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Research on the Application Value and Practice of Oilfield Digital Terminology from the Perspective of Digital Intelligence Empowerment

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Abstract

Under the multiple backgrounds of the "double carbon" goal, the promotion of the national energy security strategy and the iteration of new generation information technology, digital intelligence has become the core engine to solve the development dilemma of "two deep, one non-standard and one old" in the oil industry and promote the high-quality transformation of the traditional oil and gas industry. **Digital terminology** (defined herein as the standardized set of technical terms, semantic structures, and conceptual frameworks that emerge from the integration of digital technologies—such as AI, big data, cloud computing, and digital twins—with oilfield operations) serves as the basic carrier for technical exchange, achievement transformation and theoretical construction in the field of digital intelligence oil, and is the key link between digital technology and oil business [1]. Based on the current development status of **digital smart oil fields** (defined as oilfields that progressively move from data acquisition and automated control to intelligent analysis, collaborative decision-making, and human-machine synergy, thereby achieving optimized production, safety, and efficiency), this article clarifies the core concepts of digital smart oil and digital terminology, combines the actual application cases of PetroChina, Sinopec and other companies, explores the specific implementation scenarios of various digital terminology in the field of digital smart oil, sorts out the application paths and practical results of digital terminology in reservoir cognition, smart operation and maintenance, safety management and control, decision-making optimization, etc., and reveals the role of digital terminology in promoting the standardization and large-scale application of digital smart oil technology. It plays a core role in providing theoretical reference and practical reference for further deepening the integration and application of dig-

ital technology and the oil industry, improving the theoretical system in the field of digital intelligence in oil, and assisting the digital transformation of the industry.

Subject Areas

Terminology and Oil

Keywords

Digital Terminology, Digital Smart Oil Field

1. Introduction

In the context of multiple eras led by the "double carbon" goal, driven by the national energy security strategy and accelerating iterations of new generation information technology, the oil industry is facing unprecedented transformation pressure and historical opportunities. Traditional oil fields have long relied on the production model of "manual inspection + experience decision-making" and have gradually fallen into the development dilemma of "high cost, low efficiency, and high risk". In this context, digital intelligence transformation has become an inevitable choice to break through traditional production bottlenecks, and the implementation of software development for real-time data applications and fault diagnosis algorithms is the core engine that promotes the transformation of oil fields from "experience-driven" to "data-driven" [2]. In this profound industrial transformation, digital intelligence is no longer a multiple-choice question, but a must-answer question related to energy security and high-quality development.

The core essence of digital transformation is to realize the systematic reconstruction of production relationships and the fundamental transformation of value creation methods through the deep integration of digital technology and business scenarios. In recent years, central energy enterprises such as PetroChina and Sinopec have elevated digital intelligence to a core strategic initiative: In early 2025, PetroChina officially established "digital smart oil" as the fifth strategic initiative, coordinating and promoting the three major projects of "informatization reinforcement, digital empowerment, and smart development"; Dagang Oilfield took the lead in proposing the concept of "digital smart oil field" in 2021, clarifying the concept of "digital acquisition", "Comprehensive coverage, full realization of automated control, full operation of integrated collaboration, and full advancement of smart applications" are the construction goals. A series of strategic layouts shows that the oil and gas industry is accelerating from digitalization to a new stage of digital intelligence.

In this process, digital terminology plays a fundamental but crucial role. Terminology is not only the formal expression of technical concepts, but also the underlying unit for knowledge dissemination and system construction. The evolution of the concept from "digital oil field" to "digital smart oil field" and then to

"digital smart oil field" reflects the deep transition of industry cognition from technology tool theory to system change theory. The emergence and implementation of emerging terms such as Kunlun Large Model, Dream Cloud Platform, Digital Twin, and Industrial Metaverse not only mark the iteration of the technical system, but also reconstruct the cognitive framework and working paradigm of oil engineers. As experts say, the oil and gas industry does not lack technology, but what it lacks is systematic thinking carried by integrated awareness and terminology.

This study adopts a hybrid research method of literature review and case study. The research literature covers domestic and international academic papers, oil industry specifications, enterprise strategic documents and professional monographs on oilfield digital transformation. In terms of empirical research, this paper selects typical practical projects of PetroChina and Sinopec as research cases. As the core leading enterprises in China's oil industry, they have taken the lead in constructing digital smart oil fields with comprehensive and representative business practices. Their mature and systematic application scenarios of digital terminology fully cover the research scope of this study, which can effectively reflect the industry's current situation and ensure the credibility and pertinence of the research results.

However, the application of digital terminology in the development of digital smart oil fields has faced significant challenges. Current issues within the industry—including inconsistent term usage, ambiguous conceptual boundaries, and non-uniform Chinese-English translations—have substantially hindered the efficiency of technical communication and the quality of technological implementation. Addressing these shortcomings, this study focuses on practical applications of digital terminology in digital smart oil field systems. By clarifying core concepts of digital smart oil and digital terminology, and analyzing real-world cases from multiple oil and gas fields operated by CNPC and Sinopec, the research examines specific implementations across reservoir characterization, smart operation and maintenance, safety management, and decision optimization. It outlines application pathways and practical outcomes, highlighting the pivotal role of terminology in advancing technical standardization and scalable adoption. This study aims to provide theoretical insights and practical guidance for deepening the integration of digital technologies with the oil industry, refining the theoretical framework for digital smart oil fields, and facilitating the sector's digital transformation.

2. Definition

A systematic definition of digital terms

The connotation of digital terminology is constantly enriched and evolved in industry practice. "Digital smart oil field", as the core concept first proposed, refers to taking oil fields as the research object, organizing development and construction, production operations, enterprise management and other related data and information in three-dimensional space, and using computers and high-speed

networks as carriers to form a highly integrated information system [3] [4]. On this basis, "digital smart oil field" introduces artificial intelligence technology to achieve automatic operation and stable control [5], while "digital smart oil field" further emphasizes the deep integration of artificial intelligence and expert experience, covering six major systems: smart perception, smart control, smart early warning, comprehensive collaboration, smart analysis and scientific decision-making [6]. From the perspective of terminology evolution, "digitalization" focuses on the infrastructure construction of data collection, transmission, storage, management, and use; "intelligentization" emphasizes automatic response and optimized decision-making based on data; and "smartization" pursues the collaborative intelligence of humans and machines. Some scholars have systematically demonstrated the differences, intrinsic connections, and interdependencies between digital, intelligent, and digital smart oil and gas fields, and constructed a value model for digital, smart, and digital smart oil and gas fields based on the concept of dual business and value drivers [7].

Significant progress has been made in industry standardization for terminology normalization. The industry standard "Digital Transformation Maturity Assessment for the Petrochemical and Chemical Industry" (HG/T 6346-2025), released in 2025, clearly defines the terminology and definitions used in assessing digital transformation maturity, covering seven capability domains: organization, technology, data, resources, digital operations, production, and services, and categorizes enterprise digital transformation maturity into five levels [5]. Furthermore, the publication of the reference guidelines for integrating industrial internet with oil and gas storage and transportation has transformed this sector's digital and smart transformation from a sporadic, ad hoc approach to a coordinated effort driven by standards, systematic implementation, and ecosystem collaboration. The standardized terminology framework has removed fundamental barriers to data interoperability and business synergy across different enterprises and operational processes.

In terms of terminology translation and interdisciplinary communication, existing research indicates that oil terminology is characterized by conciseness, professionalism, vividness, interdisciplinary relevance, and abstraction; translators must strictly adhere to these five characteristics and uphold the principle of rigor in terminology translation [8]. Furthermore, the information age has led to extensive use of metaphors in oil terminology; analyzing their origins and classifications facilitates the development of appropriate translation strategies [9]. From an interdisciplinary perspective, foreign scholars have developed the O3-Pro domain ontology to address digitalization needs in the oil industry, aiming to establish a unified and clearly defined reference vocabulary that enables engineers and IT professionals to identify and correlate monitoring data, simulation results, and equipment specifications for production facilities, thereby serving as the semantic framework for digital twins in the sector. These studies provide methodological support for the standardized application of digital terminology in cross-disciplinary and

international communication.

3. Identify the Applications of Digital Terminology in the Field of Digital Smart Oil and Gas Technology

3.1. The Role of Large-Scale Modeling Digitalization in Digital Smart Oil Fields

With the emergence of digital and digital smart oil fields, the application of large-scale models has become essential. As a major player in the oil industry, China has developed advanced model platforms such as the Kunlun Large Model and Dream Cloud Platform to support corporate development. Among these, the Kunlun Large Model stands out as a leading AI solution: according to CCTV.com, it encompasses six high-level AI capability models that cover 152 application scenarios across the entire industrial chain—including oil and gas exploration and development, refining and chemical production, technical services, and capital finance—with a daily vocabulary query volume of 48.5 billion. It represents the first large-scale model platform in China's energy and chemical sector to achieve comprehensive, industry-wide deployment [10].

3.2. The Application of Digital Terminology and Its Practical Outcomes in Digital Smart Oil Industry

The Kunlun large-scale model: from empirical explanation to practical inversion

The Kunlun large-scale model has achieved a pivotal breakthrough in 3D seismic exploration by transforming full-waveform acoustic inversion from two-dimensional to three-dimensional processing, reducing the computation time from 20 days to just 3 days, cutting overall costs by over 30%, and enhancing the accuracy of high-quality reservoir identification (sweet spots) by 20% [11]. This advancement has directly elevated technical concepts such as "full-waveform inversion", "geological modeling", and "reservoir prediction" from theoretical frameworks to practical industrial applications. At Guangdong Petrochemical's digital smart factory, measures like process optimization and predictive equipment maintenance have reduced energy and material consumption, minimized unplanned downtime, lowered operational costs by 15%, decreased energy consumption per unit of output value by 9%, and increased labor productivity by 20% [12]. Terms like "digital smart geophysical exploration" and "digital smart velocity spectrum" have gained industry-wide recognition for their technical validity and performance benefits: digital smart geophysical exploration refers to automated processing and interpretation of seismic data using AI technologies, while digital smart velocity spectrum denotes automatic acquisition and analysis of velocity profiles through AI-driven methods.

The explicit definition and consistent usage of these terms have enabled cross-disciplinary teams—geophysicists, data scientists, and drilling engineers—to align on shared technical objectives, reducing misinterpretation and accelerating the

standardization of AI-assisted workflows across exploration projects.

Specific examples

The "Jianghai Zhiduan" digital smart decision-making system developed by Bohai Drilling Company integrates the entire data chain, covering drilling design optimization, in-drilling navigation warnings, and post-drilling analysis and summarization, achieving an underground risk warning accuracy rate of 83.3% [13] [14]. The digital and smart supervision platform for Xinjiang oilfields has implemented AI-based recognition of complex conditions such as overflow, well bore leakage, and blockages, having automatically alerted and addressed abnormal situations a total of 3893 times, improving on-site response efficiency by 60%, and reducing the construction duration of Well Qingbei-1 by 40% year-over-year [15]. Terms like "smart early warning", "digital twin supervision", and "smart decision-making system" have gained substantial practical significance through large-scale deployment in frontline drilling operations. These terms serve as unified communication anchors among on-site operators, remote monitoring centers, and management layers, enabling rapid situational awareness and coordinated response; their standardized usage has been codified in internal operating manuals, facilitating seamless handover between shifts and reducing training costs for new personnel.

The Kunlun large model has established a collaborative working framework comprising "large-model comprehension tasks, smart agent coordination and scheduling, and specialized execution by small models", enabling fully automated operation throughout the entire well evaluation process with a 20-fold efficiency improvement, and has been successfully deployed across tens of thousands of wells. In the field of new material development, the synthetic rubber large model can accurately predict seven core material properties, achieving a maximum prediction accuracy of 95% for key characteristics, significantly reducing redundant experiments [16]. Enterprises such as Shengli Oilfield have built a foundational service technology system centered on automation, encompassing capabilities for business anomaly monitoring and smart optimization [17]. Terms like "smart scheduling", "collaborative decision-making", and "digital twin" are demonstrating growing significance in enhancing management practices. The consistent application of these terms across multiple business units—from production planning to supply chain logistics—has broken down siloed communication, established a common language for performance indicators and exception handling, and enabled the systematic integration of disparate software platforms into a unified decision-support ecosystem.

4. Conclusions

Digital terminology serves as the foundational vehicle for technical exchange and achievement transformation in the field of digital-smart oil, and its standardization system development along with scenario-based applications is profoundly reshaping the digital-smart transformation path of the oil industry. Practices by en-

terprises such as CNPC and Sinopec demonstrate that terms like "digital smart oil field", "digital smart oil field", "Kunlun large model", "digital twin", and "smart early warning" have evolved from conceptual definitions to practical empowerment—not only reflecting technological innovation but also mirroring a leap in industry understanding [14]. Currently, China's energy sector is at a critical juncture of transitioning from "pilot applications" to "systematic advancement" in its digital transformation. Promoting the standardization, interdisciplinary integration, and multilingual specification of digital terminology is expected to further enhance the dissemination efficiency and collaboration level of digital-smart oil technologies.

This study still has certain limitations. First, the research cases are mainly confined to domestic oil enterprises in China, lacking cross-regional and international case references, which limits the generalizability of the research findings. Second, the analytical materials adopted are primarily publicly released enterprise documents and open academic resources, without involving internal undisclosed operational data. Third, this research mainly adopts descriptive analysis to summarize the application status and practical value of digital terminology, and does not carry out comparative analysis of different enterprise models or technical application differences. In the future, with the continued deepening of overarching strategies such as "digital-smart China oil", the systematic construction of digital terminology will facilitate the industry's digital-smart transformation from "key breakthroughs" to "systematic evolution", providing robust theoretical and terminological support for ensuring national energy security and advancing high-quality development in the energy sector.

Conflicts of Interest

The authors declare no conflicts of interest.

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