

Patentometric Analysis Of Plugs Used In Oil Well Operations In Brazil

Maxwell Tavares Souza¹, Kelly Anne Santos Nascimento¹,
Emerson Diaz Nascimento², Aprígio Teles Mascarenhas Neto¹,
Maria Do Socorro Cruz Linhares¹, Lara Aragão Sobral¹,
Hilton Henrique Cruz Santos Pereira¹, Denise Santos Ruzene³,
Daniel Pereira Silva^{1,2,3}

¹ Graduate Program In Intellectual Property Science - Federal University Of Sergipe, São Cristóvão/Se, Brazil

² Department Of Production Engineering - Federal University Of Sergipe, São Cristóvão/Se, Brazil

³ Northeastern Biotechnology Network - Federal University Of Sergipe, São Cristóvão/Se, Brazil

Abstract:

The presence of mature oil wells in Brazil, whose production developed predominantly in the second half of the 20th century, with the prominence of fields located on land in the north and northeast regions, brings consequently a demand for techniques associated with guaranteeing the integrity of these wells, including temporary abandonment, in which temporary barriers are used to ensure the safety of the well. In this context, the article proposes a patentometric analysis of Plugs, which are equipment commonly used to carry out these abandonments, offering an overview of this technology over time through research in patent documents.

Key Word: plug; pit; petroleum; technological development.

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I. Introduction

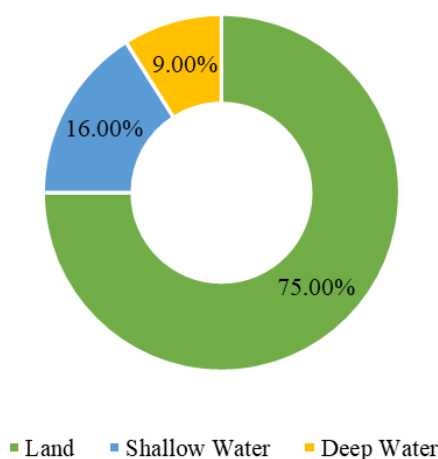
The discovery of Brazil's first oil field dates to 1941 in the city of Candeias-BA (PEYERL, 2017), with the larger-scale oil production cycle effectively starting in 1954, the year Petrobras was created (LUCCHESI, 1998), the process of opening new wells continued to grow in the following decades, reaching the estimated number of 30,450 wells drilled in June 2023 (ANP, 2023).

Jahn et al. (2008) observe that oil production can be divided into six phases, starting with the release of search in areas with production potential, followed by exploration, evaluation, production planning, production reaching the last phase that is occurs after the end of the field's production cycle, which involves the decommissioning and abandonment of the well. Chukwuemeka et al. (2023) define abandonment activity as the process of restoring wells to environmentally safe conditions at the end of their useful life, as a way of repairing forced changes in the soil in which oil is removed during the various stages that make up the exploration and production cycle, highlighting the relevance of the topic by observing that since the beginning of oil exploration in 1856, more than 65,000 wells have been drilled around the world.

ANP resolution n°. 877/2022 of the National Petroleum Agency (ANP, 2022), classifies as “marginal” the fields whose assignment contracts are in places where the development of new wells and the economic value of existing production presents marginal economicity, and thus are on the verge of the end of their production cycle. In Brazil, around 292 fields receive this classification according to the distribution shown in Figure 01.

Most marginal fields were classified as “mature” fields, defined by ANP resolution n°. 749/2018 (ANP, 2018) as fields that have been in production for more than 25 years or whose accumulated production is greater than or equal to 70% of reserves proven. Approximately 290 fields located in Brazil meet at least one of the criteria that makes them eligible for entry into the abandonment cycle. These data make clear the importance of studies that focus on technologies used at this stage of the Oil industry's production cycle.

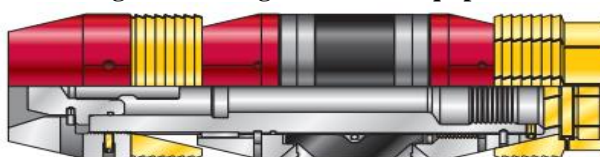
Figure 01 - Number of Marginal Fields per Environment



Source: Adapted authors (2023)

Cao et al. (2022) observe that mature fields are characterized by the need for economically expensive interventions such as drilling and injection of large volumes of water to maintain performance and that in general the wells located in this type of field are at the limit for entering the decommissioning phase and abandonment. Work in these fields involves a continuous search for technologies capable of ensuring sustainable development (LEI et al., 2019). Such characteristics require interventions that involve changing lifting methods, restoring their integrity or even temporarily closing them for various assessments. In all these stages it is necessary to establish a Solidarity Set of Barriers, defined as the combination of one or more devices installed to prevent the unplanned flow of fluids from the formation to the external environment and between the intervals in the well itself according to the ANP Resolution n°. 46/2016 (ANP, 2016), which establishes the technical regulation of the Well Integrity Management System – SGIP. It should also be noted that the mechanisms installed as a barrier are designed to withstand adverse weather conditions such as corrosion, pressure, and temperature variations in the different phases of the well.

Figure 02 - Plug - Downhole equipment



Source: PBP (2023)

The plugs (Figure 02) are part of equipment widely used as part of the Solidary Barrier Set, defined in the SLB glossary as downhole equipment positioned and configured to interrupt the flow inside the well, isolating its lower part (SLB, 2023). Plugs can be permanent or retrievable, allowing the lower zones of the well to be permanently sealed or temporarily isolated from treatments carried out in an upper zone. Furthermore, according to the Guidelines for Abandonment of Wells (2022) of the Brazilian Institute of Petroleum and Gas (IBP, 2022), this equipment has the function of preventing flow in both directions through the interior of the pipe in which it will be installed, considered as a barrier used for purposes temporary abandonment.

II. Methodology

The study started from the establishment of research criteria that would enable the search for technological information about Plugs used in oil and gas activities. The alternative adopted was based on a patentometric analysis that allowed an adequate sample of the technological development of the use of plugs in Brazil carried out in the database of the National Institute of Intellectual Property (INPI). The search strategy was based on the selection of key words that allowed the delimitation of documents associated with plugs used in the establishment of barriers in oil wells and on the individual analysis of the results observing the alignment with the proposed theme, following a flow of Patent analysis adapted from the model presented in the work of Abbas et al. (2014) which can be seen in Figure 03.

Figure 03 - Simplified Patent Analysis Flow



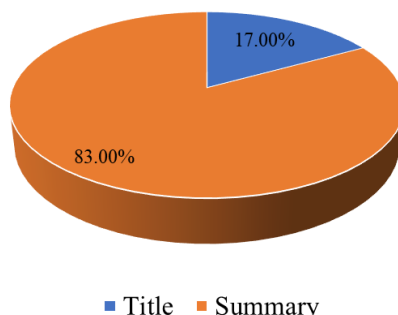
Source: Adapted from Abbas et al. (2014)

The first stage involving the adoption of key words was carried out with a search in the textual fields of the title or summary patents to allow the results to be adapted to the objective, using terms associated with plugs (“plug”) with the bias of use in well (“well”) carried out freely without restriction to other search codes available on the INPI patent search portal, term “well” was used in its Portuguese translation. With these data, an individualized reading of the patent documents selected with the results of the keywords was established, checking their coherence with the proposed theme by filtering the results, which were then used for the graphic and quantitative analyzes that supported the construction of the discussion about the topic.

III. Results

Using the steps explained in the methodology, it was carried out on 10/03/2023 in the INPI patent database, using the advanced search in the Title or Summary fields for the keywords “plug” associated with the keyword “well” as the search criteria connected through the logical conjunction “AND” conditioning the results that presented both words simultaneously, obtaining 76 results with a distribution that can be seen in Figure 04.

Figure 04 – Search results with the keywords “plug” AND “well”



Source: Authors (2023)

The initial data processing was then carried out seeking to verify the adequacy of the documents to the topic under study and inconsistencies caused by the duplicity of results generated by the research, obtaining a total of 55 documents according to data seen in Table 01, whose data were carried out for the analyzes carried out.

Table 01 – Search results with the keywords “plug” AND “well”

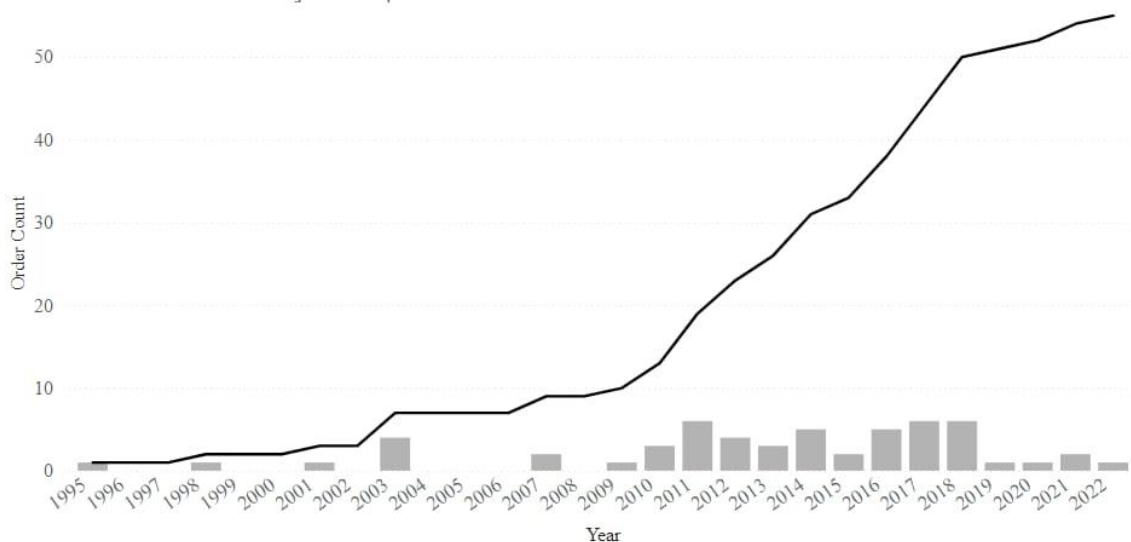
| Search and Classification Criteria | Result |
|---|-------------------|
| | Number of Patents |
| Initial Results Keyword (“plug” and “well”) | 76 |
| Duplicate Results | 11 |
| Results with Patents not associated with the Research topic | 10 |
| Result of Patents considered in the study | 55 |

Source: Authors (2023)

Evolution of patent applications over time

To analyze the temporal panorama of patent applications over time, the annual volume of publications was verified considering the date of the first request (priority date). A small number of patent filings began in the 90s, continuing with a low interest in technology development translated into a low number of requests until 2010, when a significant growth in the request rate was observed with the constancy annual number of orders until 2022, the results of which can be seen in Figure 05.

Figure 05 – Evolution of patent applications

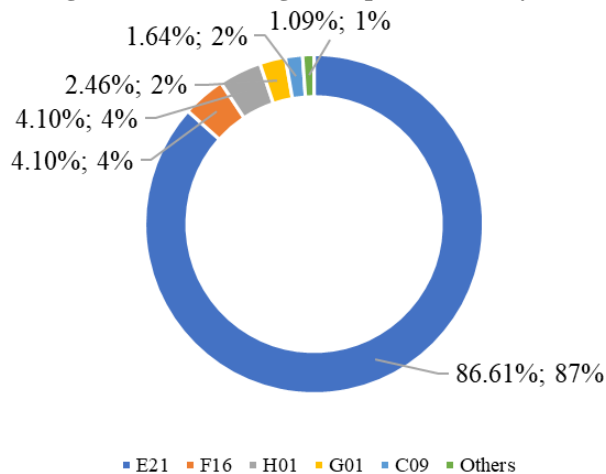


Source: Authors (2023)

Analysis of the technical fields of the deposits made

The analysis of the technical fields of the deposits made was carried out using the IPC codes, analyzing the group “Fixed constructions”, making it possible to verify that 83.61% of the codes refer to Group E21 (Ground drilling; Mining) as shown in Figure 06.

Figure 06 – Percentage of deposits made by IPC



Source: Authors (2023)

Figure 07 demonstrates the distribution of IPC codes with full taxonomy mapped associated with plug patent documents.

Figure 07 - Number of deposits made by IPC



Source: Authors (2023)

Depositor analysis

The analysis of applicants demonstrated a predominance of multinational companies that were responsible for many patent applications, while national applicants generated on average only one patent application, highlighting individual patent applications (independent inventors) that totaled 4 requests, as shown in Table 02.

Table 02 - Types of depositors

| Types of Depositor | Frequency | Percentage |
|-------------------------|-----------|------------|
| Multinational Companies | 50 | 91% |
| Independent inventors | 4 | 7% |
| National Companies | 1 | 2% |
| Total | 55 | 100% |

Source: Authors (2023)

IV. Conclusion

Data analysis demonstrated that, although there is still a considerably small number of patents, there is an increase in the development of technologies related to plugs and accessories related to their application in oil wells, consistent with the challenge of carrying out an activity security with emphasis on preserving integrity in fields with a marginal situation. New research can expand the analysis by comparing the panorama of national development with the global scenario through data from other patent banks.

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