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MONITORING OF HOT WATER CONSUMPTION IN RESIDENTIAL BUILDINGS

Annotation: The article is processed on the base of hot water off-take daily loading developments. An imperative assumption for optimal systems of hot water production and distribution design is a consumer's real demands knowledge. After contemporary status analysis execution in the field of hot water (HW) preparation and distribution the second step was an experimental observation hot water off-take in residential houses at its central preparation with intention to develop diagrams of heat consumption.

Keywords: hot water consumption, real diagrams, residential buildings

Diagrams of loading. The article is processed on the base of hot water off-take daily loading developments. Courses were classified according to both heat exchanger plants and daily characteristics in which the measurement were performed with a recording interval 3 minutes. Daily diagrams scales allow to show details for HW systems dimensioning at different terms and situations. Loading courses during the day is different accordingly types of supply objects from uniform loading to suddenly.

The area below curve represents a day-long water consumption.

$$V^d = \int_{t1}^{t2} q.dt \qquad (l.s^{-1})$$

where:

q is a momentary overflow ($l.s^{-1}$)
t_1 a begin of day period t1=0 hour
t_2 the end of day period t2=24 hours

For clock and day non-uniformity coefficients real values statement was elaborate a day diagram for separate heat exchanger stations with designation of HW maximal consumption during the day, average day loading and average weekly loading. Aggregate coefficients value for three heat exchanger stations were designated extra for week-days and days off and holidays during all period of measurement from 12 months from January to December in Kosice. For balancing data computational planning heat consumption for HW preparation is stated

according to Slovak Technical Standard STN 38 3350 - Heat supply: Part - General fundamentals - designing. The coefficients K_d and K_h are important.

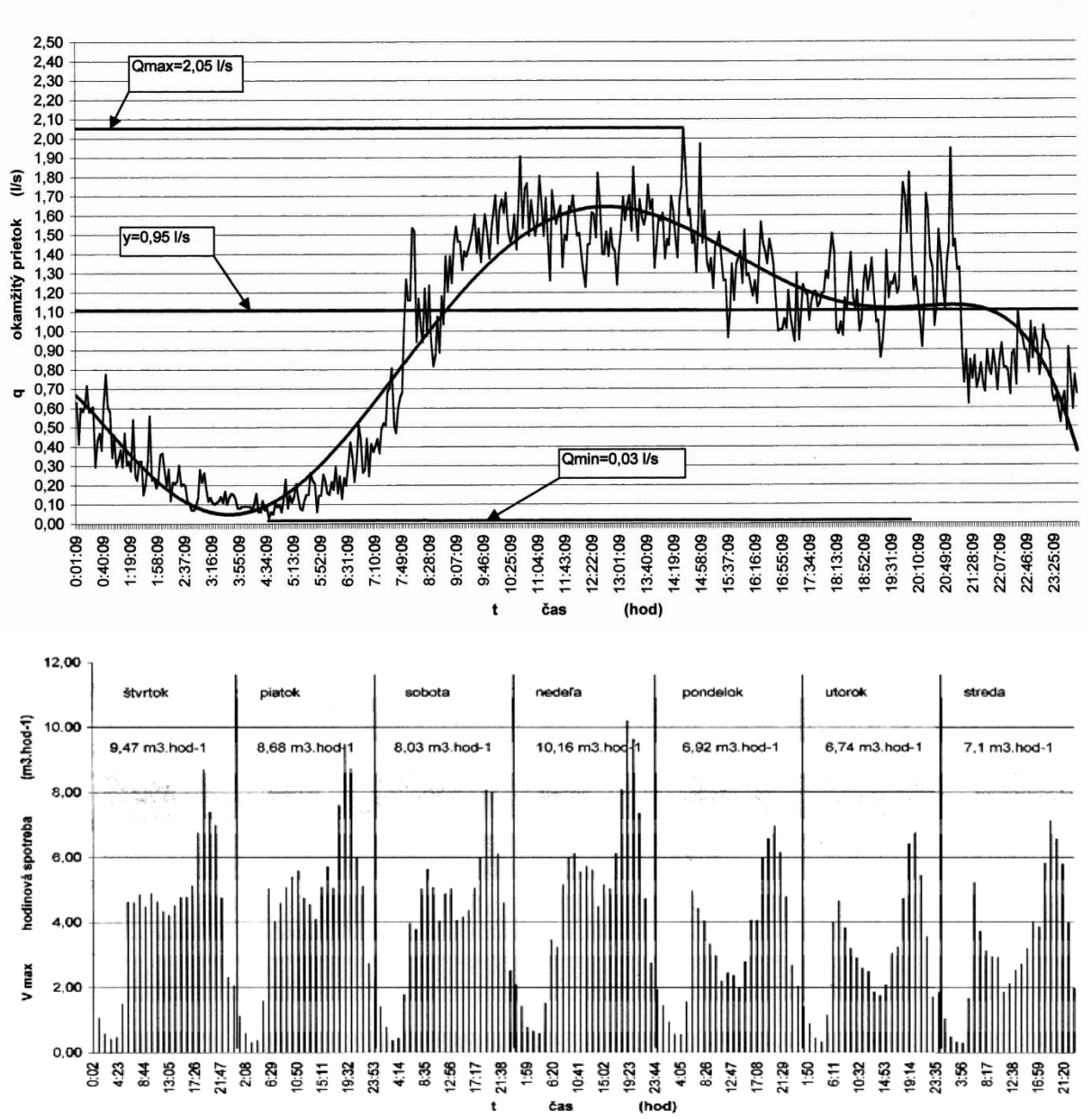

Figure 1: Hot water consumption typical course during the day and week

Their values accordingly this Standard are:

K_d coefficient of daily non-uniformity of heat consumption per week (K_d=1,2)

K_h coefficient of hourly non-uniformity of heat consumption per day with HW maximal demand (K_h=1,7 - 2,0)

Sum of the measured values. For the most severe days is necessary to designate the hourly overflow analysis with hot water hourly amount statement maximal and average values. By confrontation of these two values is possible to spot the most severe day with its values with relative high accuracy. In following table the

most severe week is images in separate heat exchanger plants (HEP). The results of momentary overflows and maximal hourly values are show in Table 1.

Table 1: Maximal, minimal and average values of momentary overflow in (l.s-1) and statement of maximal and average consumption daily and weekly.

HEP Yearly Measurement	Day	Q_{max}	Q_{min}	Q_{mean}	$V_{aver.t}$	V^{max}	V^{d}_{aver}	Kh	Kd
		Moment. overflow ($l.s^{-1}$) Daily measurement				Overflow ($l.s^{-1}$) Daily measurement			
VS 2225 – 1	MO	2,65	0,08	0,92		6,92	3,312		0,88
32 852 $m^3.y^{-1}$	TU	2,21	0,04	0,81		6,74	4,6		1,2
3,75 $m^3.y^{1}$	WE	2,51	0,03	0,86		7,1	4,356		1,15
	TH	3,13	0,06	1,14	3,78	9,47	4,104		1,08
	FR	3,19	0,08	1,21		8,68	3,096		0,82
	SA	2,95	0,06	1,12		8,03	2,916		1,04
	SU	3,95	0,06	1,28		10,16	3,312		0,87
								2,86	
VS 523 – 2	MO	3,8	0,02	1,24		6,55	4,464		1,00
29 631 $m^3.y^{-1}$	TU	6,18	0,03	1,34		7,64	4,824		1,08
3,38 $m^3.y^{1}$	WE	5,48	0,02	1,34		7,35	4,824		1,08
	TH	6,18	0,02	1,36	4,464	8,35	4,896		1,1
	FR	6,21	0,02	1,38		8,28	4,968		1,112
	SA	4,7	0,03	1,23		7,63	4,428		0,99
	SU	4,1	0,02	1,34		8,05	4,824		1,08
								1,87	
VS 1901 – 3	MO	1,78	0,75	0,05		4,57	2,7		0,88
25 360 $m^3.y^{-1}$	TU	1,72	0,79	0,04		4,42	2,844		0,93
2,89 $m^3.y^{1}$	WE	1,88	0,04	0,8		4,69	2,88		0,94
	TH	1,81	0,05	0,81	3,06	4,73	2,916		0,95
	FR	1,48	0,05	0,82		4,22	2,952		0,96
	SA	1,86	0,06	0,96		6,29	3,456		1,13
	SU	2,31	0,06	1,04		6,85	3,744		1,22
								2,24	

Where:

V^{d} is average consumption designated in $m^3.hour^{-1}$ during 24 hours

$V^{aver,t}$ is average consumption designated in $m^3.hour^{-1}$ during the week

V^{max} is maximal consumption designated in $m^3.hour^{-1}$ in given day

K_h coefficient of hourly non-uniformity of heat consumption during the day

K_d coefficient of daily non-uniformity of heat consumption during the week

Cumulative graphs – diagrams. These graphs are compiled from the most characteristic courses of several HEP for designation of sufficient capacity for hot water preparation. The maximal curve is regards for a statement of equipment performance. Diagrams are used for statement of reservoir size - a hot water needful store, maximal heat input power during the day ΔQ_{max} and for determining of a heating caloric power rating in separate plants. For evaluation the most severe hourly intervals were choose because of hot water accumulate heating. From graphical

figuration of hot water take-off and corresponding heat amount are optimal sizes of HW reservoirs following:

Table 2: Results found from off-take diagrams

HEP	V_{daily} (m^3)	Q_{daily} (kW)	Q_{loss} (kW)	$Q_{overall}$ (kW)	ΔQ_{max} (kW)	V_z (m^3)	Q_m (kW)	Number of inhabit.
1	110,99	5 809	2 904	8 713	1 150	22	363	1 693
2	89,64	4 691	2 345	7 036	1 073	20,5	293,2	1 345
3	117,4	6 145	3 073	9 220	1 125	21,5	384,2	947

Where:

Q_m nominal caloric performance of heating (kW)

V_z volume of reservoir from off-take diagram (m^3)

ΔQ_{max} max. coordinates difference between curves of supply and off-take (kW)

$Q_{overall}$ overall heat amount needful for hot water heating per 24 hours (kW)

Q_{loss} heat losses at hot water production and distribution per 24 hours (kW)

Q_{daily} overall daily hat amount for HW production and distribution per 24 hours (kW)

V_{daily} hot water volume amount per day (m^3)

With increasing number of inhabitants the coincidence of consumption coefficient decreases. This denotes that needful power per one dweller gradually declines. In comparison of the Standard in force STN 06 0320 Heating of hot service water and measured values in single objects reservoirs sizes and needful input of heater heating element following:

Table 3: Comparison of calculated and measured values of accumulators and needful power of heater heating element

HEP	According to STN 06 0320			Results of measurements from offtake diagram		
	Q_z (kW)	V_z (m^3)	a	Max Q (kW)	V_z (m^3)	b
1	685	44	1,7	1150	22	0,5
2	562	37	1,9	1073	20,5	0,55
3	421	29	2,7	1125	21,5	0,74

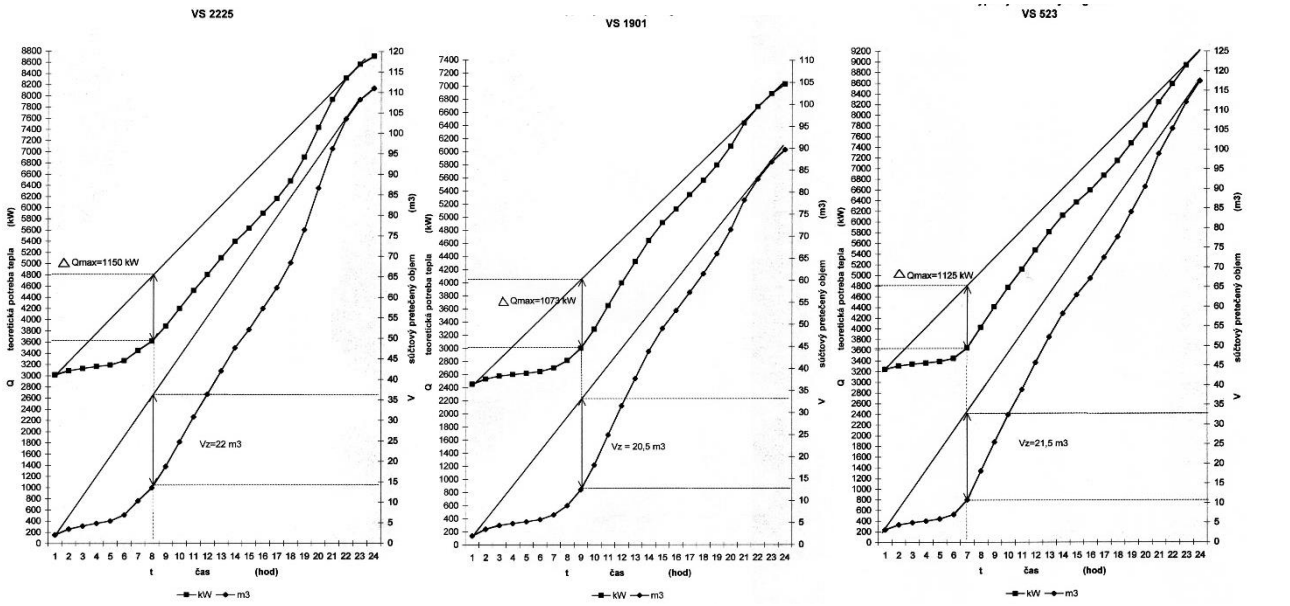

Figure No 2: Cumulative diagrams of single heat exchanger plants

Evaluation and Conclusions. For determined maximal amount of hot water in certain time interval over day the volumes of accumulators were dead appointed that are about 25-50% less than accumulators sizes calculated by means of the Standard STN 06 0320. With rising number of dwellers a hot water volume is lesser in ratio to one dweller. A coefficient **b** determines a statement in percent's a real needful accumulator volume towards calculated one. For securing of hot water optimal parameters the more power heaters are necessary, with more rapid water heating in given moment. A coefficient **a** expresses how much the heater power have to be higher as calculated value according the standard STN 06 0320. According to single heat exchanger plants measurements and data processing is possible to state:

- K_d - coefficient of daily non-uniformity of heat consumption during the week is moving in the range 0,82 - 1,22; that is an assumed value of this coefficient accordingly STN 38 3350 Heat supply
- K_h coefficient of hourly non-uniformity of heat consumption during the day is moving in the range 1,87 - 2,86; that is a higher value as a value accordingly STN 38 3350 Heat supply.

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Анотація:

В статті аналізується використання гарячої води в побутових цілях в житлових будинках. Імперативне припущення оптимальних систем виробництва гарячої води і її розподілу є реальним показником енергозбереження. Після сучасного аналізу схеми використання гарячої води (HW) і її поширення в житлових будинках, була розроблена схема споживання теплової енергії.

Ключові слова: споживання гарячої води, реальні схеми, житлові будівлі

Аннотация:

В статье анализируется использование горячей воды в бытовых целях в жилых домах. Императивное предположение оптимальных систем производства горячей воды и ее распределения реальным показателем энергосбережения. После современного анализа схемы использования горячей воды (HW) и ее распространение в жилых домах, была разработана схема потребления тепловой энергии.

Ключевые слова: потребление горячей воды, реальные схемы, жилые здания