Research on generic technology identification issues in non-ferrous metal industry

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Abstract. Non-ferrous metals are the basic strategic materials for national industrial manufacturing. Exploring the development process of the industry and identifying generic technologies in the field play a vital role in breaking through the technical bottleneck of the non-ferrous metal industry and achieving transformation and upgrading. This paper selects Derwent patent database as the data source, uses CiteSpace software to construct a visual map of the retrieved non-ferrous metal industry patent data, identifies and analyzes the generic technologies and hot fields of the non-ferrous metal industry, and puts forward reasonable suggestions for the future development of the industry.

1. Introduction
In the context of the upgrading of traditional industrial structure and the continuous rise of emerging industries, various countries and related industries have improved the existing structural defects of the industry by breaking through important technological bottlenecks and promoting the transformation of achievements, thereby promoting a new round of economic growth. To find potential technological opportunities and clarify the strategic goals and development direction in a highly competitive market environment with limited resources, it is vital for the industry to control future innovation development trends and seize technological heights.

This paper selects Derwent patent database as the data source, and uses CiteSpace software to construct a visual map of the non-ferrous metal industry patent field, so as to identify generic technologies in the non-ferrous metal industry. Finally, this article conducts an in-depth analysis of the identification results, explores the development status and problems of the industry, and proposes corresponding countermeasures.

2. Generic technology identification methods
At present, the academic research methods for the identification of generic technologies are mainly divided into three types: research methods based on expert experience, research methods based on LDA topic model, and research methods based on patent documents.

(1)Identification method based on expert experience

Discrimination through expert experience is the early generic technology identification method. Xu Lei (2011) mainly integrates the two research methods of Delphi survey and technology roadmapping to provide new ideas for the development of identification and prediction technology [1]. Zhang Qiaomu
(2017) mainly used the methods of Delphi survey and cluster analysis to identify key generic technologies, and finally selected key generic technologies in the industry after an expert meeting [2].

2) Research method based on LDA topic model

Latent Dirichlet Allocation (LDA) topic model mainly processes and analyzes the semantic structure of the text based on a large amount of text information, and mines the useful information hidden in the text as a research hotspot in this field. Guan Peng (2015) used the research method combining the topic model and life cycle theory to excavate and analyze the scientific literature topics in the domestic new energy field[3]. Ma Yonghong (2020) selects high-intensity technical topics as research objects based on patent data and LDA topic models to identify and analyze industry generic technologies [4].

3) Research methods based on patent documents

The first identification method is based on the citation relationship between patent documents to identify key generic technologies [5], which mainly includes: citation relationship analysis method and document co-citation strength method. The second identification method is mainly based on patent co-occurrence and common category information to identify key generic technologies, mainly including: mean technology co-occurrence rate method (MTCR) [6], mean technology common category index method (MTCI). When analyzing co-occurrence and common-class relationships, such methods generally use IPC classification numbers or Derwent classification codes as the identification basis.

To sum up, most of the existing documents are based on patents or papers as data sources, and identify industry generic technologies through qualitative or quantitative methods, but they all have certain shortcomings and deficiencies. The recognition method based on expert experience has strong subjectivity, and there is no unified judgment criterion and evaluation process. Although the research method based on the LDA topic model can extract the hidden information of the text, the degree of association between the text vocabulary is not clear enough compared with the standard division of patent categories. Research methods based on patent documents have time lag problems when analyzing patent citation relationships, and the identification results are easily restricted by patent classification standards. Therefore, this article comprehensively analyzes the Derwent manual codes and keywords of patent documents, uses CiteSpace[7] software to build a patent co-occurrence network, and extracts patent keywords for visual graph analysis, and finally identifies generic technologies in the industry.

3. Data source and research method

3.1. Data source

Derwent Patent Database is a world-renowned patent search platform. Its unique and comprehensive patent literature content provides researchers with the most authoritative patent intelligence and information. This article divides the non-ferrous metal industry into mining, smelting and rolling processing industries. In the Derwent Patent Database (DII), a total of 11,927 related patents were retrieved from 2000 to 2017 using a search method combining IPC classification numbers and keywords.

3.2. Research method

CiteSpace is a tool software for scientific metrological analysis and visualization developed by Professor Chen Chaomei [8]. This paper uses the bibliometric analysis method and uses Citespace software to draw a knowledge map to visually analyze the relevant patent data of the non-ferrous metal industry, identify and study generic technologies and hot areas of the non-ferrous metal industry. This paper mainly constructs the co-occurrence network and clustering map of Derwent manual codes, and ranks the frequency and centrality of Derwent manual codes to identify and analyze generic technologies.

4. Research results and analysis

4.1. Analysis of the development trend of the number of patents

This article retrieves 11,927 patent data published in the non-ferrous metal industry from 2000 to 2017. The annual number and growth rate of patent publications are shown in Figure 1. The number of patents
in the non-ferrous metal industry has increased by 4 times from 2000 to 2017. Among them, the patent growth rate in 2001 reached the maximum of 119%, and the overall growth rate has shown a downward trend since 2002. The growth rate from 2010 to 2017 remained at around 12.5%. Overall, the number of patents in the non-ferrous metal industry from 2000 to 2017 showed a relatively stable growth trend.

4.2. Constructing a co-occurrence network of Derwent manual code
Based on the patent data of the non-ferrous metal industry from 2000 to 2017, a Derwent manual code co-occurrence network is constructed with Category (MC) as the node, as shown in Figure 2. In the co-occurrence network graph, the frequency of occurrence of Derwent manual code (MC) is reflected by the size of the circle surrounding the node, reflecting the research hotspot. The purple circle outside the node indicates that the node has a high betweenness centrality and is a key node in the research field. The thickness of the connecting line between the nodes represents the strength of the correlation between the nodes. It can be seen from the co-occurrence network view of Derwent manual code that each node has a close relationship with a small number of single nodes. Among them, the non-ferrous metal industry related patents are mainly distributed in the three categories of M, L, and N of Derwent manual code. The M category represents the field of metallurgy, and the L category represents glass, ceramics, electro(in)organics, N category represents the field of catalysts.

This article analyzes the specific distribution of patents in the non-ferrous metal industry by summarizing the co-occurrence frequency and centrality value of the Derwent manual codes in the top 10, as shown in Table 1 and Table 2.
The frequency of co-occurrence indicates that this field is a hot technology. In the Derwent manual code co-occurrence network, the nodes with high frequency have large annual rings. It can be seen from Table 1 that the more frequent Derwent manual codes cover important production materials such as metal powders, catalysts, composite materials, polymers. The Derwent manual codes with frequency distribution in the top 3 are M22-H02, M22-H01, M22-H03B, namely powder metallurgy-powder treatment prior to use, metal/alloy powders, granulates, fibres, production, sintering, indicating that the current non-ferrous metal industry in the field of powder metallurgy research is very mature, including the research on powder processing, production and manufacturing is more in-depth.

According to the order of node betweenness centrality, the top 10 Derwent manual codes are counted, as shown in table 2.

| Centrality | Year | Manual Code | Meaning |
|------------|------|-------------|---------|
| 0.51       | 2008 | A10-E05B    | chemical modification by carbonisation |
| 0.49       | 2004 | A12-W11K    | catalysts and supports (polymer use) |
| 0.37       | 2000 | M22-H02     | powder metallurgy - powder treatment prior to use |
| 0.35       | 2000 | J04-E04     | catalysts |
| 0.33       | 2000 | M22-H03B    | sintering |
| 0.33       | 2004 | A12-W12F    | polymer use in metallurgy |
| 0.28       | 2000 | X16-E01C    | inorganic compounds |
| 0.27       | 2000 | E31-A02     | h2 production, storage |
| 0.22       | 2000 | M22-H03A    | compacting |
| 0.19       | 2006 | A12-E01     | electrical engineering [general] |

The intermediary centrality of nodes in the network is a manifestation of the importance of nodes, reflecting the node's ability to control resources. Nodes with higher betweenness centrality are the key bridge connecting two different fields. It can be clearly seen from the ranking table of node centrality that the three nodes with the highest betweenness centrality are A10-E05B, A12-W11K, M22-H02, namely chemical modification by carbonisation, catalysts and supports (polymer use), powder metallurgy-powder treatment prior to use, indicating that these 3 application nodes occupy the entire co-occurrence network system key position.

4.3. Cluster analysis of Derwent manual code

In the cluster map, the label of each cluster is mainly marked by extracting the title, keywords, and subject words in the abstract of the patent document. This paper conducts a cluster analysis based on the patent data of the non-ferrous metal industry. The modularity Q of the network is greater than 0.3, indicating that the clustering results are credible. The non-ferrous metal industry patent data cluster is mainly divided into 8 related topics (Cluster#0-7), as shown in Figure 3. The clustering topics are
exhaust gas, electroconductive paste, composite material, copper-gallium alloy, magnetic powder, preserving furnace, shifting device and cutting tool insert. Among them, the color of the clustering areas of themes 2, 5, and 6 is the lightest, indicating that "electroconductive paste", "magnetic powder", and "preservation furnace" are emerging application areas in the non-ferrous metal industry.

Figure 3 Derwent manual code clustering map

5. Main research conclusions and recommendations

Through the construction of the Derwent Manual Code (DMC) co-occurrence network and the visual atlas analysis based on the patent data of the non-ferrous metal industry, it can be seen that A10-E05B (chemical modification by carbonisation), A12-W11K (catalysts and supports (polymer use)), M22-H02 (powder metallurgy-powder treatment prior to use), J04-E04 (catalysts), M22-H03B (sintering), A12-W12F (polymer use in metallurgy) technology has a high degree of centrality, belonging to the non-ferrous metal industry key generic technology.

(1) The patents related to the non-ferrous metal industry are currently mainly distributed in metallurgy, glass, ceramics, electro(in)organics, and catalysts. They are specifically in metallurgical processing. Research on methods (sintering, compaction), conductive adhesives (including polymers filled with conductive metals), catalyst preparation, activation, pretreatment, and catalyst purification of exhaust gas are hot technologies in the non-ferrous metal industry, and their development is becoming mature.

(2) The Derwent manual code co-occurrence network constructed by patent data shows that powder metallurgy-powder treatment prior to use, metal/alloy powder, granulate, fibers, production, carbonization chemical modification, catalysts and carriers (for polymerization). These technical fields occupy a key position in the non-ferrous metal industry.

(3) Based on the clustering map analysis of Derwent patent data, it can be seen that research topics such as "electroconductive paste", "magnetic powder", and "preservation furnace" are currently emerging directions in the non-ferrous metal industry and need to be focused on.

According to the research results, the non-ferrous metal industry attaches great importance to technology research and development and innovation in the smelting and rolling process, and continuously optimizes and improves smelting equipment and processes. Among them, the research in the field of powder metallurgy has been more in-depth, and a series of new processes and new technologies have emerged, becoming one of the preparation technologies of high-performance materials and mechanical parts. Therefore, the state and relevant enterprises should pay attention to the structural upgrading and transformation of the smelting stage of the non-ferrous metal industry,
continuously strengthen the innovative research and development of smelting processes and technologies, and promote the promotion and application of major energy-saving and consumption-reducing advanced technologies in the non-ferrous metal smelting field. It mainly includes high-strength and high-conductivity copper alloys, hard magnetic alloys, high-temperature stable catalysts and their preparation, catalysts to purify exhaust gas, high-performance nano-sized, large-grained hard alloy tools and other key research areas.

In the future, the non-ferrous metal industry should focus on the development of new materials in information, new energy, transportation, high-end manufacturing and other fields, improve the development and utilization of rare metal resources, and encourage the development of high-efficiency, energy-saving, low-polluting, large-scale recycling and comprehensive utilization of renewable resources. Through a series of technological innovation and upgrading, the non-ferrous metal industry will achieve high-end, intelligent and green development.

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