H2020-EE-2015-3-MarketUptake

European Commission

WaterWatt

Improvement of energy efficiency in industrial water circuits
by online self-assessment, benchmarking and economic decision support

Project Title: Improvement of energy efficiency in industrial water circuits using gamification for online self-assessment, benchmarking and economic decision support

Acronym: WaterWatt

Grant Agreement No: 695820

Deliverable No.	1.3
Deliverable Title	*Catalogue of representative industrial water circuits and their units with specific energy consumption*
Due Date	31.03.2017
Date Delivered	31.03.2017
Prepared by (Lead Partner)	4 - SINTEF
Dissemination Level	Public

Table of Content

1. Executive Publishable Summary

In the frame of case studies representative circuits and their units were examined in detail. The results were documented in questionnaires (D1.2). The main circuit units were pumps, cooling towers, gravel filters, sedimentation tanks and gas scrubbers. The main electricity consumers were pumps and cooling tower ventilators. The data of these units were derived from the questionnaires to calculate specific energy consumption values. These values can be used for benchmarks definition. This deliverable (D1.3) provides joint basis for further studies in WP2.

2. Introduction

For the planned study and modelling of energy consumption in water circuits of various industries description of representative circuits and their units with real operational parameters is crucial. Case studies have shown that at industrial plants there are from one to several dozen water circuits supporting various production processes. Representative circuits were chosen on basis of

- their function (cooling, gas washing, …),
- flow,
- pressure,
- installed power and
- abundance in the industry.

The circuit flows and energy consumption of their units were studied in measuring campaigns. The results are documented in questionnaires in D1.2. In this deliverable (D1.3) specific energy consumption was calculated on basis of the data from the questionnaires. This provides data for benchmarks and energy consumption modelling.

3. Catalogue of representative industrial water circuits and their units with specific energy consumption

The case studies have been conducted in metal, chemical, paper, food and ceramic industry. An overview of the studied circuits is shown in Table 1. The circuit units with specific energy consumption are presented in Tables 2 to 12.

Table 1: Overview of studied circuits

Industry	Case study	Origin	Representative circuits	Flow [m³/h]	Installed power [kW]	Nr*
Metal	Stainless wire processing	DE	Open cooling circuit (rolling mill) with sand filtration	2400	1220	**1**
			Closed cooling circuit (inductive furnace)	63	37	**2**
	Carbon steel production	UK	Closed cooling circuit (blast furnace)	5700	901	**3**
	Carbon steel production	DE	Open gas washing circuit (basic oxygen furnace)	3200	800	**4**
	Carbon steel production	NO	Open cooling/quenching of rebar rods and wire coils	780	315	**5**
	Manganese production	NO	Closed cooling circuit (furnace)	350	171	**6**
			Open gas washing circuit	250	111	**7**
Chemical	Pharmaceuticals	DE	Open cooling circuit	3600	1254	**8**
Paper	Paper factory	PT	Fiber transportation circuit	2400	240	**9**
Food and beverage	Sugar factory	PT	Water treatment (filtration)	145	135	**10**
			Open cooling circuit	1600	627	**11**

* Case Study Number

Table 2: Open cooling circuit (rolling mill) with sand filtration (Nr. 1)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	3600	1200		
Flow real	m^3/h	2400	1200	2400	
Pressure nominal	bar	4.5	4.5	4.5	
Pressure lift real	bar	3.3	3.3	3.3	
ΔT nominal			10		
ΔT real	K		1		
Production rate	t/h				
Operational time	h/y	6600	6600	6600	
Power installed	kW	880	340	1220	Pumps: 8 × 110 = 880 kW Ventilat.: 4 × 85 = 340 kW
Specific power installed	$W\times h/m^3$	244	283		
Specific power installed	$W\times h/(m^3\times bar)$	74			
Specific power installed	$W\times h/(m^3\times K)$		28.3		
Specific power installed	W×h/t				
Power consumed	MWh/y	3890	760	4650	Estimated
Specific power consumed	$W\times h/m^3$	246	96	294	
Specific power consumed	$W\times h/(m^3\times bar)$	74		89	
Specific power consumed	$W\times h/(m^3\times K)$		96.0		
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}			1395.6	$Q = C \times q \times \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 \times K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}			505	
Installed power use	%			58	Power used/power installed

Table 3: Closed cooling circuit (inductive furnace) (Nr. 2)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	63	63	63	
Flow real	m^3/h	60	60	60	
Pressure nominal	bar	6.1	6.1	6.1	
Pressure lift real	bar	5	5	5	
ΔT nominal			10		
ΔT real	K		3		
Production rate	t/h				
Operational time	h/y	6600	6600	6600	
Power installed	kW	37		37	Pumps: 2 × 18.5 = 37 kW
Specific power installed	$W\times h/m^3$	587	0		
Specific power installed	$W\times h/(m^3\times bar)$	117			
Specific power installed	$W\times h/(m^3\times K)$		0		
Specific power installed	W×h/t				
Power consumed	MWh/y	212		212	Estimated
Specific power consumed	$W\times h/m^3$	537	0	537	
Specific power consumed	$W\times h/(m^3\times bar)$	107		107	
Specific power consumed	$W\times h/(m^3\times K)$		0		
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}			209.34	$Q = C \times q \times \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 \times K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}			154	
Installed power use	%			87	Power used/power installed

Table 4: Closed cooling circuit (blast furnace) (Nr. 3)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	5700	8000		
Flow real	m^3/h	5000	5000	5000	
Pressure nominal	bar				
Pressure lift real	bar	3.3		3.3	
ΔT nominal			7		
ΔT real	K		3		
Production rate	t/h	275	275	275	Pig iron production
Operational time	h/y	8760	8760	8760	
Power installed	kW	700	201	901	Pumps: 2 × 350 = 700 kW Ventilat.: 3 × 67 = 201 kW
Specific power installed	$W×h/m^3$	123	25		
Specific power installed	$W×h/(m^3×bar)$	37			
Specific power installed	$W×h/(m^3×K)$		3.6		
Specific power installed	W×h/t	1782	512	2293	
Power consumed	MWh/y			5510	Estimated
Specific power consumed	$W×h/m^3$	98	28	126	Distribution between pumps and ventilators was estimated on basis of power installed
Specific power consumed	$W×h/(m^3×bar)$	30		38	
Specific power consumed	$W×h/(m^3×K)$		9.4		
Specific power consumed	W×h/t	1777	510	2287	
Transferred heat power	kW_{th}			17445	Q = C × q × ΔT real; C = 1,163 kWh /(m^3 × K)
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}			36	
Installed power use	%			70	Power used/power installed

Table 5: Open gas washing circuit (basic oxygen furnace) (Nr. 4)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	4000		4000	
Flow real	m^3/h	2850		2850	
Pressure nominal	bar	6.2		6.2	
Pressure lift real	bar	5.5		5.5	
ΔT nominal					
ΔT real	K				
Production rate	t/h				
Operational time	h/y	8750		8750	
Power installed	kW	1000		1000	5 pumps with 200 kW and 800 m^3/h each, 4 in operation; 2 Dango-filter, 2 venturi scrubber
Specific power installed	$W \times h/m^3$	250			
Specific power installed	$W \times h/(m^3 \times bar)$	45			
Specific power installed	$W \times h/(m^3 \times K)$				
Specific power installed	W×h/t				
Power consumed	MWh/y	4638		4638	
Specific power consumed	$W \times h/m^3$	186		186	
Specific power consumed	$W \times h/(m^3 \times bar)$	34		34	
Specific power consumed	$W \times h/(m^3 \times K)$				
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}				$Q = C \times q \times \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 \times K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}				
Installed power use	%			53	Power used/power installed

Table 6: Open cooling/quenching of rebar rods and wire coils (Nr. 5)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	650	780	780	
Flow real	m^3/h				Depends on what is being produced
Pressure nominal	bar	16	7		
Pressure lift real	bar	10	4		
ΔT nominal					
ΔT real	K				
Production rate	t/h			75.0	Rebar rods, rebar coils, wire coils
Operational time	h/y	7785	7785	7785	
Power installed	kW	630	225	855	Pumps: 2 × 315 = 630 kW 1 × 225 = 225 kW
Specific power installed	$W×h/m^3$	969	288	1096	
Specific power installed	$W×h/(m^3×bar)$	97	72		
Specific power installed	$W×h/(m^3×K)$				
Specific power installed	W×h/t			11400	
Power consumed	MWh/y			2200	Estimated
Specific power consumed	$W×h/m^3$	380			Based on measured values
Specific power consumed	$W×h/(m^3×bar)$	45			Based on measured values
Specific power consumed	$W×h/(m^3×K)$				
Specific power consumed	W×h/t	3500			Based on measured values
Transferred heat power	kW_{th}				$Q = C × q × \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 × K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}				
Installed power use	%			33	Power used/power installed

Table 7: Closed cooling circuit (furnace) (Nr. 6)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	350	350	350	
Flow real	m^3/h	350	350	350	
Pressure nominal	bar				
Pressure lift real	bar				
ΔT nominal					
ΔT real	K				
Production rate	t/h				
Operational time	h/y	8750	8750	8750	
Power installed	kW	171	0	171	2 pumps 350 m^3/h and 160 kW; of this 1 standby for back-up 2 pumps 11 kW pressure holding; of this 1 standby for back-up
Specific power installed	$W\times h/m^3$	489	0		
Specific power installed	$W\times h/(m^3\times bar)$				
Specific power installed	$W\times h/(m^3\times K)$				
Specific power installed	W×h/t				
Power consumed	MWh/y	1500		1500	
Specific power consumed	$W\times h/m^3$	490		490	
Specific power consumed	$W\times h/(m^3\times bar)$				
Specific power consumed	$W\times h/(m^3\times K)$				
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}			0	$Q = C \times q \times \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 \times K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}				
Installed power use	%			100	Power used/power installed

Table 8: Open gas washing circuit (Nr. 7)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	250	250	250	
Flow real	m^3/h	250	250	250	
Pressure nominal	bar				
Pressure lift real	bar				
ΔT nominal					
ΔT real	K				
Production rate	t/h				
Operational time	h/y	8750	8750	8750	
Power installed	kW	111		111	5 pumps 85 m^3/h and 37 kW; of this 2 standby for back-up
Specific power installed	$W \times h/m^3$	444		444	
Specific power installed	$W \times h/(m^3 \times bar)$		0		
Specific power installed	$W \times h/(m^3 \times K)$				
Specific power installed	W×h/t				
Power consumed	MWh/y	970	0	970	
Specific power consumed	$W \times h/m^3$	443	0	443	
Specific power consumed	$W \times h/(m^3 \times bar)$				
Specific power consumed	$W \times h/(m^3 \times K)$				
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}				$Q = C \times q \times \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 \times K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}				
Installed power use	%			100	Power used/power installed

Table 9: Open cooling circuit (Nr. 8)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	6000	6000		
Flow real	m^3/h	3600	3600	3600	
Pressure nominal	bar	6		6	
Pressure lift real	bar	4.3		4.3	
ΔT nominal			10		
ΔT real	K		10		
Production rate	t/h				Various pharmaceuticals
Operational time	h/y	3000	3000	3000	
Power installed	kW	1164	90	1254	Pumps: 12 × 97 = 1164 kW Ventilat.: 3 × 30 = 90 kW
Specific power installed	$W\times h/m^3$	194	15		Based on nominal flow
Specific power installed	$W\times h/(m^3\times bar)$	45			
Specific power installed	$W\times h/(m^3\times K)$		1.5		
Specific power installed	W×h/t				
Power consumed	MWh/y	3300	180	3480	
Specific power consumed	$W\times h/m^3$	306	17	322	Based on real flow
Specific power consumed	$W\times h/(m^3\times bar)$	71		75	
Specific power consumed	$W\times h/(m^3\times K)$		1.7		
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}			41868	Q = C × q × ΔT real; C = 1,163 kWh /(m^3 × K)
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}			28	
Installed power use	%			93	Power used/power installed

Table 10: Fiber transportation circuit (Nr. 9)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	2400		2400	
Flow real	m^3/h	2400		60	
Pressure nominal	bar	2		2	
Pressure lift real	bar	2		2	
ΔT nominal					
ΔT real	K				
Production rate	t/h				
Operational time	h/y	6240		6240	
Power installed	kW	240		240	Pumps: 8 × 30 = 240 kW
Specific power installed	$W \times h/m^3$	100			
Specific power installed	$W \times h/(m^3 \times bar)$	50			
Specific power installed	$W \times h/(m^3 \times K)$				
Specific power installed	W×h/t				
Power consumed	MWh/y				
Specific power consumed	$W \times h/m^3$				
Specific power consumed	$W \times h/(m^3 \times bar)$				
Specific power consumed	$W \times h/(m^3 \times K)$				
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}				$Q = C \times q \times \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 \times K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}				
Installed power use	%				Power used/power installed

Table 11: Water treatment (filtration) (Nr. 10)

Parameter	Unit	Pumps	Remark
Flow nominal	m^3/h	80	
Flow real	m^3/h	64	
Pressure	bar	4	
ΔT nominal			
ΔT real	K		
Production rate	t/h	20.83	130,000 tons sugar
Operational time	h/y	6240	
Power installed	kW	71	
Specific power installed	$kW \times h/m^3$	0,89	
Specific power installed	$W \times h/(m^3 \times bar)$		
Specific power installed	$W \times h/(m^3 \times K)$		
Specific power installed	W×h/t		
Power consumed	kW	57	
Specific power consumed	$kW \times h/m^3$	0,89	
Specific power consumed	$W \times h/(m^3 \times bar)$		
Specific power consumed	$W \times h/(m^3 \times K)$		
Specific power consumed	W×h/t		
Transferred heat power	kW_{th}		
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}		
Installed power use	%	80.3	Power used/power installed

Table 12: Open cooling circuit (Nr. 11)

Parameter	Unit	Pumps	Cooling tower	Total	Remark
Flow nominal	m^3/h	5300	5300		
Flow real	m^3/h	1600	1600		from 400 to 1600
Pressure	bar	2.5			
ΔT nominal			10		
ΔT real	K		10		
Production rate	t/h	20.83			130,000 tons sugar
Operational time	h/y	6240	6240	6240	
Power installed	kW	750	22	772	
Specific power installed	$W\times h/m^3$	141.5	4.2		Based on nominal flow
Specific power installed	$W\times h/(m^3\times bar)$				
Specific power installed	$W\times h/(m^3\times K)$				
Specific power installed	W×h/t				
Power consumed	MWh/y	450	22	472	
Specific power consumed	$W\times h/m^3$	281.3	13.8		Based on real flow
Specific power consumed	$W\times h/(m^3\times bar)$				
Specific power consumed	$W\times h/(m^3\times K)$				
Specific power consumed	W×h/t				
Transferred heat power	kW_{th}		18608		$Q = C \times q \times \Delta T$ real; $C = 1{,}163$ kWh $/(m^3 \times K)$
Specific power consumed for heat transfer	Wh_{el}/kWh_{th}				
Installed power use	%	60	100	61.14	Power used/power installed

4. Conclusion

In the water intensive industrial branches of metal, chemical, paper, food and ceramic industry several representative circuits were studied. Water flows and energy consumption were measured to provide basis for benchmark calculation and circuit modelling. The main circuit units were pumps, cooling towers, gravel filters, sedimentation tanks and gas scrubbers. The main electricity consumers were pumps and cooling tower ventilators. Specific energy consumption documented in this deliverable (D1.3) provides joint basis for further studies in WP2.

5. Knowledge Created

KNOWLEDGE: Representative industrial water circuits and their units with specific energy consumption Responsible Person: Ole Stavset	
Owner(s)	BFI, SINTEF, ISQ
Nature	report
Registration / protection	not applicable
Description	In the frame of case studies in the water intensive industrial branches of metal, chemical, paper, food and ceramic industry several representative circuits were studied. Water flows and energy consumption were measured to provide basis for benchmark calculation and circuit modelling. The main circuit units were pumps, cooling towers, gravel filters, sedimentation tanks and gas scrubbers. The main electricity consumers were pumps and cooling tower ventilators. Specific energy consumption in the circuit units will be used for circuit modelling and benchmark calculations in WP2.
	Engineering Background is required to use the created Knowledge