Treatment of Oily Effluents Through the Combination of Flotation and Wetland in Thermal Plants Under the Focus of Patent Documents: A Prospective Study

Barbara Lima Borges[1*], Edna dos Santos Almeida[1], Valdemir Alexandre dos Santos[2]
[1]SENAI CIMATEC University Center; Salvador, Bahia;
[2]Instituto Avançado de Tecnologia e Inovação; Recife, Pernambuco; Brazil

This study aimed to present a technological search for technologies in the processing of oily effluents through the physical-chemical flotation and biological wetland process generated in thermoelectric plants in the patent database of the Derwent World Patents Index (DWPI) using keywords. We found few studies for thermal power plant-effluent processing technologies and combined technologies for flotation and wetland effluent treatment. Patents indicated high efficiency in the combination of the processes. We did not find studies in Brazil for treatment technologies of effluents in thermoelectric plants. However, due to the country's energy scenario, investments in research in this area are recommended.
Keywords: Thermoelectric Plants. Oily Effluents. Flotation. Wetland.

Introduction

Thermoelectric power plants play a fundamental role in the operation of energy supply, as they operate as a complement to the Brazilian hydrothermal system in times of low levels of these reservoirs [1].

Thermoelectric power plants produce electrical energy from thermal energy released by chemical or nuclear reactions [2]. This production currently occurs from the combustion reaction. These plants can be classified according to different criteria: main product, type of fuel, type of thermal engine, and load character, among others. The most widespread thermal machines used in non-nuclear thermal power plants are the thermal power plants with a steam cycle, gas turbine power plants operating in simple cycles (combined-cycle plants), combustion engine plant internal, and thermoelectric cogeneration plants [3].

Depending on the technology adopted, the thermal power plant's cooling system can constitute a significant source of social and environmental problems, given the volume of water collected, evaporation losses, and the generation of effluents [4].

The generation of effluents is an environmental aspect that has great potential for environmental degradation, as they can cause changes in the quality of receiving bodies and consequently their pollution, causing damage to human health, soil and water contamination, thus it should be treated before the release to the receiving body [5].

Thus, the washing systems for equipment, lines, and rainwater drainage in thermoelectric plants, which will produce water with oily residues, must direct their effluents directly to a water treatment system. This system will treat the water to meet the quality parameters established in environmental legislation [6]. The removal of pollutants is the objective of effluent treatment. However, due to its diversity, there is no ready-made formula suitable for use in any situation. To achieve the objective, there are several treatment processes based on physical, chemical, or biological phenomena or principles, or even on their combinations [7].

In general, the combined treatment processes have greater efficiency, and for effluents with high oil content, the separation process by water-oil density difference is necessary, with flotation being one of the promising techniques. Flotation is widely used to treat effluents with high concentrations of suspended solids, oils, and greases. Among the benefits of flotation, there

Received on 12 December 2021; revised 20 February 2022.
Address for correspondence: Barbara Lima Borges. Av. Orlando Gomes, 1845 - Piatã, Salvador - BA- Brazil. Zipcode: 41650-010. E-mail: caio.barbara.ifba@gmail.com.

J Bioeng. Tech. Health 2022;5(1):78-83.

is a reduction in odorous gases, raising the level of dissolved oxygen, which results in a better-quality effluent [8]. However, it is still necessary to polish the treated effluent, which can be done by a biological process, with wetland being one of the relatively low-cost alternatives. The wetland system represents a natural ecological solution for wastewater treatment. Natural systems are improvements in processes that occur in nature, but their differential is a small need for mechanical equipment, reduced electricity costs, and little or no need to use chemical inputs [9].

In this context, the objective of this work was to carry out a technological mapping in the patent base of the Derwent World Patents Index (DWPI), to assess the global panorama of the use of combined technologies for treating oily effluents generated by thermoelectric plants through the physical process -chemical flotation and biological wetland.

Materials and Methods

This technological prospection was carried out between May and July 2021, using the Text-Fields option in the Derwent World Patents Index (DWPI) database, with a license to use from the Centro Universitário SENAI CIMATEC - Salvador, Bahia, Brazil. The focus of the research was to collect data on the use of combined technologies in the treatment of effluents from thermal power plants through flotation and constructed wetlands.

To obtain the data, we searched using the association of keywords between 2000 and 2020. Four searches were performed in the patent database of the Derwent (Table 1). The surveys were based on the search for technologies with a focus on combinations of the techniques in this study.

The patents selected for data processing were those most associated with the proposed theme of combined technologies for the treatment of oily effluents through the flotation and wetland process in thermoelectric power plants.

Based on data collection in Derwent, 11 documents were identified related to the research interest area of this study. From the research, it was possible to identify the countries having the technology of interest, demonstrate the annual evolution of publications, as well as carry out an assessment of the area of analysis of the international patent classification codes (IPC) contained in the documents.

In addition, the patents found were read to identify and list the technical and environmental aspects and advantages contained in the documents.

Results and Discussion

Patent analysis is a robust approach that has been widely used to identify competition, design

Table 1. Patent Search for keywords from the Derwent World Patents Index (DWPI).

Search	Keyword	Number of Patent Documents
1	[(effluent or wastewater) near treatment] and (oil or oily) and (thermoelectric)	7
2	[(effluent or wastewater) near treatment] and (oil or oily) and (flotation) and (wetland)	4
3	[(effluent or wastewater) near treatment] and (oil or oily) and (flotation) and (thermoelectric)	0
4	[(effluent or wastewater) near treatment] and (oil or oily) and (wetland) and (thermoelectric)	0

strategies for the future, support the development of new processes and products in a given target technology field, and especially gain competitive sustainability advantages. Thus, the analysis of the evolution of a specific technology is of great importance to assess the impacts and potential market interest in a new or better technological demand [10].

Annual Evolution of Patents

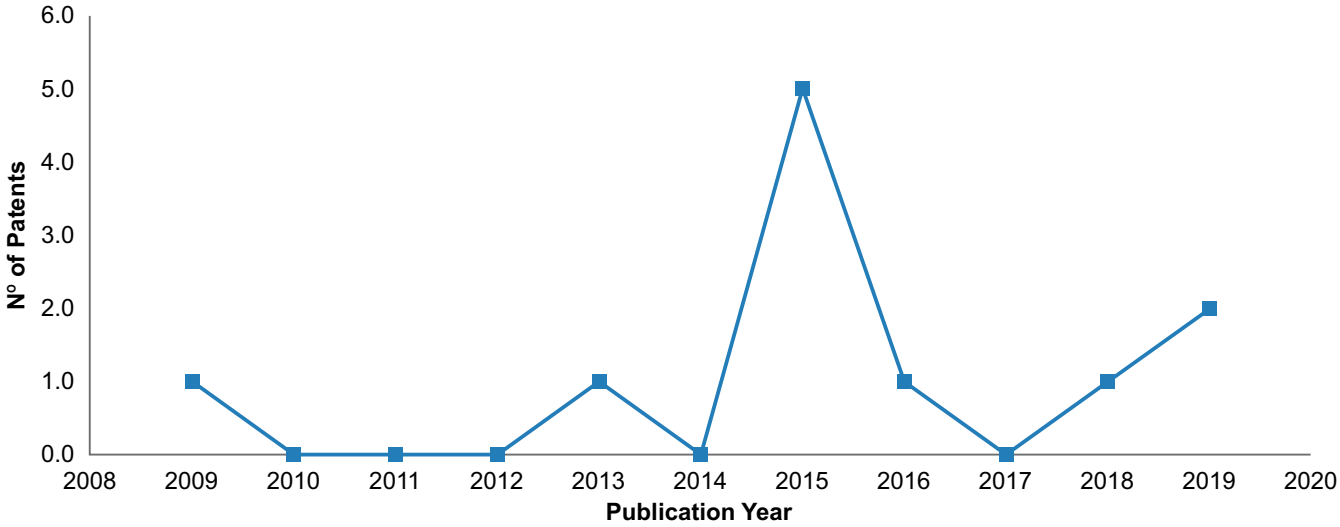
Figure 1 shows the results for the filing of patents for the technologies studied from 2009, the year in which the first registration in China took place, CN101462816A. This record features equipment characterized by a modularized structure and high treatment efficiency [11].

From the analysis of the annual evolution (Figure 1) between 2015 and 2019, the largest number of publications was identified, representing 82% (9) of the total number of documents. In 2015, the largest number of inventions in technology was carried out, representing 45% (5) of the total number of documents identified. The annual evolution data of the patents studied in this prospect, found in the period from 2000 to 2020, shows that the technology is in a stage of knowledge accumulation, where the number of patents filed is still reduced, with a total of 7 patents filed in the area. Treatment of oily effluents from thermoelectric power plants and four patents filed in the area of effluent treatment by combining flotation and wetland techniques over a period of 21 years. During this period, no patents were found filed in the study area with a combination of flotation and wetland techniques for the treatment of oily effluents from thermoelectric power plants.

International Patent Classification (IPC)

The International Patent Classification – IPC was put into effect in 1971 to establish a current categorization for registered patents. This classification helps in the search for patents, making access to technological information in documents [12]. The most common IPC was C02F 9/14, which refers to the multi-stage treatment of water, wastewater, or sewage with, at least, one step being a biological treatment (Figure 2). The IPC codes B63J 4/00, B63B 35/00, C02F 1/00, and C02F 1/44 were found in three patent

Figure 1. Annual evolution of patent document publications on oily effluent treatments through the flotation and wetland process in thermoelectric plants deposited between 2000 and 2020.



documents (Table 2). These patent codes are present in subsection B63, which refers to processing, transport, separation, and mixing operations in ships or other vessels; related equipment, and in subsection C02, which refers to the treatment of water, wastewater, sewage, or sludge and sludge.

Two documents present technologies for combined effluent treatments. Patent CN101462816A claims an integrated water treatment through an industrial pond with chemical treatment and aeration device in a thermoelectric power station. The equipment is characterized by high treatment efficiency, with a wide range of applications and little investment [11]. Patent CN207047070U claims a turbidity treatment system for organic wastewater belonging to environmental protection facilities. The system uses effluent treatment through flotation associated with a wetland pool. The model is presented as a kind of organic wastewater treatment plant that has a simple structure and high oil yield [13].

Countries Holding the Technologies

Concerning technology holders, of the 11 patent documents found for this study, China was the country with the highest number of patents filed (55% of the total), as seen in Figure 3. This result is since China has an electrical matrix in which coal-fired thermoelectric plants predominate, holding about 65% of the installed capacity, followed by hydroelectric plants, with 20% [14].

Conclusion

From this technological prospection, it is possible to conclude that, in the twenty years evaluated, few studies were found for

Figure 2. Distribution of the most used International Patent Classification codes in patent documents.

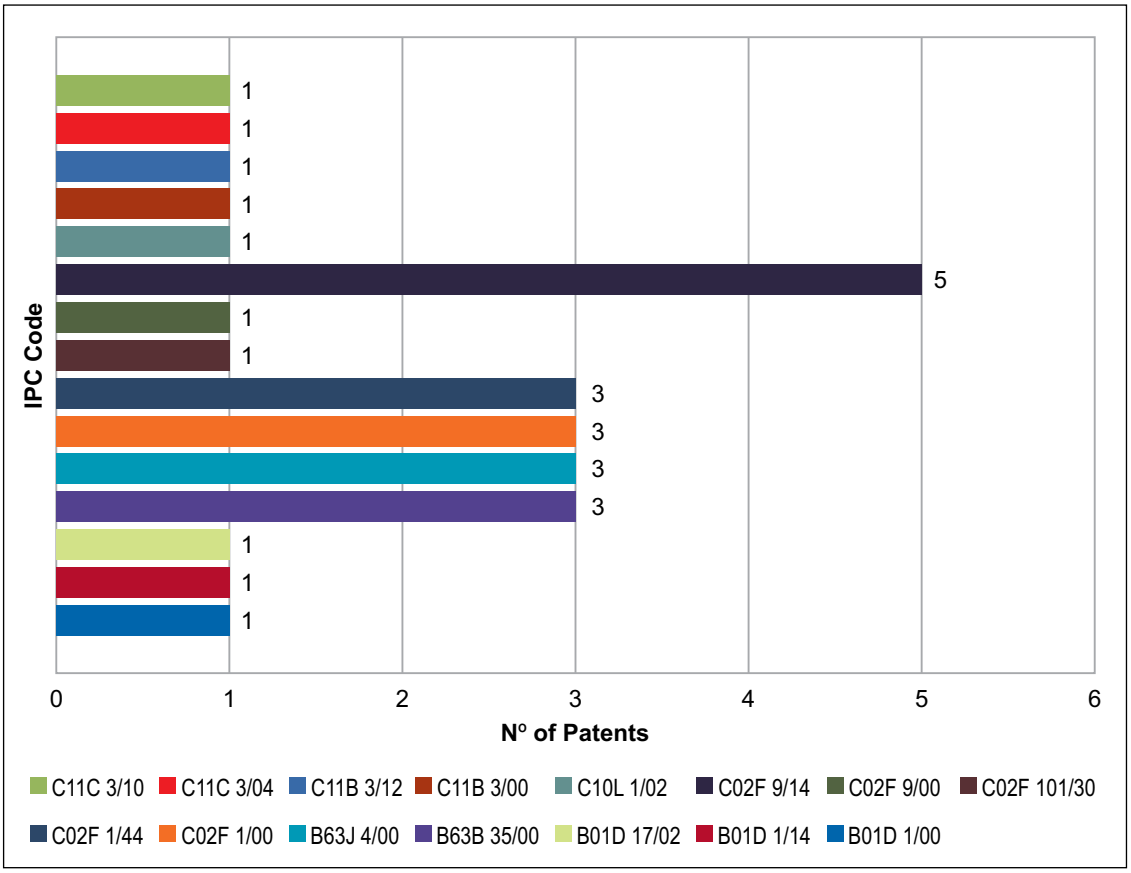
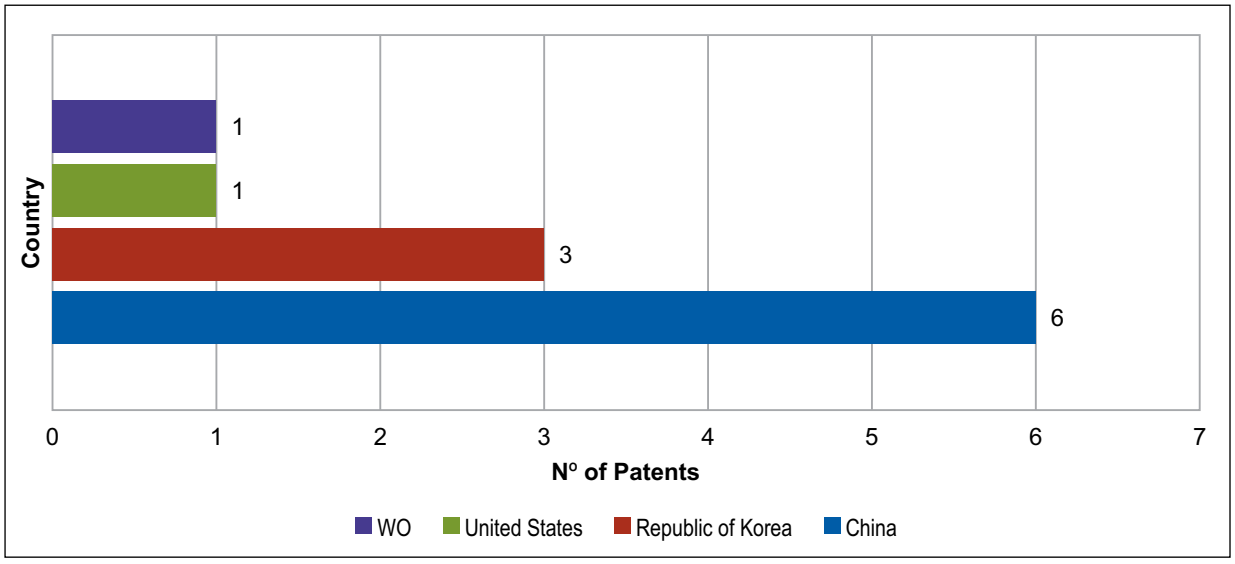


Table 2. Description of International Patent Classification codes in patent documents.

IPC Code	Code Description
B63B 35/00	Vessels or similar floating structures are specially adapted for special purposes and not included elsewhere.
B63J 4/00	Facilities for the treatment of wastewater or sewage.
C02F 1/00	Treatment of water, wastewater, or sewage.
C02F 1/44	Treatment of water, wastewater, or sewage by dialysis, osmosis or reverse osmosis.

Figure 3. Main depositor countries of the study technology between 2009 and 2020.



technologies in the treatment of effluents from thermal power plants and combined technologies for the treatment of effluents through flotation and wetland. China stands out in research on these issues, probably due to its electrical matrix. The two patents found that the use of combined physical and biological wastewater treatment processes is indicated as processes that require low financial investment and high yield. Thus, for the oily effluent condition generated in thermoelectric power plants, this combination is promising.

No studies were found in Brazil for the development of technologies for the treatment of effluents in thermoelectric plants, however with the vulnerable generation pattern in the country during the dry periods of the year, when the effective energy supply is lower than the installed hydropower capacity investment in research in this area is recommended.

References

1. Gomes LS. Avaliação do potencial energético aplicado a uma usina termelétrica de fontes renováveis. Available on https://fga.unb.br/articles/0001/2466/TCC1__Layane_VF4.pdf (Acessed on Oct 20, 2020).
2. Yoshimi AA. Estudo dos impactos ambientais de uma usina termoelétrica na cidade de Canas. Available on https://sistemas.eel.usp.br/bibliotecas/monografias/2014/MEQ14001.pdf (Acessed on Jan 01, 2021).

3. Tolmasquim MT. Energia termelétrica Gás Natural, Biomassa, Carvão, Nuclear. Available on https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-173/Energia%20Termel%C3%A9trica%20-%20Online%2013maio2016.pdf (Acessed on Mar 06, 2021).
4. IEMA – Instituto de Energia e Meio Ambiente. Regulação ambiental da termeletricidade no Brasil – gestão de recursos hídricos. Available on https://energiaeambiente.org.br/wp-content/uploads/2015/01/RegulacCCA7aCC83o-agua-2015-07-18_versaCC83o_site.pdf (Acessed on Apr 15, 2021).
5. Soares SJC. et al. Análise do efluente final gerado em uma usina termoelétrica no distrito industrial do município de São Luís – MA. Available on https://www.brazilianjournals.com/index.php/BRJD/article/view/9791/8207 (Acessed on Feb 03, 2021).
6. CEPEMAR. Descrição do empreendimento. Available on https://iema.es.gov.br/Media/iema/CQAI/EIA/2007/Termel%C3%A9trica%20de%20Viana/2%20-%20Descri%C3%A7%C3%A3o%20do%20empreendimento.pdf (Acessed on Jul 19, 2021).
7. Jerônimo CEM. Estudo de técnicas para o tratamento alternativo de efluentes oleosos oriundos da industrialização da castanha de caju. Available on https://repositorio.ufrn.br/jspui/bitstream/123456789/15901/1/CarlosEMJ_TESE.pdf (Acessed on Jun 21, 2021).
8. Andrade GC. Eficiência dos processos de flotação e filtração com uso de coagulante natural e químico no tratamento de efluente de laticínio. Available on: http://repositorio.roca.utfpr.edu.br/jspui/bitstream/1/5316/1/LD_COEAM_2015_1_07.pdf (Acessed on: Aug 04, 2021).
9. Zinato TMC, Guimarães MM. Estudo sobre a utilização de “wetlands” construídas para tratamento de águas residuárias no brasil. Available on: https://www.ibeas.org.br/congresso/Trabalhos2017/IX-001.pdf (Acessed on: Aug 04, 2021).
10. Valente CG. Technological Potential of Avocado Oil: Prospective Study Based on Patent Documents. Available on: https://pubmed.ncbi.nlm.nih.gov/31113349/ (Accessed on Jul 30, 2021).
11. Zhao W-R, Yanh Y, Bao J-Z, Rui H. et al. Apparatus for integrated treatment and comprehensive utilization of wastewater and use thereof. CN101462816A, 2009.
12. INPI. Classificação de Patentes. Available on: http://antigo.inpi.gov.br/menu-servicos/patente/classificacao-de-patentes. (Acessed on Feb 10, 2021).
13. Yang J, Mao HB. High turbidity organic wastewater system. CN207047070U, 2018.
14. Castro N. et al. O Setor Elétrico Chinês e o papel das Usinas Hidrelétricas Reversíveis. Available on: http://www.gesel.ie.ufrj.br/app/webroot/files/publications/07_castro_27_06_2018.pdf (Acessed on: Mar 22, 2021).