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Bibliometric Analyses Of Opportunities In Ceramics Kiln Efficiency

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Abstract:
Background*: The ceramic industry demand a high amount of heat, or thermal energy to perform its process. In this system, the kiln is the main responsible in this matter. The equipment consumes around half of the fuel used in the wet grind process. Due to this, the energy efficiency in the sector depends on the efficiency of this process..* (10)
Materials and Methods*: This bibliometric study evaluate what is being researched about efficiency in ceramic kilns. It was used the site Periódicos CAPES, witch concatenate many databases to look for articles. To narrow down the search key words.it was used the advanced research tool inserting a sequence of words and evaluating the number of results. The search were performed during the month of July of 2022.*
Results*: Most work focuses on simulations to address kiln efficiency, which opens up an opportunity to test these results at the plant level. Another point of attention is the lack of research on the impacts that actions can influence on ceramics and how to handle them.*
Conclusion: *The way to improve thermal efficiency in ceramic kilns is complex. It demands attention in many points. The Thermal isolation, the amount of air that is injected in the equipment, how to adjust the cooling zone in order to prevent losses, uses of regenerative burners.*
Key Word*: Productive systems; Sustainability; Bibliometrics; Knowledge.*

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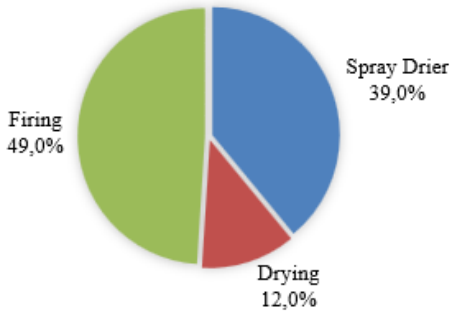
I. Introduction

The energy demand is an important topic when it is evaluated sustainability. Its importance is noticed in the United Nations sustainable development goals, the number seven focus on energy. Two points are important when talked about industry, improve the level of energy efficiency and reach for more renewable energy sources.(United Nations, [s.d.]). The demand of thermal energy is important to the industry, 72% of all energy consumption is by heat sources. Associated with that the industry in the United Kingdom is responsible for 32% of CO2, half of that generated during the production process itself.(Jouhara et al., 2018)

Jouhara et. al.(2021) points the ceramic industry as one of the most important energy consumption sector in the European industry. The majority of this energy is used as thermal energy, Alves et al.(2007), points that around 92% of the wet gridding process is thermal energy.

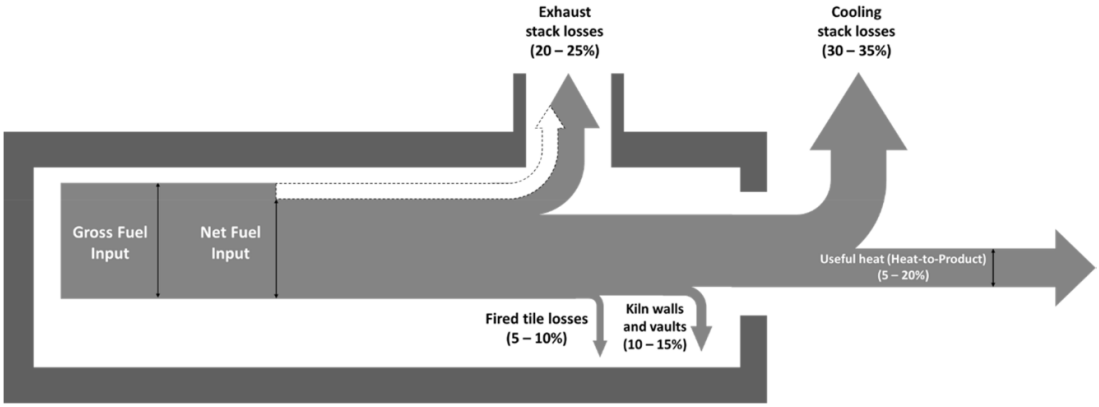
Analyzing the manufacture process there are three process that demand high temperatures to operate: (a) Spray Drier, (b) Drying and (c) Firing. The picture 1 shows the distribution of the energy consumption in each process.(Alves et al., 2010; Delpech et al., 2018; Utlu & Hepbaşlı, 2014)

Picture 1: Distribution of thermal energy demand in the ceramic process
Source: Adapted from Alves et al.(2010)



According to Picture 1 more than half of the energy is used in the firing sector. This process uses the Rollers Kilns to perform it is process. This equipment's operates on continuous cycles and high temperatures, around 1200 ºC. To reach this temperatures they use in most cases natural gas(Castro Oliveira et al., 2020; Ferrer et al., 2015). The kilns have low efficiency levels, Picture 2, Castro Oliveira et al.(2020) shows that around 5% to 20% of the input energy is used to perform the changes in the product, the rest is direct to other streams, as Castro Oliveira et al.(2020) describes waste heat. Ferrer et al.(2019) shows similar results in his study where the process efficiency is 14,95 %. According to that most energy flow through two main streams, the flue gas, 25,17% and the cooling exhaust gases, 36,45%. Picture 2 shows the distribution and use of their energy in the firing process

Picture 2: Energy uses in firing process



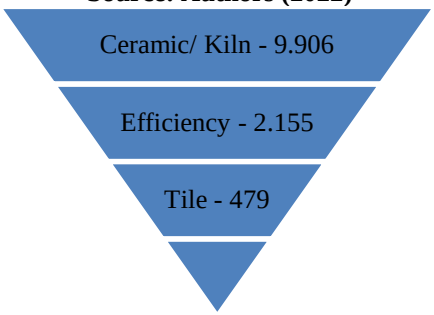
Source: Castro Oliveira et al.(2020)

As shown in many studies, (Castro Oliveira et al., 2020; Delpech et al., 2018; Ferrer et al., 2019; Jouhara et al., 2021) many initiatives are tried to recover part of this energy in another part of the production process. This proposal supports better fuel consumption in the other thermal process. Comparing the Castro Oliveira et al.(2020) study with Alves et al.(2010) is noticed that the energy consumption in the other process is getting smaller as time goes by, it can be inferred that this event is based on the studies on heat recovery. The objective of this study aim to evaluate the opportunities in the process of firing ceramics plates focus on energy efficiency.

II. Material And Methods

This bibliometric study evaluate what is being researched about efficiency in ceramic kilns. It was used the site Periódicos CAPES, witch concatenate many databases to look for articles. To narrow down the search key words.it was used the advanced research tool inserting a sequence of words and evaluating the number of results, the goal was to reach a number below 500 papers. The figure XX presents the sequence of the words used and the number of results. The search were performed during the month of July of 2022.

Picture 3: Research Plan
Source: Authors (2022)



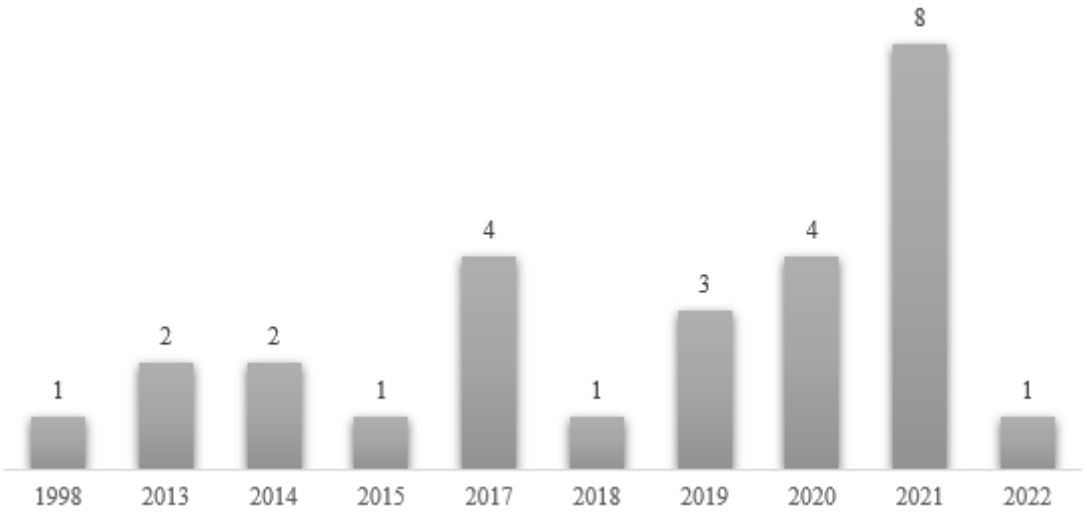
This results then were refined using the option "revised by pair" to use only studies revised by other researcher. This action narrowed down the results to 264. Then the papers where analyzed based on the title and abstract to filter the ones that has relation with the theme studied. After the last review, the results were 28 articles.

The articles were classified by publication year, study approach, proposed solution. Then the proposed solutions were tabulated to create a fast guide review to compare the technics presented and equipment's in operation.

III. Results and Discussion

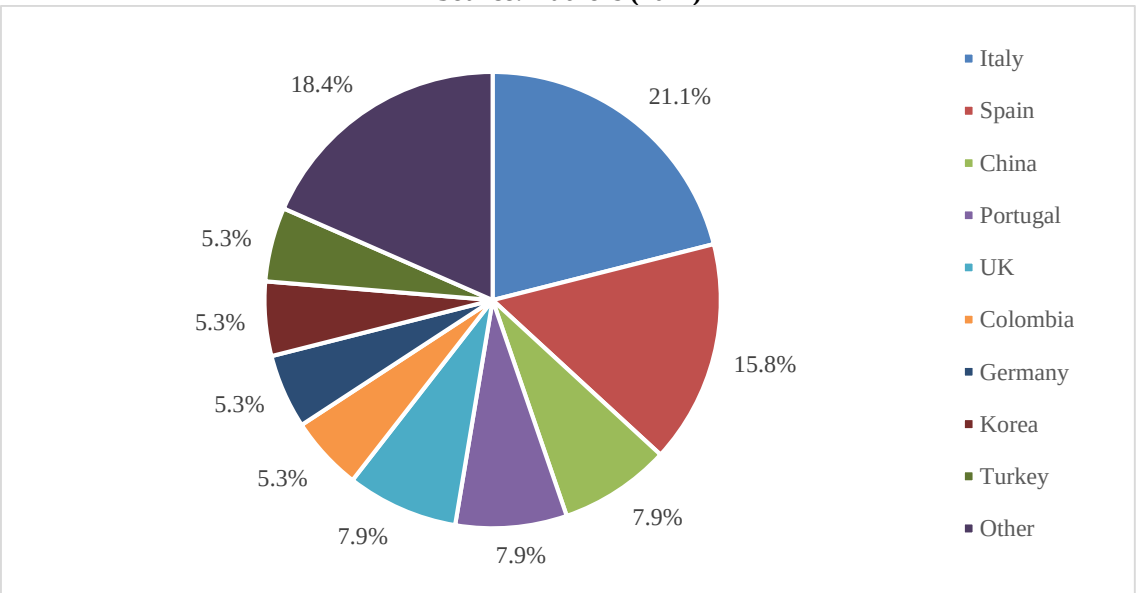
The Picture 4 shows the evolution of the publications through the years, it is noticed that the topic starts to grow in the last ten years. This situation can be related to the growing worries about the environment. Associated with that the European plan to reduce the energy consumption works as an external demand to improve industrial energy efficiency. The Picture 5 support this claim based on the high number of European countries on the count, 68,4% are from Europe with 26 publication. The second continent is Asia with 8 articles.

Picture 4: Evolution of publication per year
Source: Authors (2022)



The country with most papers is Italy, 8 papers, followed by Spain, 6 papers. It is something expected due to most of the European production are made in these two countries. China appear on the third place together with other countries, even it is the biggest industrial ceramic park in the world. India and Brazil show few publications even being the largest production countries after China, this one being the Third one in publications.

Picture 5: Publication in each Country
Source: Authors (2022)

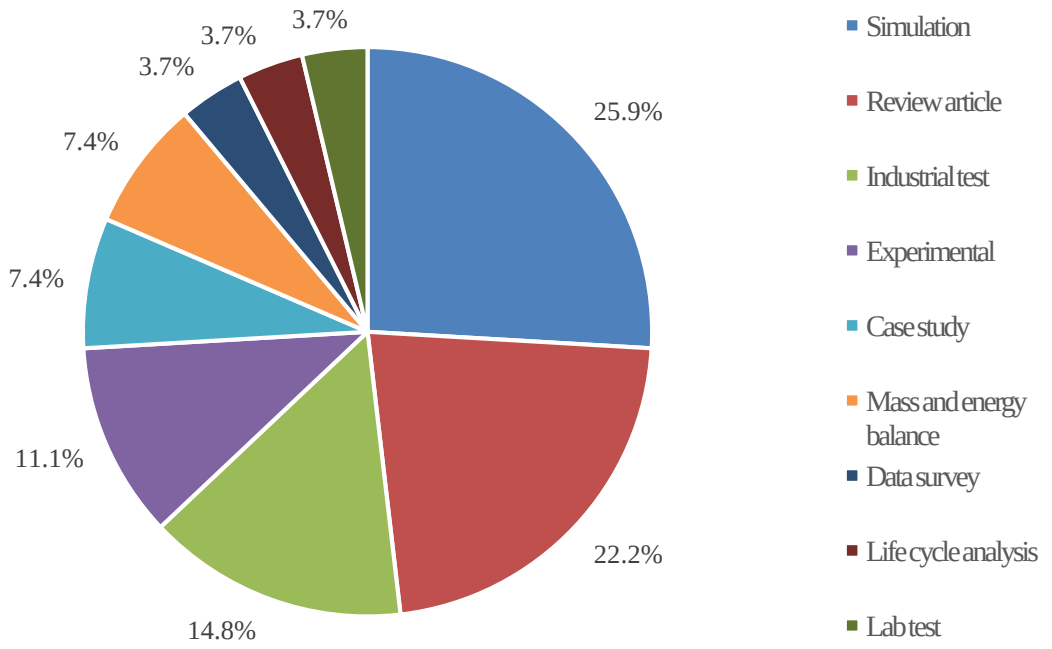


When analyzed the articles proposal many were revision ones, those one shows good practices and opportunities for improvement without implementing case studies or simulations. It was common agreement throughout the authors that better efficiency depends on reusing the exit streams of the process. The main focus was on the cooling zone hot air, this one represents a cleaner air and can be used directly in the kiln or another

thermal equipment. The flue gas has many components that can be harmful to the machines; it demands that this air must be treated before being used. Jouhara et al. (2021) shows that if this air's temperature goes lower than 140 ºC it starts to create acid compounds based on the sulfur present of the natural gas. In the same paper it shows a proposal on how to use the heat present on this air without the problems shown above.

Based on the approach used on each paper most studies focus on numerical approach, as showed in Picture 6. It is presented that there are few studies developed on industrial level, 14,8%. This justifies because it easier to test and make changes in the simulation, in the industrial level, this changes represents risks to the plan production which in many cases are not allowed. Nowadays the simulation approach very well the real condition and serves a step to support further industrial test level. The second one cannot be left behind due to it's importance in the product characteristics and stability.

Picture 6: Publication distributed by the article approach
Source: Authors (2022)



Better solutions

It's noticed that the combustion air flow is an important factor to look during the operation, and aligned with it the cooling zone can be adjusted to support energy efficiency process. Milani et al. (2019) shows that the cooling zone is important to avoid cracks and tensions in the product as well, and their proposals go on the other hand for the energy efficiency process (Ferrer et al., 2019; Milani et al., 2017). In this case it is necessary to reach to balance between this two conditions.

Recovering the cooling gas exhaust is a good way to improve energy efficiency, and it is possible to support other equipments such as driers and Spray driers. Correlating the Picture 1 and Picture 3 it is possible to admit that recovering all waste head from this stream it is possible to reduce most of the energy demand from the other process. It is important to verify the temperature needed in those processes. Checking Utlu & Hepbaşlı (2014) Study the output temperature from the kiln is too low to support the full thermal demand so it is necessary to heat up it more. In this scenario the energy savings will be noticed but the energy demand won't be eliminated. So it aligns with Ferrer et al. (2019) proposal of improve the exergy from the cooling gas, which means take it hotter, and reduce even more the thermal demand in the drying process.

Christodoulides et al.(2022) e Yin & Wang (2021) show in their review articles the use of cogeneration to improve energy efficiency. This systems use the hot air that leaves the kiln to generate electric energy. Branchini et al.(2021) investigated the impact on the use of cogeneration in the Italian Industry, it show it is possible to reach a use of 77% of the waste energy, depending on the stream conditions and the cogeneration unit used.

IV. Conclusion

The way to improve thermal efficiency in ceramic kilns is complex. It demands attention in many points. The Thermal isolation, the amount of air that is injected in the equipment, how to adjust the cooling zone in order

to prevent losses, uses of regenerative burners. Even after reach the best scenario, it is not possible to use all the produced heat.

Thinking about it the authors focus on ways to use the hot streams, the waste heat, the studies shows that the kiln can support most of thermal energy for the other processes. Even after that, it is possible to improve that use of energy by means of cogeneration systems to transform the waste heat into electric energy.Rosuvastatin 20 mg on every other regimen had equal effect when compared to daily dose regimen of atorvastatin 40 mg &rosuvastatin 20mg.

References

[1]. Alves, H. J., Melchiades, F. G., & Boschi, A. O. (2007). Levantamento Inicial do Consumo de Energias Térmica e Elétrica na Indústria Brasileira de Revestimentos Cerâmicos. Cerâmica Industrial.

[2]. Alves, H. J., Melchiades, F. G., de Brito, H. B., & Boschi, A. O. (2010). Análise do Consumo de Energia Térmica no Setor Brasileiro de Revestimentos Cerâmicos. Cerâmica Industrial.

[3]. Branchini, L., Bignozzi, M. C., Ferrari, B., Mazzanti, B., Ottaviano, S., Salvio, M., Toro, C., Martini, F., & Canetti, A. (2021). Cogeneration Supporting the Energy Transition in the Italian Ceramic Tile Industry. Sustainability, 13(7), 4006. https://doi.org/10.3390/su13074006

[4]. Castro Oliveira, M., Iten, M., Cruz, P. L., & Monteiro, H. (2020). Review on Energy Efficiency Progresses, Technologies and Strategies in the Ceramic Sector Focusing on Waste Heat Recovery. Energies, 13(22), 6096. https://doi.org/10.3390/en13226096

[5]. Christodoulides, P., Agathokleous, R., Aresti, L., Kalogirou, S. A., Tassou, S. A., & Florides, G. A. (2022). Waste Heat Recovery Technologies Revisited with Emphasis on New Solutions, Including Heat Pipes, and Case Studies. Energies, 15(1), 384. https://doi.org/10.3390/en15010384

[6]. Delpech, B., Milani, M., Montorsi, L., Boscardin, D., Chauhan, A., Almahmoud, S., Axcell, B., & Jouhara, H. (2018). Energy efficiency enhancement and waste heat recovery in industrial processes by means of the heat pipe technology: Case of the ceramic industry. Energy, 158, 656–665. https://doi.org/10.1016/j.energy.2018.06.041

[7]. Ferrer, S., Mezquita, A., Aguilella, V. M., & Monfort, E. (2019). Beyond the energy balance: Exergy analysis of an industrial roller kiln firing porcelain tiles. Applied Thermal Engineering, 150, 1002–1015. https://doi.org/10.1016/j.applthermaleng.2019.01.052

[8]. Ferrer, S., Mezquita, A., Gomez-Tena, M. P., Machi, C., & Monfort, E. (2015). Estimation of the heat of reaction in traditional ceramic compositions. Applied Clay Science, 108, 28–39. https://doi.org/10.1016/j.clay.2015.02.019

[9]. Jouhara, H., Bertrand, D., Axcell, B., Montorsi, L., Venturelli, M., Almahmoud, S., Milani, M., Ahmad, L., & Chauhan, A. (2021). Investigation on a full-scale heat pipe heat exchanger in the ceramics industry for waste heat recovery. Energy, 223, 120037. https://doi.org/10.1016/j.energy.2021.120037

[10]. Jouhara, H., Khordehgah, N., Almahmoud, S., Delpech, B., Chauhan, A., & Tassou, S. A. (2018). Waste heat recovery technologies and applications. Thermal Science and Engineering Progress, 6, 268–289. https://doi.org/10.1016/j.tsep.2018.04.017

[11]. Milani, M., Montorsi, L., Stefani, M., & Venturelli, M. (2017). CFD analysis of a full-scale ceramic kiln module under actual operating conditions. E3S Web of Conferences, 22, 00117. https://doi.org/10.1051/e3sconf/20172200117

[12]. Milani, M., Montorsi, L., Venturelli, M., Tiscar, J. M., & García-Ten, J. (2019). A numerical approach for the combined analysis of the dynamic thermal behaviour of an entire ceramic roller kiln and the stress formation in the tiles. Energy, 177, 543–553. https://doi.org/10.1016/j.energy.2019.04.037

[13]. United Nations. ([s.d.]). Ensure access to affordable, reliable, sustainable and modern energy. UN Sustainable Development Goals. Recuperado 1o de janeiro de 2023, de https://www.un.org/sustainabledevelopment/energy/

[14]. Utlu, Z., & Hepbaşlı, A. (2014). Exergoeconomic analysis of energy utilization of drying process in a ceramic production. Applied Thermal Engineering, 70(1), 748–762. https://doi.org/10.1016/j.applthermaleng.2014.05.070

[15]. Yin, W., & Wang, K. (2021). Analysis of energy saving in domestic ceramic industry kilns. E3S Web of Conferences, 267, 01011. https://doi.org/10.1051/e3sconf/202126701011National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (AdultTreatment Panel III) Third report of the national cholesterol education

[16]. Pharmaceutical Management Agency. Prescription for pharmacoeconomic analysis: methods for cost-utility analysis.