

Computational Approach for Energy Intensity Reduction of Professional Laundry Care Process

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New computational tool which enables to analyze flows of energy through the professional laundry care process from utilities to every single consumer was developed in this field and is introduced in the paper. The tool combines theoretical balance modelling with experimental data from real premises.

The tool is presented through a case study involving a steam heated industrial laundry with capacity of 1.5 t of linen/h first with outdated energy system second with up-to-date energy system and apparatuses. The case study shows how it is possible to conclude the impact of each process parameter to the total energy demand.

1. Introduction

Today's ever rising prices of energy and water has negative impact upon competitiveness of the companies which consume large amounts of these commodities in their production processes. Professional laundry care is among the industries where it is advisable to be concerned with decrease of energy intensity. Common approach to replace single old machinery for new and more efficient one is not always the best solution. Since the process is made up by several operations (apparatuses), it is worth handling it as a whole.

Since 2006, Institute of Process and Environmental Engineering at Brno University of Technology (VUT ÚPEI) has been concerned with optimization of energy and water utilization in professional laundry care services. This issue also corresponds with research program of a new project called NETME Centre – New Technologies for Mechanical Engineering – regional research and development centre established at the Faculty of Mechanical Engineering at Brno University of Technology.

As it is mentioned in Bobák et al. (2010), significant heat consumers of professional laundry care process are continuous batch washers (CBW), system dryers (SYD) and ironers (IRO). In this paper the tunnel finisher (TUF) is also considered as dominant heat consumer.

2. Computational tool – laundry simulation software

The tool combines theoretical balance modelling with experimental data from real premises. It further identifies places in the process with excessive energy consumption. It is then possible to assess arrangements applied for decrease of energy intensity of the process such as implementation of heat exchangers for waste heat recovery and impact of partial optimization of the equipment upon the whole process. The software is based on Waste-to-Energy (W2E) software which was also developed at VUT ŮPEI and presented in Touš et al. (2009). Figure 1 shows screenshot of the software user interface.

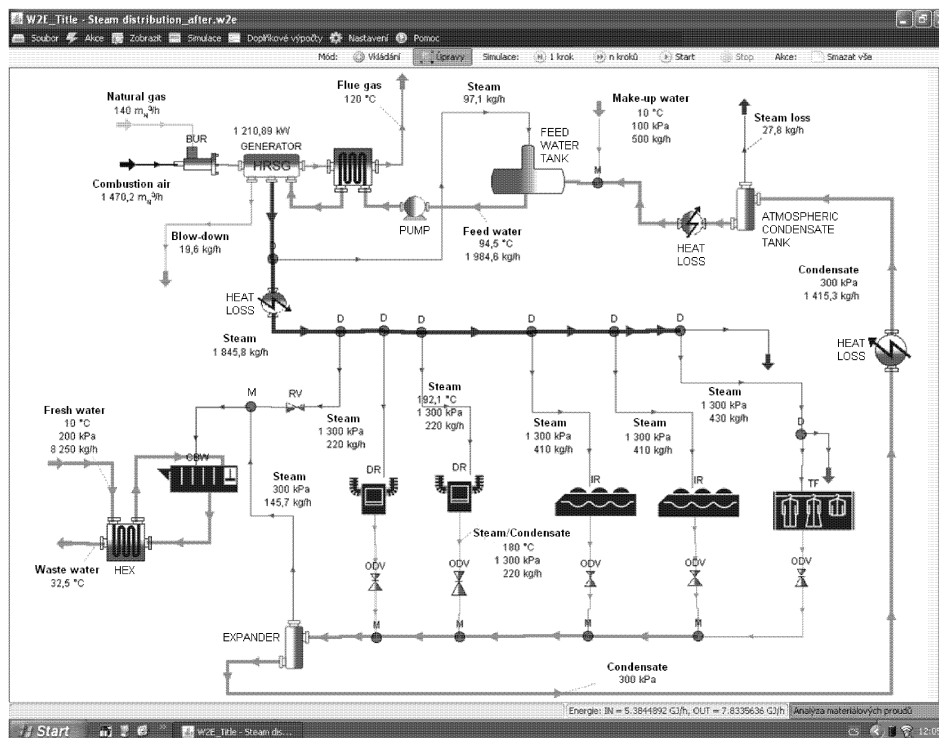


Figure 1: Screenshot of the laundry simulation software user interface

3. Case study

The following study shows application of this tool on laundry premise with capacity of 1.5 t of linen/h. For illustration, 1.5 ton of linen with areal weight of 150 g/m² covers 10 000 m², which is approximately equal to 1.5 times the area of a football field. In Table 1, there are data for Cases 1 and 2, which is actually a selection of input and/or output data of the laundry simulation software.

3.1 Case 1 – steam heated laundry with outdated energy system

The Case 1 represents steam heated laundry premise with outdated energy system (Figure 2), however, this design is still often used. The hi-pressure steam is produced by steam generator which utilizes heat of flue gas from burner where natural gas is combusted. The hi-pressure steam is then used for heating of all main apparatuses such as continuous batch washer (CBW), system dryers (SYD), ironers (IRO) and tunnel finisher (TUF), including its steaming chamber. From these apparatuses, excl. CBW and steaming chamber of TUF, the mixture of steam and condensate is streaming via steam traps to condensate tank. The condensate contains significant share of flash steam which is created after pressure relief at the steam trap. The gas and liquid phase is not separated until it reached an atmospheric condensate tank. It represents a significant heat and water loss.

Steam used for CBW and steaming chamber of TUF also gets away from the energy system. Steam used for heating CBW is directly fed into the washing bath and then goes out with waste water to the sewage. Steam used in steaming chamber expands to the atmosphere.

From the condensate tank, the water streams to feed water tank, where it is mixed with make-up water and live steam, then it is pumped back to the steam generator.

In the Case 1 old apparatuses with large energy consumption are used and the pipeline of energy system is in poor condition, which enables steam losses.

3.2 Case 2 – steam heated laundry with up-to-date energy system

The Case 2 represents up-to-date steam heated laundry premise (Figure 3). The second case differs from the first one in following ways:

- pipelines are in good condition, i.e. there are no pipe defects and steam traps do not release steam into condensate line,
- the energy system contains expander to utilize expanded steam from condensate; this steam is used for heating CBW,
- feed water is preheated by flue gas in heat exchanger (economizer),
- fresh washing water is preheated by waste water from CBW in heat exchanger which provides reduction of heat (steam) demand for heating the washing bath of CBW,
- up-to-date apparatuses with low energy consumption are used and each of them is well optimized.

3.3 Conclusion of Case study

From Table 1 can be observed that two laundry premises with the same capacity (1.5 t/h) can have significantly different total amount of demanded energy represented by natural gas (NG) consumption. In the first case the NG demand is 354 m³/h, i.e. 2.4 kWh/kg of linen, in the second case it is just 140 m³/h, i.e. 0.95 kWh/kg of linen.

Significant reduction of energy consumption was achieved by employing provisions given in chapter 3.2. Reduction of steam consumption in CBW was achieved by preheating the fresh water with waste water. Moreover, steam consumption is covered

by low-pressure steam supplied by expander which would otherwise be released from condensate tank into air.

Table 1: Case study data

stream no.	stream name	Case 1 (outdated energy system)			Case 2 (up-to-date energy system)		
		pres. [bar]	temp. [°C]	hourly flow rate	pres. [bar]	temp. [°C]	hourly flow rate
1	natural gas	-	-	354 m _N ³	-	-	140 m _N ³
2	combustion air	-	-	4 055 m _N ³	-	-	1 470 m _N ³
3	flue gas	-	250	4 409 m _N ³	-	120	-
4	steam to feeding tank	13	-	274 kg	13	-	97 kg
5	make-up water	0.1	10	1 500 kg	0.1	10	500 kg
6	expanded steam loss	-	-	230 kg	-	-	28 kg
7	blow-down	-	-	46 kg	-	-	20 kg
8	feed water	0.1	95	4 559 kg	0.1	95	1 985 kg
9	steam	13	-	4 288 kg	13	-	1 846 kg
10	steam to CBW	6	-	1 000 kg	13	-	220 kg
11	steam to SYD1	13	-	470 kg	13	-	220 kg
12	steam to SYD2	13	-	470 kg	13	-	220 kg
13	steam to IRO1	13	-	750 kg	13	-	410 kg
14	steam to IRO2	13	-	750 kg	13	-	410 kg
15	steam to TUF	13	-	750 kg	13	-	430 kg
16	steam loss	-	-	48 kg		N/A	
17	condensate	6	-	3 015 kg	3	-	1 415 kg
18	expand. steam to CBW		N/A		3	-	146 kg
19	fresh water to CBW	0.2	10	15 000 kg	0.2	10	8 250 kg
20	waste water from CBW	0.2	51	16 000 kg	0.2	33	8 616 kg

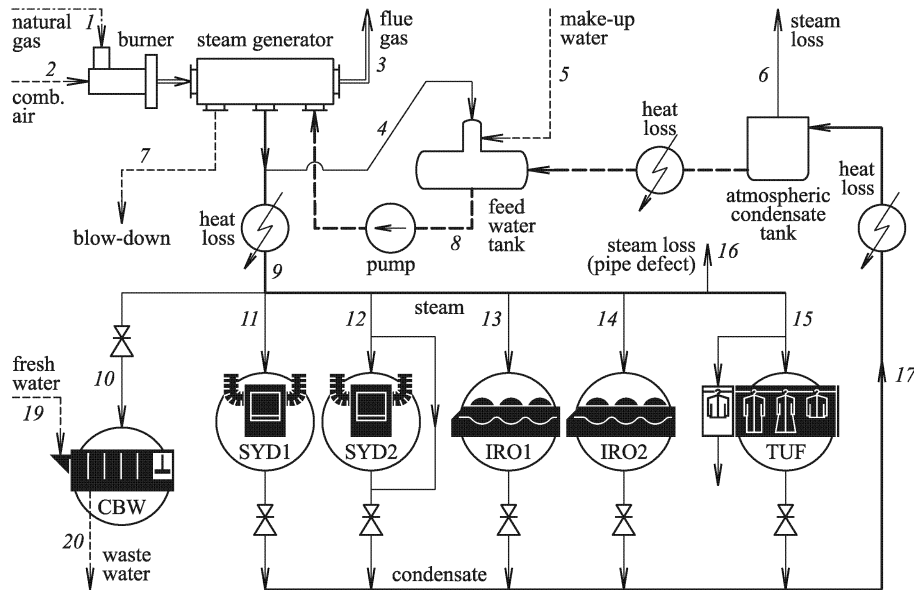


Figure 2: Steam heated laundry with outdated energy system

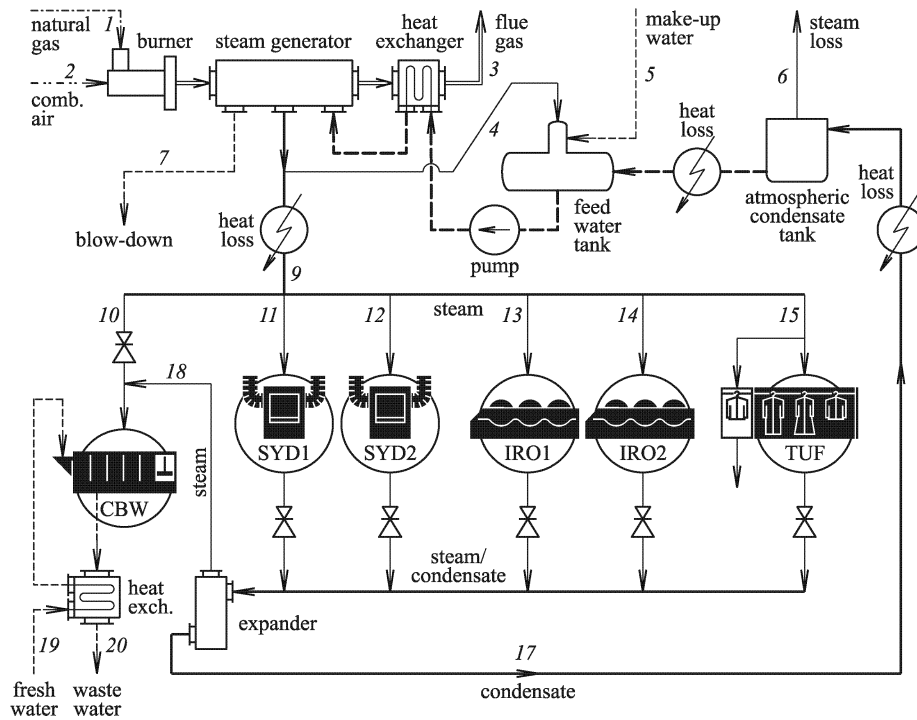


Figure 3: Steam heated laundry with up-to-date energy system

4. Conclusion

A way to drive down operational costs is the whole process optimization and integration of various pieces of equipment such as heat exchangers for effluent water waste heat utilization. New computational tool which enables to analyze flows of energy through the professional laundry care process was developed and is introduced in the paper. It is able to analyze advantages and disadvantages of up-to-date approaches as follows:

- usage of centralized vs. distributed heat supply,
- integration of renewable sources of energy (solid biomass, liquid bio-fuels) – “green” laundry concept,
- integration of unconventional solutions (cogeneration, heat pumps).

Acknowledgement

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Nomenclature

CBW ... continuous batch washer
IRO ... ironer
SYD ... system dryer
TUF ... tunnel finisher
NG ... natural gas

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