TREATMENT OF OILY EFFLUENTS THROUGH THE COMBINATION OF FLOTATION AND WETLAND IN THERMAL PLANTS UNDER THE FOCUS OF PATENT DOCUMENTS: A PROSPECTIVE STUDY

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Abstract: This study aimed to present technologies in the processing of oily effluents through the physical-chemical flotation and biological wetland process generated in thermoelectric plants. This work is a literature review that uses keywords at the patent database of the Derwent World Patents Index (DWPI). Few studies were found 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. No studies were found 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.

ESTUDO PROSPECTIVO DO TRATAMENTO DE EFLUENTES OLEOSOS ATRAVÉS DA COMBINAÇÃO DE FLOTAÇÃO E WETLAND EM CENTRAIS TERMELÉTRICAS SOB FOCO DE DOCUMENTOS DE PATENTES

Resumo: Este estudo teve como objetivo realizar uma prospecção tecnológica de busca das tecnologias no tratamento de efluentes oleosos através do processo físico-químico flotação e biológico wetland gerado em centrais termelétricas, por meio de buscas na base de dados de patentes do Derwent World Patents Index (DWPI) empregando palavras-chave. Poucos estudos foram encontrados para tecnologias de tratamento de efluentes de usinas termelétricas e tecnologias combinadas para tratamento de efluentes por flotação e wetland. As patentes indicaram elevada eficiência na combinação dos processos. Não foram encontrados estudos no Brasil para o desenvolvimento de tecnologias para o tratamento de efluentes em usinas termelétricas, porém em função do cenário energético do país, investimentos em pesquisas nesta área é recomendado.

Palavras-chave: centrais termelétricas; efluentes oleosos; flotação; wetland.

1. 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 level of these reservoirs [1].

Thermoelectric power plants are characterized by producing electrical energy from thermal energy released by chemical or nuclear reactions [2], with generation from the combustion reaction being more common. These plants can be classified according to different criteria, such as: main product, type of fuel, type of thermal engine, load character, among others. Regarding the most widespread types of thermal machines used in non-nuclear thermal power plants, there are: thermal power plant with steam cycle, gas turbine power plant operating in simple cycle, combined cycle plant, combustion engine plant internal and thermoelectric cogeneration plant [3].

Depending on the technology adopted, the thermal power plants' cooling system can constitute a significant source of social and environmental problems, given the magnitude of 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 the action that should be taken in this case it is the treatment 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 so that it meets 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 is the reduction in the levels of odorous gases, in addition to 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), in order 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.

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2. METHODOLOGY

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 wetland.

To obtain the data, a search strategy was developed, taking into account the association of keywords in the period between 2000 and 2020. As shown in Table 1, four searches were performed in the patent database of the Derwent. The surveys were based on the search for technologies with a focus on combinations of the techniques in this study.

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

The patents selected for data processing were those most associated with the proposed theme of the use 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 main 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 main technical and environmental aspects and advantages contained in the documents.

3. RESULTS AND DISCUSSION

Patent analysis is a robust approach that has been widely used to identify competition, design strategies for the future, support the development of new processes and products in a given target technology field, and especially to gain competitive sustainability advantages. Thus, the analysis of the evolution of a specific

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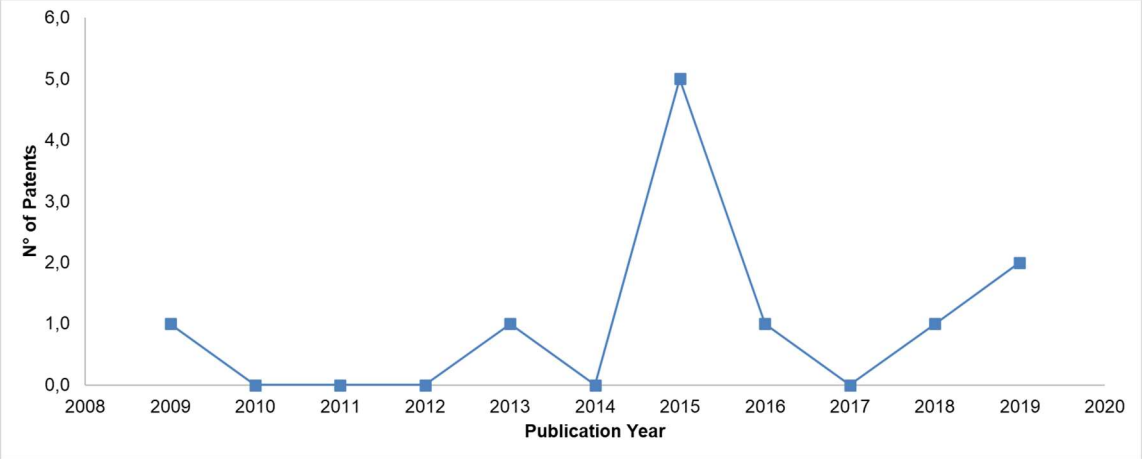
technology is of great importance to assess the real impacts and potential market interest in a new or better technological demand [10].

3.1. Annual Evolution of Patents

Figure 1 shows the results for the filing of patents for the technologies studied from the year 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].

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.



From the analysis of the annual evolution (Fig. 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 of the 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.

3.2. International Patent Classification (IPC)

The International Patent Classification – IPC was put into effect in 1971 to establish a common categorization for registered patents. This classification helps in the search for patents, making access to technological information in documents simpler [12].

As shown in Figure 2, 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.

As shown in Table 2, the IPC codes B63J 4/00, B63B 35/00, C02F 1/00 and C02F 1/44 were found in three patent documents. These patent codes are present in subsection B63 which refers to processing, transport, separation, mixing operations in ships or other vessels; related equipment and in subsection C02 which refers to the treatment of water, waste water, sewage or sludge and sludge.

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

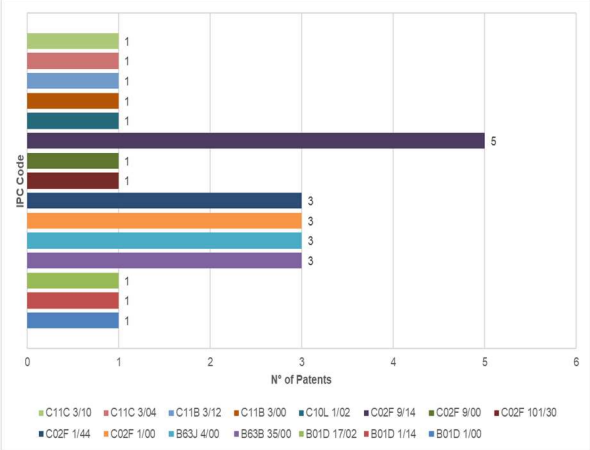


Table 2. Description of International Patent Classification codes in patent documents

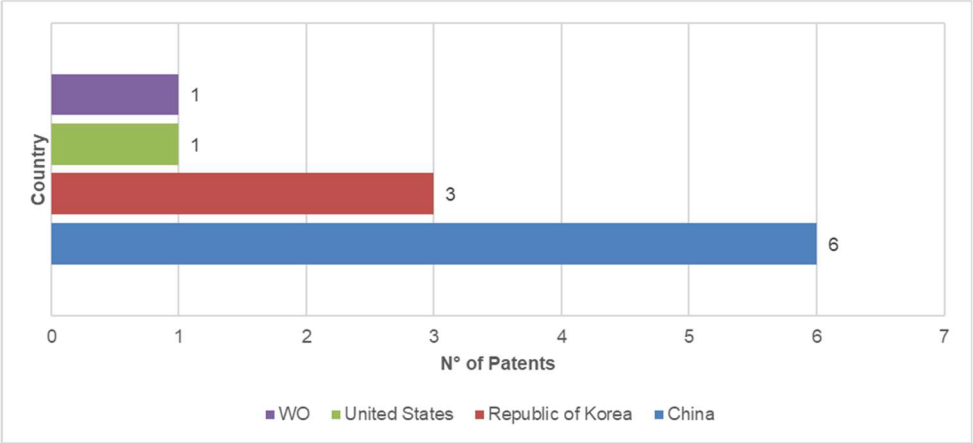
IPC Code	Code Description
B63B 35/00	Vessels or similar floating structures specially adapted for special purposes and not included elsewhere.
B63J 4/00	Arrangements of facilities for the treatment of waste water or sewage.
C02F 1/00	Treatment of water, wastewater, or sewage.
C02F 1/44	Treatment of water,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

Only two of the patent documents used in the study 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 application 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].

3.3. Countries holding the technologies

With regard to 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 due to the fact that 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].

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



4. CONCLUSION

From this technological prospection, it is possible to conclude that, in the twenty years evaluated, few studies were found for 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 use combined physical and biological wastewater treatment processes are 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.

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