ENERGY EFFICIENCY IN INDUSTRIAL APPLICATIONS OF NATURAL GAS

Jorge G. W. de Azevedo[1], André D. Ferraz [2], Antônio R. Machado Jr.[3] Ivan C. C. da Rocha[4], Ricardo Konishi[5], Willian A. Lehmkuhl[6] , Vicente de Paulo Nicolau[7], Talita Sauter Possamai[8], Renato Oba[9], Andréa Trombini Nunes[10], Agenor De Noni Jr.[11]

Abstract

In various industries served by Santa Catarina Gas Company – SCGÁS, opportunities to reduce energy losses which can be obtained with relatively simple measures, resulting in lower specific consumption of natural gas were detected. This paper reports the main studies conducted in 2013 involving SCGÁS´ customers and universities of Santa Catarina, especially in ceramic and textile sector. These sectors are very important to the local economy with dozens of businesses consuming natural gas and exporting its products, so the control of production costs is very important factor. The cases of roller furnaces, dryers, atomizers and textile dyeing are discussed. The methodology combines field measurements and computer simulations, resulting in detailed heat balances which allow proposing simple and effective actions to increase the overall efficiency of the evaluated processes. An analysis technique was developed, enabling an advanced level of knowledge of the influence of the variables of each process, and getting its best fit points. An approach for machine appears, but also about the production process as a whole. Potential for heat recovery above 13% were identified in the case of ceramic processes, and above 17% in textile dyeing. These results are very important for the correct perception of the value of natural gas by SCGÁS´ customers and it has become a tool for the development of a strategic business relationship based on knowledge, technology and partnerships.

1. Introduction

For proper care of their customers Santa Catarina Gas Company – SCGÁS, realized the need for a specialized technical support, and it was structured the Natural Gas Technology Department (GETEC) to promote solutions that bring greater viability of use this fuel. Among the main activities carried out by this department are technical support, research and technological development, and the dissemination of knowledge about the natural gas applications. One of the programs developed through the strategy of ongoing partnerships with universities and technological support institutions is the Energy Efficiency Program, to devote himself primarily to:

• Reduction of specific consumption in conventional industrial processes;

• Feasibility of new potential uses of NG;

• Identification and recovery of energy losses.

For this purpose SCGÁS has a policy approved with annual allocation of 0.25% of its gross margin for investment in R&D projects and has a specialized team of 6 engineers to support customers.

[1] Mestre, Engenheiro Químico - SCGÁS
[2] Engenheiro Civil – SCGÁS
[3] Mestre, Engenheiro Químico – SCGÁS
[4] Engenheiro Eletricista – SCGÁS
[5] Engenheiro de Produção Química – SCGÁS
[6] Mestre, Engenheiro Mecânico – SCGÁS
[7] Dr. Engenheiro Mecânico - UFSC
[8] Dr[a]. Engenheira Mecânica - UFSC
[9] Mestre, Engenheiro Mecânico - UFSC
[10] Mestre, Engenheira Mecânica – UFSC
[11] Dr. Engenheiro Químico - UNESC

In many industries some opportunities to decrease energy losses were detected, that can be obtained with relatively simple measures. This work highlights the final results of two studies conducted in 2013 involving customers in the textile and ceramic industries. These sectors are very important to the economy of Santa Catarina, with dozens of businesses consuming natural gas and exporting its products. The results of studies of energy efficiency are very important for better understanding the value of natural gas and have become a tool for developing a business relationship based on knowledge, technology and training partnerships.

2. Methodology

The following studies were performed in a dyeing industry and in a manufacturing of ceramic tiles located in Santa Catarina state. It was performed as the first stage of operation data collection of furnaces, kilns, dryers, boilers, with temperature measurements and fluid dynamic flows considered, proceeding then with the development of computer simulations of processes production. It was assumed as steady-state operation of equipment, considering the physical phenomena of conduction, convection and radiation, as well as the transport of gases, raw materials and final products, and the water vapor across the boundaries of equipment. In the second phase, validation was performed through simulations and prepared the propositions of technical actions related to preheat combustion air, thermal insulation, heat exchangers and reuse of thermal currents between different devices inspired by Pinch Point Technique. Some equipment for obtaining field data were used, such as thermocouples, infrared cameras, pyrometers, gas meters, anemometers and Pitot tubes, and flue gas analyzers.

Figure 1. Example of instrumentation used in field measurements.

3. Results

The Figure 2 schematically shows the studied textile dyeing, which is useful for not having how to expand the production area and thereby obtain scale´s economies, adopted a competitive strategy of cost reduction by exploiting the potential of energy efficiency. SCGÁS supported the strategy of the customer applying the methodology presented in the previous section and discuss some alternative solutions that are presented below:

- ✓ The recycle energy through heat exchange between the hot water used in dyeing (effluent) and cold treated water to enter the process, which is captured in a river located next to the company (affluent). The installation of a compact heat exchanger water-water type could save 8.9% energy and it is a relatively simple work to perform.

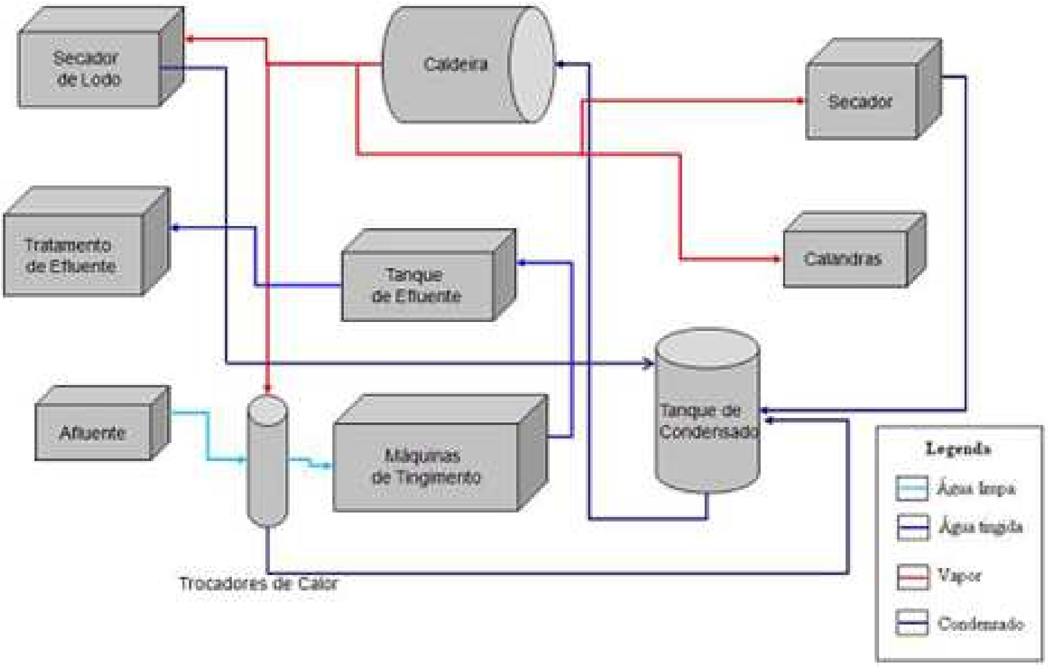
- ✓ The recycle energy through heat exchange between the condensate before the tank and the cold water (influent). Savings of 1.5%. This energy is actually lost on purpose to reduce the temperature of the condensate and thereby avoid the occurrence of cavitation in the return water pump to the boiler. It is noteworthy because all energy consumption is generated in natural gas boiler and it is distributed in the industrial plant by steam lines.

- ✓ The recycle energy through improvements in heat exchange between the air dryer and cold water (influent). Potential savings of 17%. The dryer is the point of higher energy consumption of the entire plant, and also where the greatest losses occur. However, enter any modification to this equipment implies a greater degree of difficulty in terms of various steam radiators and air recirculation existing.

- ✓ The preheating the incoming air in the dryer with the damp air exhausted through the chimney of the same. Savings of 3%. This measure is difficult due to the low temperature involved, which could be overcome through a network based on the use of heat pipe solution.

- ✓ The application of insulation on exposed surfaces. Potential savings of 14.3%. Some heated surfaces are easy and cheap to insulate, and points where the escape of heat is relevant were identified.

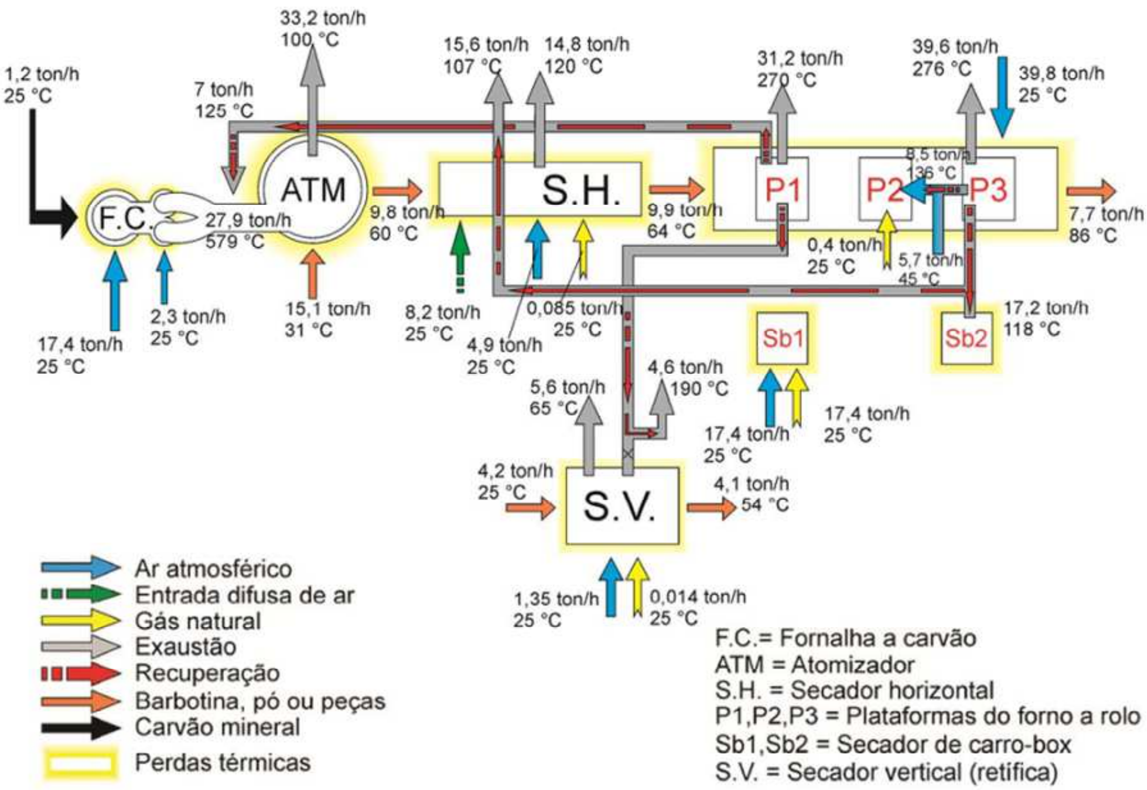
Figure 2. Representation of a fabric dyeing industry process.



The Figure 3 schematically shows the studied ceramic industry, which does not have a high production, but positions itself in the market through a strategy focused on high value-added products. Because it is consider a benchmark industry, it was imagined in the beginning few remaining opportunities to be explored. Some series of measurements was performed in all thermal systems in operation: atomizer, horizontal dryer, dryers, box car, furnace roller, vertical dryer. The energy consumption of equipment added to the natural gas is 1,583 Nm^3/m^2 (m^3 of natural gas by the m^2 pottery produced). Considering all the thermal demand (including coal nozzle) in terms of gas, the value would be 2,663 Nm^3/m^2. This demand is distributed as follows: 43.2% corresponds to the oven, 36.8% corresponds to the atomizer, 9.0% to the horizontal dryer, 4.1% to the dryer box car nº2. Also, 3.9% corresponds to the dryer box car nº1 and 3.1% corresponds to the vertical dryer reconditioning.

These equipments could reduce energy consumption: Dryer box car nº2: 100% chance to reduce; Dryer vertical grinding: 50%; Atomizer: 23%; horizontal dryer: 15% and oven: 1%. Considering only the equipment that consumes natural gas, the potential for consumption reducing is **12.5%,** or 0.20 Nm^3/m^2. The most significant case is the possibility of making the box car dryer operating with 100% recovery of energy from the furnace, which is 0.11 Nm^3/m^2. Considering the nominal output of 10,000 m^2/day of ceramic, the natural gas consumption reduction of this equipment would be 33,000 Nm^3/month. Considering the atomizer charcoal, reduced energy consumption could reach **16%** of the total factory.

Figure 3. Representation of a porcelain industry process.



The following presents an example of an equipment evaluation. However, analyzes were performed on all devices individually, and also the process as a whole.

- **Horizontal Dryer:**
  Maximum operating temperature: 240 ° C.
  Production: 450 m² / h.
  Product online: Porcelain Enameled.

Technical considerations inspired by Pinch Point:

The horizontal dryer gas inlet has a large amount of diffused air. During the analysis it was operated with average evaporation capacity of 450 kg_H_2O/h. Approximately 64% of the energy demand is issued by the main exhaust exits, through fired product 9%, and 27% of the parts are diffuse losses. There is a current utilization of hot air from the oven, but that saving gas only 2%. The air volume ratio: gas is about 12: 1 in proper amount for a good combustion efficiency range. The device of reusing the warm air from furnaces releases in the atmosphere approximately 15.6 ton/h of hot air at 107 °C, resulting in 0.31 Gcal/h. This energy does not reach into the dryer, and therefore is not used. To take it in the most convenient equipment itself, it would inflate along with the airstream dilution, which currently presents flow of 3.3 ton/h 25 °C. The reduction in gas consumption would be approximately 0.064 Gcal/h or 7.5 Nm^3/h (approximately 7% savings on gas dryer). Still, it would be wasted and 12.3 ton /h of hot air.

Comparing this horizontal dryer with five channels of rolls, with similar equipment (three channels), reported in the literature, the specific consumption can be considered low. Dryers with three channels usually show specific consumption between 106-177 kcal/kg of fired product. The equipment in question had 115 kcal/kg of fired product. The energy use as described could reduce the value to approximately 107 kcal/kg of fired product. Moreover, the results presented in Table 1 show that the specific consumption depends largely on the stability of production. For 31/07 consumption was 0.24 m^3/m^2 for a production of 456.9 m^2/h. On 30/07 the consumption rose to 0,324 m^3/m^2 because production decreased due operational problems. Figure 5 shows the behavior of the specific consumption due to the production, along with the trend line. The result clearly demonstrates that the consumption increases significantly with the reduction of production. The type of adjustment resulting equation shows that even at times less production gas flow does not suffer large modulations. The result is a significant increase in specific fuel consumption. To improve this production condition, enameling to work with well-tuned teams and including those involving the maintenance staff. The monitoring showed that in some moments it came to working with consumption 16% below average, with production 22% above average. The factory has an advanced box car system, which can be used to limit, to keep the dryer and the line of enameling always operating at full load. It is an alternative large impact on the energy efficiency of horizontal dryer without relying on use of hot air.

Figure 4. Horizontal dryer ceramic tiles.

Table 1. Mass and energy balance - Dryer Horizontal (SH).

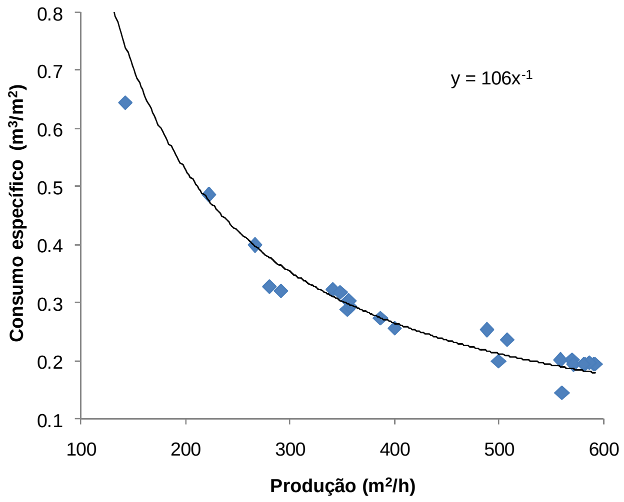
Corrente	Descrição	Vazão (ton/h)	Temperatura (°C)	Umidade (ton/h)	Energia (Gcal/h)
ES1	Gás Natural	0,085	25	-	0,93
ES2	Ar de combustão	1,6	25	0,02	0,00
ES3	Recuperação de calor proveniente do forno a rolo	1,1	107	0,10	0,02
ES4	Ar de secagem diluição, entrada canalizada	3,3	25	0,04	0,00
ES5	Entradas difusas de ar de secagem	8,2	25	0,10	0,00
ES6	Peça cerâmica (biscoito) proveniente da prensa	9,2	25	0,65	0,00
TES	**Total Entrada Secador**	**24,7**	**-**	**0,90**	**0,95**
SS1	Peça cerâmica na saída do secador	8,8	64	0,10	0,08
SS2	Exaustão do secador após combustão	14,8	120	0,65	0,61
SS3	Recuperação proveniente do forno que saindo para atmosfera sem entrar no secador	15,6	107	0,15	0,31
TSS	**Total Saída canalizada Secador**	**40,3**	**-**	**0,90**	**1,00**

E.Entrada; S.Saída; C.Fornalha; A.Atomizador; T.Total

Table 2. Specific consumption of the dryer.

Data da medição	30/07	31/07
kcal/ kg H_2O evaporada	-	2159
kcal /kg peça seca	148,8	109
kcal/m^2	-	2016
Produção m^2/h	308,6	456,9
Consumo gás Nm^3/h	99,9	109,8
Nm^3/m^2	0,324	0,240

Figure 5. Variation of specific fuel consumption based on production.



All these considerations represent an effective potential for improvement. To be performed, however, are necessary investments and sizing of the recovery systems. In general, the return takes place in about 2 years. But it is also necessary to keep a production schedule that minimizes the dead time of the process, as empty load kilns and dryers. At the end of the work identified for potential reduction of energy consumption 16%, of which 12.6% relates to the use of natural gas distribution as shown in Table 3. These results are important considering that between 20-25 % of the final cost of manufacturing of ceramic products corresponds to the consumption of natural gas.

Table 3. Energy balance and opportunities for improvement in a porcelain factory.

	Consumo (Nm^3/m^2)	Participação	Possibilidade Melhoria
Forno	1,15	43,2%	1%
Atomizador	0,98	36,8%	23%
Secador Hor.	0,24	9,0%	15%
Secador CB1	0,104	3,9%	0%
Secador CB2	0,11	4,1%	100%
Secador Ver.	0,083	3,1%	50%
Equipamentos a Gás		-12,5%	-0,20 Nm^3/m^2
Todos Equipamentos		-16%	

3. Final Thoughts

This research project developed by SCGÁS generated valuable data regarding the feasibility of implementing improvements in the textile and ceramic industry, from technical solutions based on the use of natural gas. Potential heat recovery above **13%** was identified in the case of **ceramic processes**, and above **17%** in **textile** dyeing. The information contained herein constitutes the foundations so that it takes careful investment decisions. The option for a technological edge that allows the production process such cost reduction translates directly into financial returns. The partnership in new technologies development, as well as pioneering in its applications, contributes to the positioning of companies as a leader in its industry. Besides the advantages mentioned above in the proposed solutions, one of considerable importance relates to the environmental impact. The reduction of energy use, in this sense, it contributes to greater sustainability and efficiency of the economy as a whole.

4. Thanks

Executive Team: Prof. Vicente de Paulo Nicolau, Dr. – Coordinator - **vicente@emc.ufsc.br** ; Eng[a]. Talita Sauter Possamai, M.Sc – Pesquisadora - **talita@labcet.ufsc.br;** Eng. Renato Oba, M.Sc – Pesquisador – **renatooba@labcet.ufsc.br** e Eng[a]. Andréa Trombini Nunes, M.Sc – UFSC.
Labcet – Laboratório de Combustão e Engenharia de Sistemas Térmicos
Departamento de Engenharia Mecânica – UFSC. (Universidade Federal de Santa Catarina)
88040-900 – Florianópolis - SC.

Executive Team: Prof. Agenor De Noni, Dr. – Coordinator – **agenordenoni@gmail.com;** Students team of chemical engineering of UNESC: João Vitor Vieira Ronconi e Mosart Ferrari dos Santos.
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