-7}$ $c_2 = -0.16\cdot10^{-6}$ $c_3 = 0.158\cdot10^{-8}$

Using the equation of state, the following thermal parameters were calculated:

- the i**sothermal compression coefficient**κ_T/MPa^{-1} :

$$\kappa_T(p,T) = (1/\rho)(\partial p/\partial\rho)_T^{-1}. \quad (3)$$

Using equation (8), the equation for calculating the isothermal compression coefficient κ_T can be obtained from the equations of state (1-2):

$$\kappa_T(p,T) = 1/[2A(T)\rho^2 + 8B(T)\rho^8 + 12C(T)\rho^{12} . \qquad (4)$$

The calculated values of the isothermal compressibility coefficient κ_T/MPa^{-1} of the water "Garibler" of the Masalli region of Azerbaijan are giveninTable 1 and Figure 5.

- the coefficient of **thermal expansion of the isobar** α_p/K^{-1} is a notherthermal coefficient that plays an important role in the analysis of the quality of experimental work.

$$\alpha_p(p,T) = (1/\rho)(\partial p/\partial T)_\rho(\partial p/\partial \rho)_T^{-1}. \qquad (5)$$

Using equation (5), the isobaric expansion coefficient αp/K^{-1} can be calculated using the equations of state (6-7):

$$\alpha_p(p,T) = [A'(T) + B'(T)\rho^6 + C'(T)\rho^{10}]/[2A(T) + 8B(T)\rho^6 + 12C(T)\rho^{10}, \qquad (6)$$

where A´, B´ and C´ arederivatives of thecoefficients A, B and C of thefollowingequation of state:

$$A'(T) = \sum_{i=1}^{4} i a_i T^{i-1}, B'(T) = \sum_{i=1}^{3} i b_i T^{i-1}, C'(T) = \sum_{i=1}^{3} i c_i T^{i-1}. \qquad (7)$$

The calculated values of the isobaric expansion coefficient α_p/K^{-1} of the Garibler water in the Masalli region of Azerbaijan are giveninTable 1 and Figure 7.

- the difference between **isobaric** and **isochar specific heat capacity**$(c_p(p,T) - c_v(p,T))$ /C·kq^{-1}·K^{-1}:

$$c_p(p,T) = c_v(p,T) + \left[T\left(\frac{\partial p(T,\rho)}{\partial T}\right)_\rho^2 \Big/ \rho^2\left(\frac{\partial p(T,\rho)}{\partial \rho}\right)_T\right]. \qquad (8)$$

Thus, it is difficult tomeasure the heat capacity at constant volume c_v/J kq^{-3} K^{-1}. But it is not difficult to measure the heatcapacity cp/J kq^{-1} K^{-1} at constant pressure. There fore, the calculation of the difference between isobaric and isochoric specific heat capacities (cp – (cp – cv)/J kq^{-1} K^{-1} can always be used to determine the heat capacity at constant volume cv/J kq^{-3} K^{-1}. Using relation (13), from the equations of state (6-7) we can obtain an equation for calculating the difference between isobaric and isochoric specific heat capacities (cp – cv)/J kq^{-1} K^{-1}:

$$c_p(p,T)\text{-}c_v(p,T) = \frac{\alpha_p^2(p,T)\cdot T}{\rho\cdot\kappa_T(p,T)}. \qquad (9)$$

The calculated values of the difference in isobaric and isochar specific heat capacities (cp – (cp – cv)/J kq^{-1} K^{-1} of the Garibler water in the Masalli region of Azerbaijan are given inTable 1 and Figure 7.

- the thermal pressure coefficient is found as γ/MPa K^{-1}, the ratio of the coefficient of isobaric expansion α_p/K^{-1}to the coefficient of isothermal compression κ_T/MPa^{-1}:

$$\gamma(p,T) = \frac{\alpha_p(p,T)}{\kappa_T(p,T)}. \qquad (10)$$

The calculated values of the thermal coefficient of water pressure γ/MPa K-1 "Garibler" of the Masalli region of Azerbaijan are giveninTable 2 and Figure 8.

- Internal pressure, p_i/MPa, in dicates how much the internal energy of a system changes when the temperature of the system in creasesorre mains constant. It has the same unit of measurement as pressure and is defined as the fraction of the derivative of in ternal energy by volume at a constant temperature. Internal pressure in p_i/MPa is related to the thermal coefficient of pressure and isdefined as

$$p\left(\frac{\partial U}{\partial V}\right)_T \left(\frac{\partial p}{\partial T}\right)_V \frac{T\cdot\alpha_p(p,T)}{\kappa_T(p,T)}_{int} \qquad (11)$$

Various dependencies of the determined thermal properties are shownin Fig. 4-9.

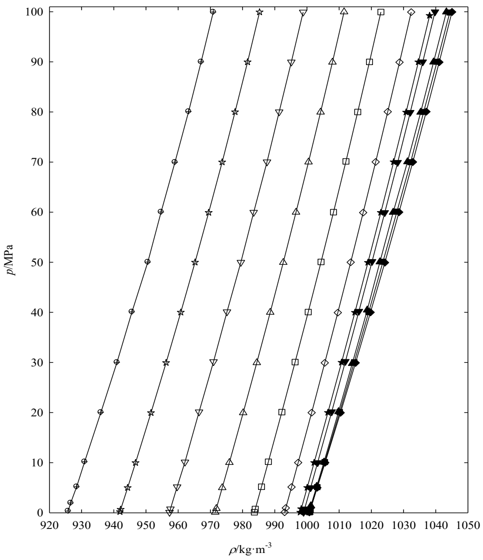

Figure 4: Dependence of density ρ on pressure p of waterGaribler of Masalli region of Azerbaijan:◆, 273.15 K; ■,278.12 K; ▲, 283.21 K; ▼, 293.18 K; ★, 298.15 K; ◇, 313.15 K; □, 333.15 K; △, 353.15 K; ▽, 373.16 K; ☆, 393.15 K

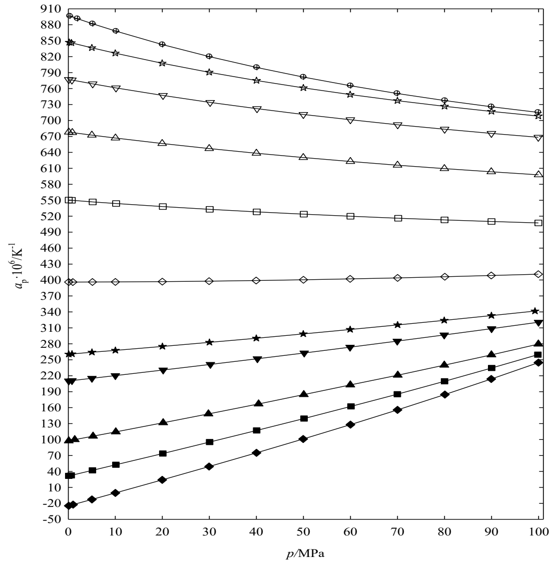

Figure 7: Dependence of isobaricthermalexpansion $\alpha_p\cdot10^6$ of thewater "Garibler" of theMasalli region of Azerbaijan on thepressure p:◆, 273.15 K; ■, 278.12 K; ▲, 283.18 K; ▼, 293.18 K; ★, 298.15 K; ◇, 313.15 K; □, 333.15 K; △, 353.15 K; ▽, 373.16 K; ☆, 393.15 K.

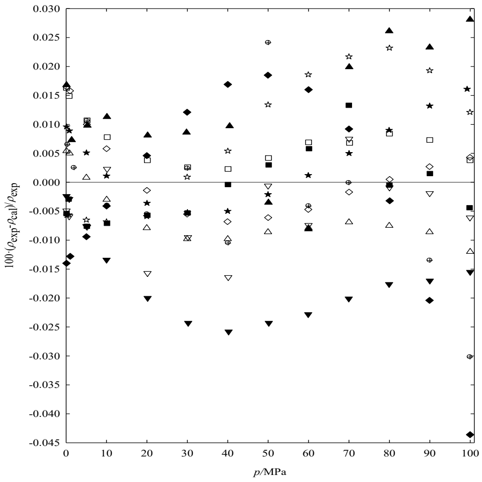

Figure 5: Dependence of pressure p on the pressure p of the difference between the experimental lymeasured density of water Garibler in the Masalli region of Azerbaijan, on the density ρ_{exp}, calculated using the equation of state:◆, 273.15 K; ■, 278.12 K; ▲, 283.21 K; ▼, 293.18 K; ★, 298.15 K; ◇, 313.15 K; □, 333.15 K; △, 353.15 K; ▽, 373.16 K; ☆, 393.15 K.

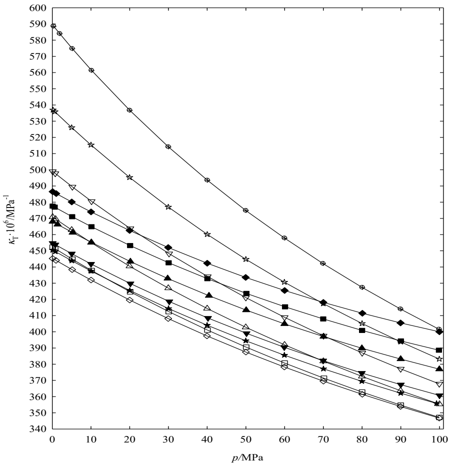

Figure 6: Dependence of isothermal compression $\kappa_T \cdot 10^6$ of waterGaribler of Masalli region of Azerbaijan on pressure p:◆, 273.15 K; ■, 278.12 K; ▲, 283.18 K; ▼, 293.18 K; ★, 298.15 K; ◇, 313.15 K; □, 333.15 K; △, 353.15 K; ▽, 373.16 K; ☆, 393.15 K.

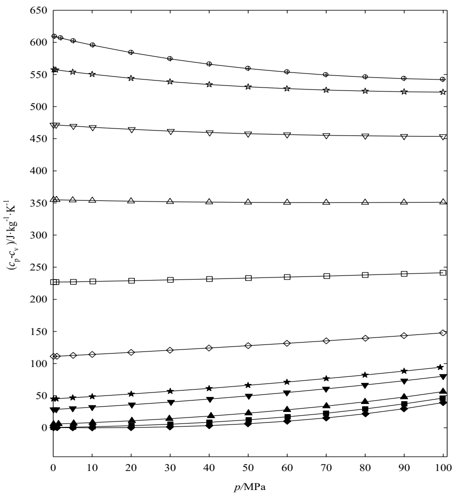

Figure 8: Dependence of thedifference (c_p-c_v) of isobaric and isochoric heat capacities of the thermal water “Garibler” of the Masalli region of Azerbaijan on thepressure p:◆, 273.15 K; ■, 278.12 K; ▲, 283.18 K; ▼, 293.18 K; ★, 298.15 K; ◇, 313.15 K; □, 333.15 K; △, 353.15 K; ▽, 373.16 K; ☆, 393.15 K

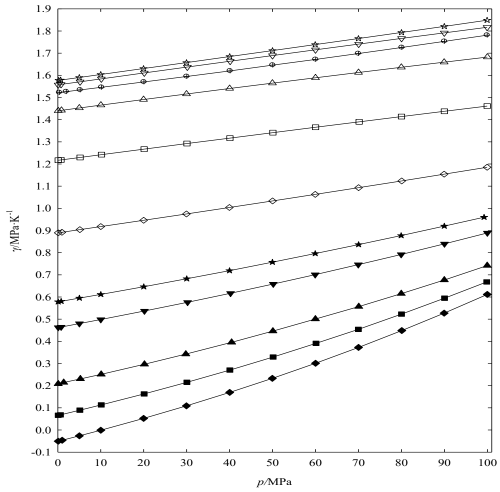

Figure 9: Dependence of the thermal pressure coefficient γ of the thermal water "Garibler" of the Masalli region of Azerbaijan on thepressure p.:◆, 273.15 K; ■, 278.12 K; ▲, 283.18 K; ▼, 293.18 K; ★, 298.15 K; ◇, 313.15 K; □, 333.15 K; △, 353.15 K; ▽, 373.16 K; ☆, 393.15 K.

IV. Conclusion

The thermophysical properties of geothermal springs in the Gakh region of Azerbaijan were studied for the first time, so their comparison with literature data is not possible. The obtained data were compared with the thermophysical properties of pure water and it was found that the behavior of the studied properties has similar known anomalies to water [1].

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