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dr inż. Karol Prałat

Properties of selected heat-insulating polymers significant in reduction of thermal losses of internal environment

Summary of professional accomplishments

Attachment 3

(English version)

KALISZ 2015

SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

1. Name and surname

Karol Prałat

2. My academic degrees

a) Diploma of completion of MSc studies, Faculty of Food Chemistry and Biotechnology of Łódź University of Technology, Łódź 2000. Title of dissertation: ***Assessment of urease Corynebacterium glutamicum activity in a process of biosynthesis of L-glutamine acid from different sources of coal***.

b) Diploma of Doctor of Technical Science, Faculty of Chemical Technology of Poznań University of Technology, Poznań, 2008. Title of dissertation: ***Research on correlation of rheological and thermal properties of Non-Newtonian systems***.

3. Information about employment record

a) Lecturer, Polytechnic Institute, State Higher Vocational School in Kalisz, 2001-2008,
b) Senior lecturer, Polytechnic Institute, State Higher Vocational School in Kalisz, 2008-2011,
c) Senior lecturer, Faculty of Polytechnic, major: Environmental Engineering, State Higher Vocational School in Kalisz, 2011-still.

4. Indicated achievements resulting from art. 16 sec. 2 of the Act of 14 March 2003 on Academic Degrees and Academic Title and Degrees and Title in Art (Dz. U. No. 65, item 595 with changes):

a) title of academic achievement: one-thematic cycle of publications entitled: ***Properties of selected heat-insulating polymers significant in reduction of thermal losses of internal environment***.

b) (author/ authors, title/titles of publications, year of edition, name of a publishing house)

[1] Lubomira Broniarz-Press, **Karol Prałat**: *Experimental studies on thermal conductivity of polimer solutions as a function on shearing rate and their rheological properties.* 7th World Conference on Experimental Heat Transfer,

Fluid Mechanics and Thermodynamics, CD-ROM, Full text MT-19, pp. 2115-2122, Krakow 2009 (share 50%).

[2] Lubomira Broniarz-Press, **Karol Prałat**: *Shear rate dependent thermal conductivity measurements of stokesian liquids.* 8 World Congress of Chemicall Engineering, Montreal, Canada, 23-27 August, 2009 (share 50%). www.researchgate.net/publication/265805689 (on-line 18.08.2015)

[3] Lubomira Broniarz-Press, **Karol Prałat**: *Thermal conductivity of Newtonian and non-Newtonian liquids.* International Journal of Heat and Mass Transfer, 52(2009), pp. 4701-4710 (share 50%).

[4] Dariusz Heim, **Karol Prałat**, Andrzej Mrowiec: *Zastosowanie metody "gorącej nici" do wyznaczania przewodności cieplnej płynnych kwasów organicznych,* Inżynieria i Aparatura Chemiczna, 49 (41), nr 1, 51-52 (2010) (share 70%).

[5] Dariusz Heim, **Karol Prałat**, Andrzej Mrowiec: *Badania przewodności cieplnej organicznych materiałów fazowo zmiennych przy zastosowaniu metody „gorącej nici".* Fizyka budowli w teorii i praktyce, Tom V, Nr 2, str. 15-20, Łódź 2010 (udział 50%).

[6] Dariusz Heim, **Karol Prałat**, Andrzej Mrowiec: *Udoskonalona metoda pomiarów przewodności cieplnej płynów – stanowisko badawcze małych mocy.* Fizyka budowli w teorii i praktyce, Tom VI, Nr 2, str. 35-40, Łódź 2012 (share 70%).

[7] Dariusz Heim, **Karol Prałat**, Andrzej Mrowiec: *Zastosowanie stanowiska badawczego małych mocy do pomiarów przewodności cieplnej cieczy o gęstości większej od wody.* Inżynieria i Aparatura Chemiczna, 53, nr 1, 21-22 (2014) (share 70%).

[8] Dariusz Heim, Andrzej Mrowiec, **Karol Prałat**: *Analysis and interpretation of results of thermal conductivity obtained by the hot wire method*, Experimental Techniques, (2015) (share 50%).
http://onlinelibrary.wiley.com/doi/10.1111/ext.12092/full (on-line 30.04.2014).

[9] **Karol Prałat**: *Research on thermal conductivity of the wood and analysis of results obtained by the hot wire method,* Experimental Techniques, (2015) (share 100%)
http://onlinelibrary.wiley.com/doi/10.1111/ext.12143/full (on-line 12.06.2015).

[10] **Karol Prałat**: *Zastosowanie metody elektrokalorymetrycznej do wyznaczania ciepła właściwego wodnych roztworów soli sodowej karboksymetylocelulozy* Inżynieria i Aparatura Chemiczna, 54, nr 1, 14-15 (2015) (share 100%).

[11] **Karol Prałat**: *Comparison of electrocalorimetric and cooling methods to determine specific heat of aqueous solutions of the sodium salt*

carboxymethylcellulose, Arabian Journal for Science and Engineering, (2015) (share 100%).
http://link.springer.com/article/10.1007/s13369-015-1858-8 (on-line 12.09.2015).

[12*] **Karol Prałat**: *Determining specific heat of aqueous solutions of the sodium salt carboxymethylcellulose with cooling method*, Chemical and Process Engineering, the article reviewed in 2014 (share 100%).

c) review of scientific goal of above mentioned articles and results

Modern countries and world economies understand that we have to protect environment. They try to lower greenhouse gas emission, protect waters, soils, reduce noise, recycling, look for an alternative sources of energy and energy efficiency. Modern construction industry, in which we spend up to 80% of our life, is an important element of our environment and landscape. Ensuring an appropriate state of internal environment is very important when we design and build a building, both in health and comfort of use aspects. For many people, taking care about natural environment is also a priority.

Science and industry are used to reduce thermal losses of internal environment. Different methods allow to decrease demand for energy and its consumption. The subject of energy efficiency is the most important in most of the buildings. Energy efficiency is becoming a standard in modern construction industry.

Different methods of reduction of energy consumption are introduced in the ecological buildings in order to reduce consumption of conventional energy and, as a consequence, to protect environment. Above goal is achieved mainly through:

- use of energy from alternative sources (renewable),
- use of systems of heat recovery,
- introduction of unconventional methods of obtaining, storing and conversion of energy.

High-tech energy efficient construction industry uses different methods of exchange of solar radiation energy. The basic methods include:

1. Passive solar solutions, which make use of a shape, setting of a building solid to manage available solar energy. It transforms into proper architectural and construction project. Passive systems use and absorb solar radiation from the elements of a building. Proper walls accumulating energy acting as storehouses are used. Heated air (obtained energy) is distributed through channels to the rooms.
2. Active solar solutions, which are usually installation solutions. Photothermal conversion emerges in such systems, that is, conversion of solar radiation energy into thermal energy or photovoltaic conversion, that is, conversion into electric energy.
3. Construction-material-installation solutions aiming at applying other unconventional methods of obtaining energy contained in natural

environment, for example, using heat pumps and unconventional methods of its storing in the soil, stone deposits, substances with a low temperature of phase changes. Modern solutions may include: systems of heat recovery, controlling conditions of internal environment microclimate, measurements of energy consumption, non-classic constructions of windows with low values of a coefficient of thermal transmission. Nowadays, very broad field of science within the framework of modern, pro-environmental material solutions is focused on looking for insulations and construction composites with low values of a coefficient of thermal conductivity λ.

Low values of a coefficient of thermal conductivity λ of insulating and construction materials is obtained with the help of an addition or building phase change materials (PCM) in their structure, which are able to absorb, accumulate and release large amount of energy within the range of a phase change temperature. During absorption of energy, temperature of material does not change. The materials used in the articles are inorganic (hydrated salts) and organic compounds (paraffin, fatty acids, ionic liquids).

A new way to lower value of a coefficient λ is to add polymers dissolved in water to construction materials. It is assumed that adding a polymer has a considerable impact on crystallization of calcium sulphate (gypsum) and on rate and the way of binding water in it.

It is important to have a basic knowledge aiming at finding material constants of aqueous solutions of polymers, such as: viscosity η, thermal conductivity λ or specific heat C_p. Another important aspect is the impact of polymer on the value of conductivity of prepared construction materials – mainly gypsums.

In my cognitive and experimental work described in theses [1-12*] and non-published materials, I mainly dealt with:

I) research on thermal properties of solutions of polymers, particularly carboxymethylcellulose sodium salt (Na-CMC), creating appropriate research posts, building them and determining thermal conductivity λ and specific heat C_p.

II) working out a quick method of determining thermal conductivity λ of liquids and insulating materials, for example, wood.

III) using properties of selected aqueous solutions of heat-insulating polymers (carboxymethylcellulose sodium salt Na-CMC and hydroxymethyl-ehthyl-cellulose (HMEC) significant in reduction of thermal losses of internal environment to the environment in the construction industry and environmental engineering, aiming at obtaining new gypsum composites with lower values of thermal conductivity λ; working out a method of measurement of thermal conductivity of modified construction materials.

Articles [1-3] present a theoretical and experimental of correlations of coefficients of thermal conductivity of liquids and their rheological properties, with particular emphasis on shear rate and temperature. Analysis of state of research on coefficients of thermal conductivity in non-Newtonian systems was also presented. It was found that not only temperature, but also shear rate considerable impact on the value of coefficient of thermal conductivity λ of non-Newtonian systems. Moreover, attempts to connect rheological and thermal properties of systems with complex flow properties were made.

Measurement of values of coefficients of thermal conductivity were performed during rotary motion of an external cylinder in a coaxial arrangements of cylinders. There was a necessity of accurate measurement of temperature during motion of an external cylinder. For the needs of the research, a cordless measuring system for measurement of temperature in the whirling, external cylinder was created.

For innovative solution of measurement of temperature in the whirling cylinder, described in the articles mentioned above, I won a distinction in the third edition of a competition (2011) *Kuźnia Talentów* organized by Marshal's Office of the Wielkopolska Region within the framework of system project *Regional networks of innovations and promotion of innovations in the region*.

Measurements were performed for three Newtonian liquids: water, diesel oil and 50% aqueous solution of glycerine with a density $\rho \in (830;\ 1260)$ [kg/m^3] and dynamic viscosity $\eta \in (1.0;\ 6.0)$ [mPa·s]) and 18 aqueous solutions of polymers and their mixtures, inflexible non-Newtonian liquids watered down with shearing, using thermal conductivity of coaxial arrangements of cylinders of my own construction. It was found that values of coefficients of thermal conductivity of Newtonian liquids do not depend on values of shear rate, but only on temperature, which is confirmed by subject literature. Coefficients of thermal conductivity λ for tested non-Newtonian liquids depend on rheological characteristics, shear rate, temperature and molar mass of a dissolved polymer. Values λ for solutions of polymers increase linearly with the increase in shear rate γ and temperature. This effect is presented with the help of generalized correlation dependency:

$$\lambda = a_o + a_1 \cdot \gamma + a_2 \cdot T + a_3 \cdot \gamma \cdot T$$

Increase in concentration of polymer in the aqueous solution caused decrease of value of coefficient λ. Increase in molar mass (solutions of carboxymethylcellulose sodium salt) or partially hydrolysed polymer (polyacrylamide with molar mass $M = (2 \div 4) \cdot 10^6$ [kg/kmol]) in a solution caused increase in value of coefficient of thermal conductivity.

Critical values of shear rate were observed in non-Newtonian systems, below which coefficients of thermal conductivity do not depend on shear rate. It was found that in all tested Newtonian and non-Newtonian liquids, there is a dependence of coefficients of thermal conductivity on viscosity η, both Newtonian and non-Newtonian (coefficients of conductivity decreases as viscosity increases), which can be shown as a polynomial function:

$$\lambda = C - C_1 \cdot \eta + C_2 \cdot \eta^2 - C_3 \cdot \eta^3$$

Articles [1-3] allowed to learn more about physicochemical properties of aqueous solutions of polymers. The goal of subsequent research works was to measure specific heat of selected liquids, particularly aqueous solutions Na-CMC. Calorimeter, designed and used in the research was built on the basis of a well-known solution. However, four Pt-100 sensors were placed in a construction. Recorded temperature was the average value, obtained from four measurements.

Determining physicochemical parameters is very important in the research on aqueous solutions of polymers, such as: viscosity, thermal conductivity, specific heat. The same polymer (e.g.: Na-CMC), may differ in, among others: molar mass or degree of substitute. Trade batches of the same polymer, produced in time intervals, can have different rheological and thermal properties. Features of a polymer are often very diverse, depending on a producer and technology of production. Therefore, it is important to work out a method of determining unknown values of specific heat C_p. Physicochemical properties of aqueous solutions of polymers must be determined every time in an engineering's practice. Measurement of specific heat of carboxymethylcellulose sodium salt was performed in the article. A result of these considerations was an article [10].

Obtained experimental values of specific heat of standard liquids did not exceed 1.1% error, in comparison with literature data. Good conformity of values of specific heat obtained during experiment, in comparison with literature data, enabled to use a measuring post to determine unknown values of specific heat, aqueous solutions Na-CMC. In case of a polymer, specific heat increases together with increasing concentration. Molar mass has also significant impact on the results. The highest values C_p, were obtained for Na-CMC with a molar mass $7{\cdot}10^5$ [kg/kmol] and concentration 0,005 [kg p/kg]. Obtained result was by over 15% higher than water.

There were also research aiming at determining specific heat of aqueous solutions Na-CMC using a cooling method [11,12]. Method of determining specific heat of liquids with a method based on Newton's law of cooling was presented in these articles. For the purposes of the experiment, a research post was built, enabling to determine specific heat of two model liquids with a density smaller and higher than water. Calculated values of specific heat were compared with the literature data. An error of measurement was lower than 1%. Moreover, research post enabled to determine specific heat of the aqueous solutions Na-CMC with different mass share of a polymer in a mixture. The highest values C_p, were obtained for the aqueous solutions Na-CMC with a molar mass M = $7{\cdot}10^5$ [kg kmol^{-1}] and concentration u_p = 0.005 [kg p kg^{-1}]. Obtained result was by over 19% higher than water. For studied solutions of polymers, generalized dependency was proposed:

$$C_{Na\text{-}CMC} = D \cdot \ln u_p + E$$

Interesting elements was to find all physicochemical constants in a Prandtl number for a polymer. On the basis of the articles [1-3, 10-12], dependency allowing to calculate Prandtl Number of aqueous solutions of carboxymethylcellulose sodium salt was proposed:

$$\Pr = \frac{C_p \cdot \eta}{\lambda} = 2.095\ K^{0.95}\ C_p\ \dot{\gamma}^{0.881\,n - 1.021}$$

Comparison of two methods (electrocalorimetric and cooling) of determining specific heat of aqueous solutions of polymers was presented in the article [11]. Research results from above articles were also presented during world congresses of Chemical Engineering in Prague, Cracow and Montreal and published in post-conference materials.

Environmental engineering includes activities aiming at maintaining natural environment in a state of equilibrium and keeping capability to self-regeneration and self-cleaning. Such actions are taken in the construction industry, agriculture and industry. People look for compounds, mixtures, composites with low value of thermal conductivity λ, enabling to create new insulating materials used in the construction industry.

Analysis of literature sources has shown that there is not enough data concerning thermal conductivity of phase changing organic materials, including eutectic mixtures of fatty acids. Measurements of this parameter are additionally complex due to phase changes in different ranges of temperatures. For the needs of the research, measuring device to measure a coefficient λ using *hot wire* method was created. Proposed measuring method is of universal character, and it is characterized by high accuracy. It can be applied both to solid and loose bodies. It is important to eliminate the impact of convection during measurements of liquids. It is applied to examine materials with relatively low thermal conductivity. As a result of the research, values of coefficient of thermal conductivity of five selected, clean fatty acids were obtained. The research were conducted for materials in liquid and solid state [4].

On the basis of analysis of the research results of three selected, clean fatty acids, no direct dependency of a coefficient of thermal conductivity on number of carbon atoms in a particle. Significant differences were observed in materials with different state of matters. The lowest values of coefficient of thermal conductivity in both state of matters were obtained for hexanoic acid 0.125 W/(m·K) (in solid state) and 0.132 W/(m·K) (in liquid state). The highest thermal conductivity was obtained for decanoic acid 0.170 W/(m·K) (in solid state) and 0.292 W/(m·K) (in liquid state) [4,5].

Constantly improving and developing measuring post was used to measure thermal conductivity of liquids [6-8]. In these articles, improved method of measuring a coefficient of thermal conductivity using *hot wire* method with small powers emitted by heating element was presented for selected liquids: water and three liquids with density higher than water. For the experiment's purposes, precise temperature measuring analogue converter R/U of my own construction was produced. In the measuring post, a small Pt500 platinum resistance temperature sensor was permanently attached to the resistance wire. Measuring sensor in the bridge circuit was powered by direct current of value I=0.8 mA, from temperature-compensated source of LM 234 current, and voltage resulting from it was amplified using precise amplifier of INA 122 type. Pt500 sensor with measurement system created precise temperature measuring analogue converter with voltage output. Temperature analogue converter R/U was connected to the computer measuring post that consisted of multifunctional output of 14-bit converter A/C type NI USB-6009 produced by National Instruments with interactive software for registration and measurements. PC computer was equipped with drivers NI-DAQmx and NI-LabVIEW for the service of a measuring module. Results of measurements were registered using computer system PC with a sampling time every 0.1 second (Fig. 1). The main part of measuring system was a research chamber equipped with a resistance wire with an insulating power which had 0.2 mm in diameter.

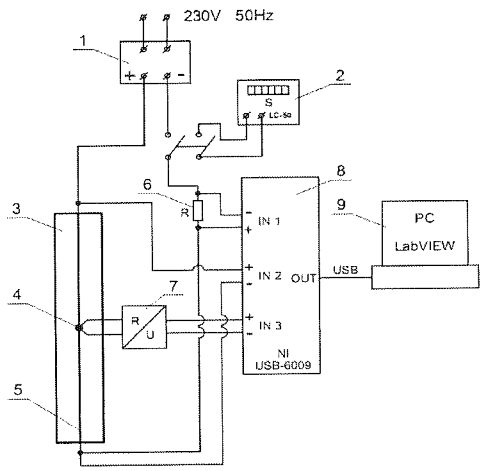

Fig. 1. Experimental set up to measure thermal conductivity of liquids:

1 – regulated power supply, 2 – stopwatch, 3 – tested sample, 4 - Pt500 sensor, 5 – heating wire, 6 - 100 Ω standard resistor, 7 – temperature converter, 8 – data recorder, 9 – PC computer

Using a research post, experimental measurements of coefficient of thermal conductivity of four liquids were performed. Seven measurements in a series were performed for each of them, with selected heating power within the range 0.2÷1.0W. Graph (Fig. 2) presents exemplary dependencies of temperature in a function of time with heat power 0.2W. For a dependency $T\text{-}T_0 = f(ln\ t)$ in time range 1÷10 [s] linear dependency was obtained (Fig. 2b).

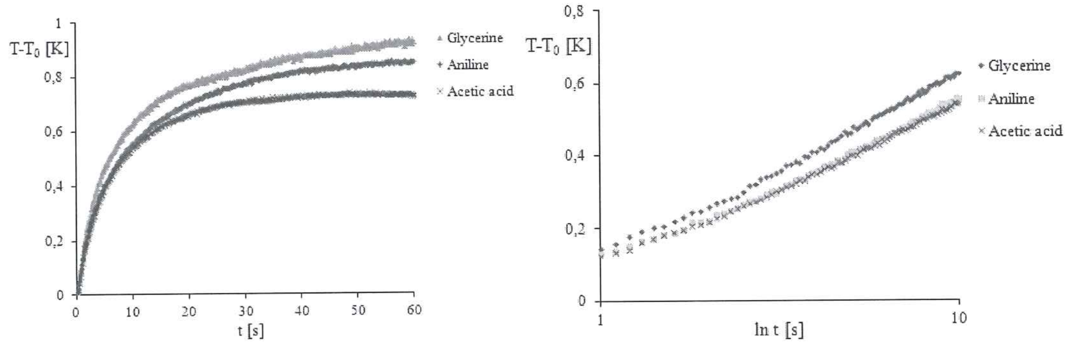

Fig. 2. Temperature of heating wire as a function of time in three tested samples of liquid: a) $T\text{-}T_0 = f(t)$, b) $T\text{-}T_0 = f(ln\ t)$

The author's measuring post allowed to determine with accuracy ± 5%, values of coefficient of thermal conductivity of model liquids, with a density higher than water. Proposed measuring system can be applied in determining thermal conductivity of liquids with unknown values λ. Generalized dependency for all the studied liquids and for every power was found and presented with the help of a formula:

$$T\text{-}T_0 = A \cdot ln(t) + B$$

Results of experimental research, determining the coefficient of thermal conductivity λ of selected liquids with density higher and smaller than water are presented in an article [8]. Three methods of interpretation of measurement data were presented in the article. The methods of measurement and interpretation of results of the experiment were presented in order to determine a coefficient of thermal conductivity of selected liquids. Knowledge of physical properties of the studied materials enabled to determine the required scope of temperatures, for which λ coefficient was determined. In order to find the required range of temperatures, a computer program for analyses of experimental database was written. Moreover, dependencies of coefficients of method, initial time t_1 and slope coefficient S, on selected physical parameters were found. Determined dependencies allow to determine coefficients of a method for the needs of further research on thermal conductivity of materials with unknown properties.

Graphs of dependencies $T\text{-}T_0 = f(t)$ were made for all studied liquids, with different heating powers. Together with the increase of power delivered to a heating wire, its temperature increases. The highest increase in temperature was observed for a vaseline oil, and the lowest for water. After interim period (first phase of experiment), function $T\text{-}T_0 = f(lnt)$ takes the form of linear character.

Calibration of used measuring equipment is usually required in measurements in which *hot wire method* is used. It is also very important to find a range of time, for which it is possible to calculate values of coefficient of thermal conductivity. This range is assessed due to its scope (coefficient S) and initial point (time t_1). In order to solve inconveniences resulting from the necessity of ambiguous interpretations of results, the computer program enabling optimization of a process of searching proper range of data was written. During 60s long measurement, 600 measurement points registering values of heating wire temperature were collected.

Due to large number of measuring posts and a number of calculation combinations of coefficient of thermal conductivity (N =179700), there was a problem of their selection for further analyses (within time range from 1 to 10 seconds N = 4005). For the purposes of the experiment and further lists of measurement data, an original application in Java programming language, using *Eclipse* software environment was written. Special components enabled to collect experimental data from the program and record calculated values of thermal conductivity to Excel.

Statistical analysis of many thousands of calculations enabled to find slope coefficients S straight in a coordinate system $T\text{-}T_0=f(lnt)$, allowing to calculate values of coefficients of thermal conductivity λ from a simple dependency:

$$\lambda = \frac{Q}{4\pi L} \cdot \frac{1}{S} = \frac{q}{4\pi} \cdot \frac{1}{S}$$

In an article [8], determined values of straight slope coefficients S and values of thermal conductivity λ calculated from above dependency were listed. Moreover, time slots were analysed, in which the closest values of λ from literature data were obtained. In all cases, an error was maximum 10%.

Provided that reverse task that is to find method parameters for the known final values, lambda coefficient is not a complex problem, but when it comes to materials with unknown coefficients, interpretation of measurement results is an additional challenge. In order to give precise results for the method, it is necessary to determine additional dependencies of parameters from other physical properties, for example, density and specific heat. On the basis of measurement data analysis with the help of the author's software program, values of slope coefficients were found. Dependencies of slope coefficient S and initial time t_1 in a volumetric function of heat capacity $C_v = Cp \cdot \rho$ were also determined (Fig. 3 and 4).

Comparing materials with different physical parameters, density and specific heat, generalized dependencies were proposed:

$$S = 0{,}7891 \cdot e^{-6 \cdot 10^{-7} \cdot \rho \cdot C_p}$$

$$t_1 = 112{,}8 \cdot e^{-2 \cdot 10^{-6} \cdot \rho \cdot C_p}$$

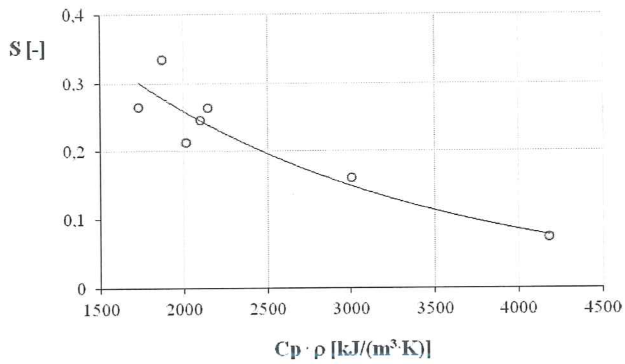

Fig. 3. Graphs of dependencies of a slope coefficient $S = f(C_p \cdot \rho)$ for tested liquids

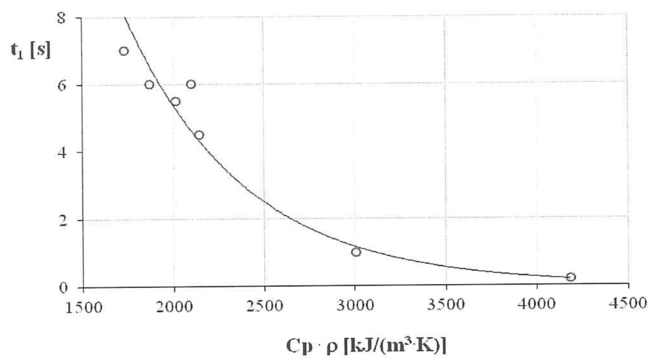

Fig. 4. Graphs of dependencies of initial time $t_1 = f(C_p \cdot \rho)$ for tested liquids

In order to work out an universal method of measuring data analysis obtained by the *hot wire* method, dependencies of selected physical quantities from slope coefficient and initial temperature were determined. It was found that a parameter which is the best for describing selected functions is a product of specific heat C_p and density ρ. Obtained dependencies have a character of exponential functions. On this basis, generalized dependency of calculating the values of coefficient of thermal conductivity λ as a function of two variables, specific heat and density of material, was proposed.

$$\lambda = 0.0565 \cdot \left(e^{-6 \cdot 10^{-7} \cdot \rho \cdot C_p} \right)^{-1}$$

An effect of conducted research and analyses is a possibility of determining a coefficient of thermal conductivity using *hot wire* method of any materials, including mixtures of liquids and composite materials. Knowledge of basic thermal parameters of liquids, that is, specific heat and thermal conductivity, is necessary for planning and using them in creating new materials with low thermal transmission.

Method of *hot wire* was worked out for research on liquids, and adapted to experimental determining of thermal conductivity λ of different wood species used as insulating material [9]. Value of thermal conductivity for six species of wood was calculated. Obtained values were within the range 0.126÷0.225 [W/(m·K)] and were not different than literature values by 10%. The lowest values were obtained for pine wood, the highest for hornbeam wood. General dependency of calculating the value λ of the wood on the basis of a known value of density was proposed.

$$\lambda = 0.00446 (0.5519 - 0.0004 \cdot \rho)^{-1}$$

Hot wire method was also used in the research on thermal conductivity of construction materials, mainly building gypsum which were not published yet. Gypsum materials were modified with polymer – carboxymethylcellulose sodium salt (Na-CMC) – dissolved in water. For all samples, I used a permanent mass ratio of polymer to gypsum 0.001 [g polymer/g gypsum] – 0.1%, and permanent ratio of water to gypsum w:g=0.7. Samples without polymer were also measured.

Current research have shown that thermal conductivity of gypsum without polymer was 0.4011 [W/(m·K)] in the air and humidity conditions. Adding a polymer caused reduction of thermal conductivity by 9% and it was 0.3660 [W/(m·K)]. Small concentration of polymer contributed to reduction of coefficient λ.

In the research on the impact of hydroxymethyl-ehthyl-cellulose (HMEC) on the value of thermal conductivity of building gypsum, permanent ratio of polymer to gypsum 0.1% was applied, changing measurements with different values of ratio of water to gypsum (0.54; 0.60; 0.66; 0.74; 0.82; 1.0). Six samples of gypsum without polymer were prepared in parallel. Measurements of conductivity λ were performed: 1, 3, 7, 14 and 21 days after the date when samples were made. Density of gypsum blocks ρ was determined every day. It was found that increase in ratio of water to gypsum caused reduction of thermal conductivity and density of gypsum samples with polymer (Fig. 5).

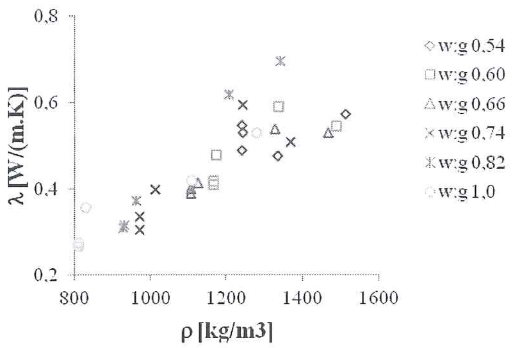

Fig. 5. Graphs of dependencies $\lambda = f(\rho)$ of samples with admixture of polymer for different ratios of water to gypsum

Moreover, it was found that in all samples, there was a loss of water and its binding in the structures of gypsum in every day of measurement. Density and thermal conductivity was decreasing. Very small addition of polymer caused reduction of density of samples in comparison with analogous gypsums without its addition. The lowest values of density and thermal conductivity were obtained for samples, with ratio of water to gypsum w:g=1.0 with addition of polymer (ρ=810 kg/m^3, λ=0.2749 W/(m·K)). Similarly, without addition of polymer (ρ=884 kg/m^3, λ=0.3443 W/(m·K)). Value of conductivity decreased by over 25%. For all gypsum samples, generalized linear dependency of change of thermal conductivity in a function of density was proposed $\lambda=f(\rho)$:

$$\lambda = F \cdot \rho - G$$

Heat-insulating materials with cellulose-based polymers, decreasing value of thermal conductivity λ and creating proper microclimatic conditions in the summer, contribute to lower energy expenditure for air-conditioning or airing of rooms. New composites may reduce, to a large degree, demand for energy to heat the rooms during a heating season.

Modern and innovative solutions enable for proper impact of buildings on the external environment. Building should store as much energy as possible from natural environment, ensuring less pollution and degradation.

5. Summary of scientific, teaching, education and organizational activities

Within the framework of teaching work, I conducted or conduct different forms of classes (lectures, classes, design engineering, laboratory) of such subjects as: *General Ventilation*, *Elementary Processes*, *Fluid Mechanics*, *Devices in Environmental Protection*, *Building Physics* or *Alternative Sources of Energy*. Until now, I have promoted 38 engineers and 26 Masters of Science. I reviewed 38 engineer's theses and 47 master's theses.

I have dealt with **promotion of science** for many years. I cooperate with School Complex no. 9 in Kalisz. I initiated, with a group of pupils of Gymnasium no. 9, the research on environmental protection.

a) In 2009, I organized a seminar in the State Higher Vocational School in Kalisz, propagating and promoting rheology among pupils of high school *Applied rheology*.

b) In 2012, Final of Competition *Young Scientists* organized by *National Fund for Children* with support of *Warsaw University* took place in *Copernicus Science Centre* in Warsaw. They presented a work *The impact of non-central placement of a stirrer and barriers on power of mixing*. They were the youngest participants of the competition. They have received a written declaration, from a pro-vice chancellor of *Jagiellonian University*, about favourable conditions during entrance exams, as well as possibility of obtaining special scholarship during first year of studies.

c) In 2014, in the final of the competition *Physical Paths* organized by *National Centre for Nuclear Research* and *Institute of Physics in Polish Academy of Sciences*, the pupils created a work related to alternative sources of energy, and in particular to wind energy *The impact of the structure of a rotor and direction of the wind on rated power of wind turbine*. Many modifications of a laboratory wind turbine were made during the research. This article was positively reviewed by the peer reviewers from the world of science. Only five articles were presented in the final in the *Polish Academy of Sciences* in Warsaw. The pupils also received student's books for a *Jagiellonian University* in Cracow.

d) I established cooperation with *National Fund for Children* in Warsaw. This Fund deals with development of specially talented children and young people, through numerous additional seminars, conferences, meetings and scholarships. I proposed one of the pupils from Kalisz school to this Fund.

e) Thanks to cooperation with me and to my commitment, one of the graduates of Gymnasium no. 9 was granted a scholarship. Since a school year 2014/2015, he has started education in Maastricht, Holland. It will be finished with international baccalaureate.

f) In 2011, I participated in Kalisz meetings of *Copernicus Science* presenting a lecture *Combinatorial games*.

g) In 2015, I participated, together with pupils in a competition *Heroes of the future* organized by chemical *company BASF*, in which pupils presented an environmental engineering work related to alternative sources of energy. The pupils received a distinction for the presented results of research.

h) In 2015, pupils from Kalisz won the fourth place in a competition *Interesting experience – fascinating explanation*, organized by *Lodz University of Technology* for a work related to the use of wind energy in environmental engineering.

i) I have been promoting environmental engineering activities for three years during a holiday of Niecała street in Kalisz.

Since 2012, I have been a deputy dean for student affairs in the Faculty of Polytechnic of the State Higher Vocational School in Kalisz. In 2014, I was responsible for preparation of *Self-evaluation Report* for *Polish Accreditation Commission*, visiting a major Environmental Engineering in the State Higher Vocational School in Kalisz.

In the years 2009-2010, I was a member of a Selection Committee of State Higher Vocational School, and I am still a chairman of Department Grant Commission. In the years 2009-2012, I conducted a research club *You live in the environment* working by the major Environmental Engineering. Scientific seminars of students are still organized within the activity of this club (there will be 9 seminars for pupils from schools in Kalisz in this year).

In the years 2011-2014, I worked in a team realizing EU project in the State Higher Vocational School:

a) major Building: *Build your energy-efficient future*,

b) major Mechanical Engineering and Machine Design: *Mechanical Engineering and Machine Design – professional start to Your career.*

In 2010, I worked in a team creating and then realizing projects in the State Higher Vocational School in Kalisz: *Uniwersytet Gimnazjalisty*, *Uniwersytet Licealisty* and *Politechnika dziecięca* within the framework of the Program Operacyjny Kapitał Ludzki, Priorytet IX, Działanie 9.5 Grass-roots educational initiatives on rural areas.

In an academic year 2011/2012, I was a plenipotentiary of a vice-chancellor for postgraduate studies.

I was awarded four times by the Vice-chancellor of the State Higher Vocational School in Kalisz for the achievements in education, teaching, scientific and research work.

Participation in the competitions and grants:

1) In 2011, I was given a distinction in the third edition of a competition *Kuźnia Talentów* organized by Marshal's Office of the Wielkopolska Region realized within the framework of system project *Regional networks of innovations and promotion of innovations in the region*, for the article *Research on correlation of rheological and thermal properties of non-Newtonian solutions*.
2) Co-executor of a grant: ***Promoting balanced approach to energy effectiveness in the construction industry as a tool of climate protection in the cities in Poland and Germany: working out a facade technology for the needs of buildings with zero emission***, WPN/5/2013. Grant was given by *National Centre for Research and Development* – bilateral cooperation, Polish and German program.
3) Co-executor of a grant: ***New hybrid materials (building binder - polymer-water) with optimal structure and properties.***

Membership in the scientific associations:

- Since October 2007, I have been a member of *Polish Society of Engineering Rheology*.
- A reviewer in a scientific magazine: *Building Physics in Theory and Practice*.

Internships:

In July, 2012, I underwent a holiday internship in *Ryerson University* (Toronto), *Department of Mathematics, Biomathematics and Fluids Group*.

I am an author or co-author of 33 publications in domestic and foreign magazines and conference materials, and 20 presentations on the scientific conferences. According to Google Scholar, Hirsch Index is 2, and articles were quoted 19 times.

Summary of a scientific and research achievements

Scientific and research achievements	**Before doctorate**	**After doctorate**	**In total**
Magazines from a JCR list	-	**4 (+1)***	**5**
Articles in Polish magazines	2	6	8
International conference materials	1	3	4
Domestic conference materials	2	14	16
Summary impact factor IF	-	**3,851 (+0,653)***	**3,851 (4,504)***
Number of delivered reports	3	17	20
Number of quoting according to Google Scholar	-	19	19

Kalisz 8.10.2015 Karol Prałat