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ARTICLE

Research on Human Post-Editing Methods for Machine Translation of Petroleum Science and Technology Texts

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ABSTRACT

In the context of globalization, with the continuous advancement of artificial intelligence technology, machine translation technology has developed rapidly. Although the quality of machine translation has improved, there are still limitations in ensuring accuracy, especially in texts requiring high levels of professionalism and precision. Therefore, it is particularly important to study the translation model that combines machine translation with human post-editing. This study takes the article *Synthetic polymers: A review of applications in drilling fluids*, the most-cited article in *Petroleum Science* in 2024, as an example. Based on the manual comparative review, the study deeply analyzes problems such as mistranslated vocabulary, incorrect sentence structure segmentation, and poor discourse cohesion in machine translations of petroleum science and technology texts. It also explores human post-editing methods such as verification, sentence structure clarification, and cohesive techniques to address these problems and improve the translation quality of petroleum science and technology texts. This study finds that machine translation demonstrates high efficiency in the translation of petroleum science and technology texts, capable of rapidly generating roughly accurate translations. However, there are still deficiencies at the lexical, syntactic, textual, symbolic, and graphical levels. The author hopes that this study can provide valuable insights for the application and development of the human-machine collaboration model in the translation of specialized texts.

Keywords: Machine Translation; Human Post-Editing; Petroleum Science and Technology Texts

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1. Introduction

With the rapid development of artificial intelligence and deep learning technologies, machine translation (MT) has significantly improved the translation speed and efficiency[1]. However, translations produced by current machine translation systems often fall short of meeting high-quality practical requirements, making human post-editing necessary[2]. Many researchers have examined common errors in machine translation, such as terminology mistranslation, lexical omissions[3], over-translation, formal errors, formatting errors[4], improper voice conversion, and clause translation errors[5]. All of these problems underscore the need for human post-editing in addressing the limitations of machine translation.

Petroleum science and technology texts are characterized by a high degree of specialization, dense technical terminology, and extremely high requirements for accuracy and consistency. These features contribute to a writing style that is highly professional, objective, and concise[6]. Compared with general texts, machine translation does show higher efficiency in processing scientific and technical texts. However, due to the complexity of concepts, frequent use of specialized terms and long, complicated sentences, as well as the need for precise contextual interpretation in the petroleum field, the outputs of machine translation often fail to meet professional standards[7], necessitating human post-editing. This study will analyze issues in machine translation of petroleum science and technology texts at lexical, syntactic, textual, symbolic, and graphical levels. Through specific examples, it will discuss how human post-editing can resolve these problems, offering insights into a human-machine collaboration model for improving translation quality.

2. Literature Review

This section makes a comprehensive review of the relevant domestic and foreign studies, which is divided into four main parts. The first part introduces the research status of the translation of petroleum science and technology texts. The second part discusses the research status of machine translation, while the third part explains the research status of post-editing. The last part summarizes the problems found in previous studies and outlines the research direction of this paper.

2.1. Studies on Translation of Petroleum Science and Technology Texts

The translation research of petroleum science and technology texts has received extensive attention in recent years, which is not only due to the important position of the petroleum industry in the global economy, but also due to the actual needs of cross-cultural communication and technology dissemination. Currently, academic research on the translation of petroleum science and technology texts exhibits a multi-dimensional exploration trend. The focus of research is concentrated on two major areas: studies on language features and translation strategies, and studies on practices under the guidance of translation theory. Some scholars also delve into the problems and corresponding countermeasures in the translation of petroleum science and technology texts, forming a research pattern that closely integrates theory with practice.

2.1.1. Studies on Language Features and Translation Strategies

In the realm of language features and translation strategies, scholars have conducted systematic analyses from lexical, syntactic, and textual perspectives. Zou Yu[8] examined petroleum scientific and technical English (PSTE) through lexical, syntactic, textual, rhetorical, and stylistic dimensions, discussing appropriate translation methodologies for this domain. At the lexical level, he highlighted the precision of word formation, extensive use of abstract nouns, and conciseness in terminology. Syntactically, he emphasized the objectivity of PSTE texts while noting their interdisciplinary nature, vividness, and humor. Additionally, he observed the emergence of numerous neologisms in PSTE texts and proposed corresponding translation principles based on these characteristics. Cui Weihui and Cui Weili[9] take PSTE as an example to analyze its features from lexical and syntactic perspectives, and put forward corresponding translation strategies, which is similar to Han Shuqin[10] to some extent. However, Han Shuqin's classification of lexical features of PSTE is more detailed, with professional terminology and acronyms being the sole commonality among these scholars' lexical observations.

Building upon the foundations laid by Cui Weihui and Cui Weili[9] and Han Shuqin[10], Xiu Wenqiao and Xu Fangfu[11] conducted a tripartite stylistic analysis of PSTE

encompassing lexical, syntactic, and textual dimensions. Their study integrated translation examples to address specialized uses of general vocabulary, restructuring of long sentences, and logical cohesion, subsequently formulating context-specific translation strategies and methods. Their research aimed to accurately and faithfully convey the meaning of the original sentence, objectively and completely express the original information, so that the translation can be faithful to the original content and meet the reading needs of the target language readers.

Latysheva[12] revealed the correlation between factors determining the adequacy of oil and gas terminology translation, developing a specialized vocabulary translation algorithm for oil and gas source texts aimed at enhancing decision-making efficiency and translation adequacy in target testing scenarios. Based on the discourse cognition method, the algorithm uses the translation strategies of oil and gas lexical units and related translation techniques to draw the relationship between alternative discourse parameters representing different types of knowledge. Efanova and Zabrodina[13] argued that the evolving landscape of the oil and gas industry drives linguistic innovation, with technological advancements in production methods and equipment catalyzing the emergence of neologisms. Therefore, it is necessary to accurately translate neologisms in the oil industry. The two scholars explained the characteristics of neologisms and the principles to be followed in translating such neologisms, striving to present higher-quality translations of neologisms and terminology.

2.1.2. Studies on Practices under the Guidance of Translation Theory

In the studies on the translation practices of petroleum science and technology texts, most scholars are based on the guidance of a certain translation theory to translate petroleum science and technology texts and produce their own translation practice reports. Li Yajing[14], guided by Professor Huang Zhonglian's innovative translation variation theory, argued that petroleum science and technology texts, as a type of informative texts prioritizing knowledge transmission, require rapid and concise translation. Translation variation theory can well match this feature of petroleum science and technology text translation. Through specific case analysis, she elucidated the great significance of translation variation theory to guide the translation of petroleum science and technology texts. Zhang Lijiao[15], operating within Nida's functional equivalence theory, analyzed lexical and syntactic challenges in scientific English translation while proposing corresponding strategies.

Similar to Zhang Lijiao[15], Wang Nana[16] took functional equivalence theory as the guiding theory of translation practice report, but expanded the analysis to four dimensions: lexical, syntactic, textual, and stylistic levels. Yang Wenping[17] and Jiang Qiaomei[18] both employed Reiss's text typology theory to explore PSTE features and summarize the translation strategies of petroleum science and technology texts with specific examples. The difference between the two is that Yang Wenping[17] emphasized industry-specific standards derived from the analysis and research of text typology theory, while Jiang Qiaomei[18] focused on self-reflective improvement through practical translation deficiencies identified in her work. In international research, Herman et al.[19] investigated the realization of speech function through systemic functional linguistics perspective, while Thao[20] also applied Halliday's register theory to the translation practice of petroleum science and technology texts. Shatova's[21] typological study of equivalence theory and the conceptual translation research conducted by Kongsvik et al.[22] within the framework of organizational learning did not focus on the ontology of technical texts, but their proposed classification system of translation dilemmas still has reference value.

2.1.3. Studies on Problems and Countermeasures in Translation

In the studies on the translation of petroleum science and technology texts, although the current research focuses on the two major fields: studies on language features and translation strategies and studies on practices under the guidance of translation theory, some scholars have discussed the problems existing in the translation of petroleum science and technology texts and put forward corresponding countermeasures, which is particularly important for translators to produce high-quality translations.

For instance, Tian Chuanmao[23] mentioned the pitfalls in the translation of science and technology. He believed that there is a "false friend" in the translation of PSTE, that is, the expression of the same or similar forms but different meanings in the source language and the target language. When translating such texts, the translator needs to pay special attention to this problem and avoid falling into the trap

of "false friends". He also put forward his own coping strategies for such problems in order to help translators further improve their translation level. International contributions further enrich this discourse: Manhura and Sereda[24] focused on the lexical problems of oil and gas. The difficulties of technical translation in the oil and gas sector are aggravated by the fact that specialized terminology and symbols are often developed by people who arenot native English speakers. Shatova[21] held that translators should pay attention to various problems in translation, pointed out the common difficulties faced by translators, and put forward approaches and suggestions for the translation of petroleum texts. In their article, Efanova and Zabrodina[13] put forward requirements for translators, as well as the problems that arise when translating neologisms and the principles that should be followed, striving to present higher-quality translations of neologisms and terminology.

2.2. Studies on Machine Translation

In recent years, machine translation, as an important branch of natural language processing, has made remarkable progress in its research and application worldwide. At present, studies on machine translation are showing a booming trend. In order to understand the current situation in this field more comprehensively, this part will delve into four dimensions: historical development of machine translation, corpus-based machine translation systems, quality and efficiency evaluation of machine translation, and computer-aided translation.

2.2.1. Studies on Historical Development of Machine Translation

Machine translation can be traced back to 1933, evolving alongside advancements in computer science and linguistics. From rule-based translation to statistical translation models, and then to deep learning-based neural machine translation, the evolution of technology has greatly improved the quality of translation. Slocum[25] and Hutchins[26] argued that machine translation is not mainly a field of abstract knowledge inquiry, but the application of computer and language science in system development to meet actual needs. Both scholars have made a brief introduction to machine translation, explaining to readers what machine translation is, what stages of machine translation have gone through, and how machine translation may develop in the future. Klimova et al.[7] focused on the neural machine translation (NMT) prospective landscape, outlining its core principles and methodologies before reviewing cutting-edge advancements and offering projections for its future directions.

Ma Xiao et al.[27] categorized MT development into three phases: rule-based machine translation, statistics-based machine translation, and deep learning-based NMT, which is similar to Wang et al.[28]. In this paper, the latest progress of NMT is reviewed and systematically sorted out, focusing on the application and innovation of large language models in the field of translation. Additionally, they also introduced the evaluation indicators and commonly used data sets of machine translation, and looked forward to the research prospects of low-resource language translation improvement, interpretable and controllable translation systems, cross-cultural adaptive translation, computing resource optimization, privacy protection, and security controllability. Jolley and Maimone[29] investigated thirty years of machine translation in language teaching and learning. By summarizing and drawing connections between the assumptions, methods, and findings of key studies, they provided a historical perspective and suggested new directions for future research.

2.2.2. Studies on Corpus-Based Machine Translation Systems

Studies on corpus-based machine translation systems constitute a significant branch of contemporary machine translation studies. Domestic scholars Luo Jimei and Li Mei[3], based on the "Automotive Technical Document Translation Corpus", conducted a comparative analysis of machine translation and human translation (HT) outcomes. They elaborated on the results of comparative statistics and identified common error patterns in MT regarding vocabulary, syntax, and symbol translation. This study not only narrowed down the scope of linguistic formalization but also provided linguistic analytical foundations for improving translation systems. Building on this, researchers can further supplement formal rules and define lexical scope to ultimately enhance the quality and efficiency of E-C machine translation.

International research has expanded corpus types. Corpas Pastor and Noriega-Santiáñez[30] argued that MT has re-

shaped market dynamics and translators' workflows, though its application has not yet penetrated the creative domain of literary translation. Focusing on idiom translation in literary texts, they validated the effectiveness of corpus-based methods in studying culture-loaded items through comparative analysis of MT and HT outputs. Liu Yanmeng[31] and Cheng Nan[32] both conducted corpus-based MT research but with distinct focuses. Liu Yanmeng[31] utilized a self-built corpus of traditional Chinese medicine (TCM) cultural translation to compare syntactic features between MT texts and non-translated texts, revealing configuration characteristics of the syntactic features of MT. However, Cheng Nan[32], employing corpus tools, performed quantitative linguistic analysis on MT outputs from the five tools and official translations of the speeches of state leaders in ten major diplomatic occasions. The study identified common issues in the machine translation of political texts, including limited vocabulary use, transfer redundancy, and inaccurate translation of specialized terms, while noting ChatGPT's superior performance in aligning with official HT textual features. Both studies contribute to refining MT tools and strengthening MT's role in the "going out" of Chinese traditional culture.

2.2.3. Studies on Quality and Efficiency Evaluation of Machine Translation

The ultimate goal of machine translation research is to achieve more efficient, accurate, and humanized translation services. Sun Qifeng and Gao Tingmin[33] evaluated MT quality and efficiency by comparing translations from four major NMT systems—Baidu, Tencent Translator, DeepL, and Google. Their study revealed that current NMT systems struggle with accurate translation of poetry or culture-loaded terms, guiding efforts to strengthen human-machine collaboration and enhance post-editing effectiveness for quality improvement in the digital intelligence era.

As a hot topic, studies on quality and efficiency evaluation of machine translation have gained international attention. Way[34] pointed out that while MT's practicality is widely recognized, not all agree on its efficiency-enhancing potential, with many remaining skeptical. To address this, Way[34] elaborated on current MT deployment methods, output evaluation approaches, and quality improvement strategies, emphasizing that translation quality should no longer be judged by a single "gold standard" but should consider specific application scenarios, particularly the intended "validity period" of translations. Different from the above scholars, Toyoshima et al.[35] conducted a year-long empirical study tracking English proficiency changes in a specific class using MT assistance, finding that students' English levels improved or remained stable with MT use. Moneus and Sahari[36] compared MT and HT across various text types to assess MT quality and efficiency in legal contexts, exploring advantages and limitations in different scenarios.

2.2.4. Studies on Computer-Aided Translation

Studies on computer-aided translation (CAT) have attracted significant scholarly attention. Chan[37] and Kit and Wong[38] introduced readers to the concepts of broad and narrow CAT tools in their literature, elucidating the benefits of applying translation memory software. Lv Lisong and Mu Lei[39] and Qian Duoxiu[40] integrated CAT with translation pedagogy. Lv Lisong and Mu Lei[39] analyzed the integration of CAT technologies with translation pedagogy against the backdrop of China's domestic translation market, proposing requirements for translators in the new era. However, Qian Duoxiu[40], focusing on the CAT course offered at Beijing University of Aeronautics and Astronautics in the past five years, shared pedagogical reflections to promote curriculum refinement and expansion through academic exchange. The intersection of CAT and translation pedagogy remains a hot research topic, while recent studies have diversified into areas such as CAT's role in enhancing translation quality and optimizing CAT technologies. For example, Tang Ayan[41] argued that CAT has significantly improved translators' efficiency and quality, analyzing its effective application in business English translation through pre-translation, while-translation, and post-translation processes.

2.3. Studies on Post-Editing

Post-editing, as an important branch of the translation field, has garnered widespread attention in both academic and industry circles at home and abroad in recent years. To provide a comprehensive overview of the research trajectory of post-editing, this section will conduct a review from four dimensions: an overview of post-editing, the application of post-editing in translation practices, competency development and talent cultivation of post-editing, as well as the development and application of post-editing tools.

2.3.1. Studies on Overview of Post-Editing

Foreign studies have pioneered the hierarchical categorization of post-editing. Allen[42] classified post-editing into inward-oriented and outward-oriented translation approaches. The former, sometimes termed absorptive machine translation, emphasizes information comprehension, while the latter, called disseminative machine translation, focuses on information exchange. Inward-oriented approaches can be divided into no post-editing and rapid post-editing, whereas outward-oriented approaches include no post-editing, minimal post-editing, and full post-editing. Cui Qiliang[43] called the traditional post-editing as "narrow post-editing" or "machine translation post-editing", that is, the post-editing of the translation obtained directly by machine translation; the post-editing of the initial translation output by the integrated translation environment is called "generalized post-editing" or "integrated translation post-editing", that is, the post-editing of the translation obtained by the integrated translation environment composed of translation memory, machine translation and translation management system.

Feng Quangong and Cui Qiliang[44] analyzed the focal points and development trends of post-editing, arguing that as expectations for machine translation decrease and demand for high-volume translation grows, post-editing work models will gain widespread recognition and application. They predicted post-editing could surpass translation memory in practical value, becoming the leading service mode for language service providers. Building on previous studies, Feng Quangong and Liu Ming[45] developed a three-dimensional model of post-editing competence encompassing cognitive, knowledge, and skill dimensions, detailing the constituent elements and characteristics of each.

Zhao Tao[46] posited that MTPE has become an indispensable component in the translators' work environment, though current understanding remains inadequate. He advocated for increased pedagogical research and training in post-editing capabilities. While the aforementioned scholars focused on domestic developments, Lu Yanqi[47] took a different approach by analyzing international research hotspots in MTPE (2011–2020) using Web of Science data. He identified three future priorities: neural machine translation, literary text post-editing, and translator competence development. Lu Yanqi[47] projected these trends would advance human-machine collaboration toward cognitive science integration, offering new perspectives and methods for domestic research through analysis of hotspots and development trends of foreign studies.

2.3.2. Studies on Application of Post-Editing in Translation Practices

The application of post-editing in translation practices constitutes another critical area of research. These studies primarily examine the effectiveness of post-editing across diverse text types and the impact of post-editing strategies and methods on enhancing translation quality. Guerberof[48] conducted a comparative analysis of MT outputs versus fuzzy matches from translation memory (TM) in terms of workflow efficiency and final quality. By making translators complete questionnaires without knowing the source of text segments, the study revealed that post-editing MT outputs yield higher productivity and quality compared to handling fuzzy matches from TM. Building on these findings, Green et al.[49] acknowledged that while MT improves translation efficiency, its quality lags far behind skilled human translation. Their experiments demonstrated that post-editing MT outputs significantly enhances both efficiency and translation quality. Giselle de Almeida and Sharon O'Brien[50] and Läubli et al.[51] all applied post-editing to their translation practices and evaluated the efficiency of post-editing based on their years of translation practices.

Domestic scholars Cui Qiliang and Li Wen[4] provided an overview of post-editing mechanisms, analyzed MT error types through specific cases, characterized post-editing workflows, and proposed corresponding editing methods. Zhu et al.[52] explored post-editing principles at the textual, referential, cohesive, and natural levels through concrete examples, aiming to optimize translation output efficiency and quality. Yao Bin[53] offered a broader perspective by briefly reviewing existing studies on requirements, standards, and practices of UN document translation. Analyzing typical issues of mainstream machine translation engine translation at home and abroad from seven dimensions: terminology standardization, discourse cohesion, domain-specific knowledge, semantic precision, syntactic adaptability, idiomatic Chinese expression, and stylistic consistency, the study proposed targeted post-editing improvements to assist translators in achieving higher-quality outputs.

2.3.3. Studies on Competency Development and Talent Cultivation of Post-Editing

In the realm of post-editing competence and talent cultivation, Wang Xiangling and Wang Tingting[54] employed keystroke logging and surveys to investigate differences in translation speed, translation quality, and translators' attitude among 31 student translators during E-C scientific text translation. Based on experimental data, they analyzed post-editing effectiveness and influencing factors, aiming to provide insights for MT post-editing talent cultivation. Yang Yanxia and Wei Xiangqing[55] adopted a cognitive perspective to examine categorical transfer mechanisms between post-editing skills, translation competence, and revision skills. They constructed a post-editing skill framework model and proposed pedagogical guidelines to inform talent cultivation efforts.

Internationally, Mitchell et al.[56] examined MT applications for user-generated content (UGC) translation, emphasizing the necessity of post-editing to ensure accuracy and user comprehensibility across contexts. However, professional post-editing by translators is not always feasible for online community UGC, so sometimes community members are invited to translate or post-edit on behalf of the community. The study proposed three quality assessment methods for community-edited UGC: (1) error annotation by trained linguists, (2) fluency and fidelity evaluation by domain experts, and (3) fluency assessment by community members. Through the analysis of the above scholars, it can be concluded that post-editing does play a certain role in improving the efficiency of translators, but for post-editing of some texts, foreign language translators are not necessarily suitable, so it is necessary to pay attention to the cultivation of post-editing talents. Latysheva[12] reviewed post-editing research trends in the past few years, discussing emerging MT challenges, future directions, and the maturation of post-editing as both a practice and service. While advocating for professional certification systems, the study noted the absence of standardized training frameworks.

2.3.4. Studies on Development and Application of Post-Editing Tools

With the continuous advancement of machine translation technology, the development and application of post-editing tools have gradually gained scholarly attention, but there is still much room for development. The earliest contribution dates back to 1995, when Huang Heyan and Chen Zhaoxiong[57] published *Design and Implementation Algorithm of an Intelligent Post-Editor*. In this work, the authors first introduced two common types of errors in machine translation, then proposed design principles and algorithms for an intelligent post-editing tool aimed at enhancing MT systems' learning and adaptive capabilities to improve post-editing efficiency. In 2012, Azizet al.[58] described a standalone tool, and this tool has two main purposes: facilitate the post-editing of translations from any MT system so that they reach publishable quality and collect sentence-level information from the post-editing process.

Different from the above scholars, Zhou Xinghua and Li Yiyang[59] conducted a comparative analysis of domestic and international post-editing tools. Noting the scarcity of fully functional, widely adopted dedicated post-editing tools, they examined four mainstream translation software programs, focusing on their post-editing capabilities of CAT software. Their findings revealed that, from the perspectives of MT application, post-editing workflows, and operational efficiency, CAT software outperforms tools highlighted in earlier post-editing studies. It is hoped that more attention will be paid to the post-editing function of the main translation working environment (i.e., CAT software) in future research, so as to obtain high-quality translations better and faster.

2.4. Summary

The review of the research status on the translation of petroleum science and technology texts reveals that this field not only focuses on language features and translation practices, but also deeply explores the existing problems and coping strategies in translation, demonstrating the depth and breadth of research in this domain. In the fields of MTPE, academic circles are showing a vigorous development trend. Regarding machine translation, academic studies have covered various aspects, including current status, prospects, corpus applications, MT quality, and computer-aided translation (CAT), with an emphasis on post-editing and the enhancement of translation quality.

In terms of post-editing, academic circles primarily focus on studies on an overview of PE, its applications in translation practices, and the cultivation of translators' capabilities,

while paying relatively little attention to the development and application of PE tools. Through reviewing literature on the translation of petroleum science and technology texts, machine translation, and post-editing, the author observes that although these research areas are all flourishing domestically, there are relatively few studies combining machine translation and post-editing with the translation of petroleum science and technology texts. Therefore, this study explores the translation of petroleum science and technology texts under the MTPE model, aiming to provide new perspectives and methods for translation studies in the petroleum field and promote the interdisciplinary development of translation studies.

3. Theoretical Framework

The main guiding theory of this paper is the text typology theory of Reiss. Under the guidance of this theory, the author analyzes the results of machine translation and proposes post-editing methods suitable for petroleum science and technology texts.

3.1. Introduction to Text Typology Theory

In the field of translation studies, the text typology theory refers to the framework concerning text types, language functions, and translation strategies first proposed by Katharina Reiss, a representative of the German functionalist school, in her book *Translation Criticism: The Potentials & Limitations* (as cited in Zhang Meifang, 2009[60]). The proposition of this theory not only opens up new perspectives for translation studies but also provides theoretical guidance for translators in practical translation processes. This theory challenges and transcends traditional translation theories, which often prioritize the source language and emphasize principles of faithfulness and fluency. Reiss, adopting a functionalist perspective, places greater emphasis on the purpose and effect of translation. She argues that translation is not merely a linguistic conversion but the realization of textual functions and communicative purposes. Therefore, during the translation process, translators need to select appropriate translation strategies and methods based on the text type and its functions.

Reiss's text typology theory is grounded in the categorization of the three functions of language proposed by German psychologist and functional linguist Karl Bühler (as cited in Zhang Meifang, 2009[60]). In 1934, Bühler introduced the "instrumental model" of language functions, encompassing four components: (1) signs, (2) context, (3) speakers, and (4) addressees. The sign, as language, derives its function from its relationship with other elements. For instance, the relationship between signs and context (i.e., the objective world) is termed "representational"; between signs and speakers, it is "expressive"; and between signs and addressees, it is "appellative". Based on these components and their interrelations in the "instrumental model", Bühler identified three language functions: informative, expressive, and appellative. This framework has inspired subsequent scholars, including Roman Jakobson's theory of language functions, M.A.K. Halliday's three metafunctions of language, and Peter Newmark's "language functions and text types" (as cited in Zhang Meifang, 2009[60]). Furthermore, Reiss's student Hans Vermeer developed the Skopos Theory based on her text typology, exerting a profound influence on the entire functionalist translation theory.

3.2. Text Types and Functions

Reiss categorizes texts into three main types based on their primary functions: informative, expressive, and operative. Each text type embodies specific functions and communicative purposes, exerting decisive influence on the selection of translation strategies and methods.

Informative texts primarily convey facts, information, knowledge, or viewpoints. Their language features include strong logical coherence, prominent content focus, and relatively secondary formal structure. Common examples include news reports, business correspondence, inventories, user manuals, patent descriptions, official documents, and specialized literature in humanities, natural sciences, and technical fields. When translating such texts, accuracy and completeness of information must be prioritized, while maintaining logical clarity and fluency. Translators should convey concepts identically to the source text through plain, concise language. Specific methods involve: precise translation of terminology, clarification of contextual meanings for common words, supplementation of implicit information, resolution of metaphorical imagery, restoration of synonymous expressions, addition of cohesive devices to clarify implicit logic, and adherence to norms and conventions of the target language.

Expressive texts convey the information sender's emo-

tions and attitudes toward people or objects. The language of these kinds of texts emphasizes aesthetic characteristics, with the author's or sender's style and form of expression becoming focal points. Genres include essays, biographies, belles-lettres, novels, and various poetic works. Translating these texts requires an imitation approach that faithfully reproduces the original's aesthetic and artistic form. This requires the translator not only to accurately understand the content and emotion of the original text, but also to find the corresponding expression in the target language, so as to realize the similarity between the translation and the original text in aesthetic effect.

Operative texts aim to persuade or induce readers to take specific actions. This kind of text is reader-oriented and effect-oriented, and the language form usually has the nature of dialogue. Common examples include advertisements, political speeches, and closing arguments in legal settings. Translating such texts requires adaptation or compilation methods to achieve a persuasive impact. This demands not only accurate information transfer but also cultural adaptation and linguistic polishing based on the target readers' background and reception habits, ensuring the translation produces the intended response among the readers.

The petroleum science and technology text is a typical informative text, whose core function is to convey facts, knowledge and technical information. The principles of accuracy, fluency and logicality should be taken into consideration in translation. Therefore, the translator should pay special attention to these points in post-editing to avoid information distortion, so as to produce a better post-editing translation.

4. Machine Translation Problems

This paper selected the highly cited 2024 article *Synthetic polymers: A review of applications in drilling fluids* from the authoritative petroleum journal *Petroleum Science*, which is recognized as a top-tier journal by institutions including SCI and EI, as the translation material. The article is in English, with a total of 22,695 words. This article, characterized by its abundance of professional terminology, numerical data, and complex sentences, is concise and clear in its language with a logical structure, making it a typical informative text. The translator adopted a human-machine collaboration model, using SDL Trados Studio 2024 as the machine translation platform. After importing the termbase, the text underwent initial machine translation. It was found that while the machine system generally conveyed the meaning of the text, numerous problems remained.

Based on the manual comparative review, during the post-editing of 1142 machine-translated sentences, it was discovered that problems occurred at the lexical, syntactic, and symbolic levels, accounting for 14.6%, 7.7%, and 2.4% of the total problems, respectively. Contextual analysis revealed that problems accounted for 2.9% of the total at the textual level. Furthermore, when performing the human post-editing on the 21 images from the original text, problems at the graphical level occurred at a rate as high as 95.2%. The detailed percentages are illustrated in **Table 1** below.

Table 1. The Percentage of Problems at Each Level of Machine Translation.

Level	Problem	Percentage
Lexical Level	Lexical Mistranslation	5.6%
	Incorrect Part-of-Speech	4.6%
	Lexical Omission	3.9%
	Lexical Redundancy	0.5%
Syntactic Level	Structural Segmentation Error	3.1%
	Inflexible Voice Conversion	4.1%
	Ambiguous Reference	0.5%
Textual Level	Ambiguous Reference	1.2%
	Poor Cohesion	1.3%
	Semantic Repetition	0.4%
Symbolic Level	Data Unit Symbol Error	0.5%
	Punctuation Error	0.4%
	Format Symbol Error	1.5%
Graphical Level	Incomplete Content, Disordered Layout, Impaired Image Quality	95.2%

5. Post-Editing Methods

To address the problems of machine translation mentioned above, this section will explore corresponding post-editing methods through specific case studies across lexical, syntactic, textual, symbolic, and graphical levels. The aim is to produce higher-quality translations. After the review by the supervisor and the industry expert, the post-editing results of all cases have a certain guarantee.

5.1. Lexical Level

Problems at the lexical level mainly include lexical mistranslation, incorrect part-of-speech, lexical omission and lexical redundancy. Based on these types of problems, the author summarizes the following specific post-editing methods.

5.1.1. Vocabulary Verification

Scientific and technical texts contain numerous specialized terms and common words with specific meanings. The meanings of specialized terms are generally concise and relatively fixed, whereas common words with specific meanings are primarily characterized by polysemy[61]. To address these two types of vocabulary, translators can employ a combination of online dictionaries and search engines to verify terms and determine their accurate meanings.

[Eg 1]
Source Text (ST): Specifically, in terms of environmental impacts, because SBDF is less toxic, achieves fast penetration rates, results in less fluid-related nonproductive time, and degrades faster than diesel and mineral oils. (P2)
Machine Translation (MT): 具体来说，就环境影响而言，由于 SBDF 毒性较小，渗透率较快，与流体相关的非生产时间较少，并且降解速度比柴油和矿物油更快。
Post-Editing (PE): 具体来说，就环境影响而言，SBDF 具有多重优势。首先，其毒性较低；其次，钻进速度较快，从而减少了因流体问题导致的非生产时间；最后，其降解速度比柴油和矿物油更快。

A search on the termOnline platform shows that "penetration rates" has two domain-specific meanings: 机械钻速 and 渗透率. When translated as 渗透率, it is typically associated with journalism and communication studies. However, in the petroleum or drilling industry, "penetration rates" usually refer to the mechanical drilling speed, i.e., the depth drilled by the bit per unit of time. Therefore, modifying the translation to 钻进速度 better aligns with the term's meaning in petroleum-related texts.

5.1.2. Conversion of the Part-of-Speech

Due to the lack of human cognitive abilities, machine translation systems often struggle to accurately recognize and flexibly perform part-of-speech conversion. With nouns being more frequent in English and verbs being more prevalent in Chinese[5], post-editing requires careful consideration of the contextual meaning to select the most appropriate part of speech. Skillful part-of-speech conversion can further enhance the readability and fluency of the translation.

[Eg 2]
ST: Such dynamics involve a more complex range of sub-surface conditions now being associated with productive formations. (P2)
MT: 这种动态涉及现在与生产性地层相关的更复杂的地下条件范围。
PE: 这种动态变化导致与油气层相关的地下条件变得更加复杂。

In terms of part of speech, "complex" can function both as an adjective meaning 复杂的 and as a noun referring to a 复合物 or 复杂系统. The machine translation output 复杂的, using it as an adjective to modify 地下条件范围, is not grammatically incorrect but sounds unnatural, as 复杂 should modify 地下条件 rather than 范围. During the human post-editing, it is rephrased as 变得..... 复杂, treating 复杂 as a complement to reflect a dynamic process, resulting in a smoother and more understandable translation.

5.1.3. Amplification

Amplification of words usually occurs when machine translation omits words, primarily for two reasons: first, the omission of vocabulary is a highly professional term or abbreviation, which is not included in the dictionary of the knowledge base of machine translation; second, the machine system itself malfunctions. During human post-editing, it is necessary to add the missing vocabulary, ensuring that the supplemented terms align with the context and semantics of the original text to avoid introducing new errors or ambiguities.

[Eg 3]
ST: Mass radical polymerization, also known as bulk polymerization, is a method of synthesizing polymers in the absence of a solvent. (P9)
MT: 本体聚合，也称为本体聚合，是一种在不存在溶剂的情况下合成聚合物的方法。
PE: 本体自由基聚合，也称为本体聚合，是一种在不存在溶剂的情况下合成聚合物的方法。

Through the pre-established translation termbase, it is known that "radical polymerization" refers to 自由基聚合. The machine translation engine fails to accurately recognize this term and does not apply its correct translation in the output. Furthermore, when searching the term 本体聚合 on the termOnline platform, only the expressions "mass polymerization" and "bulk polymerization" are retrieved. The machine translation omits part of the original text's information. Therefore, during the human post-editing, the translation of "radical" is added, rendering the term as 本体自由基聚合.

5.1.4. Omission

When the machine translation uses too many or unnecessary words, resulting in duplication of information or lengthy expression, the translator can choose to delete them from the translation, but to ensure the semantic integrity and accuracy of the translation, avoid the change of sentence meaning or the loss of information due to the deletion of words, and pay attention to maintaining the smoothness of the translation. In the process of this translation practice, such problems appear less frequently.

[Eg 4]
ST: The term "drilling fluid" has evolved over time, along with the operationally synonymous reference to "drilling mud", "drilling fluid". (P1)
MT: 随着时间的推移，术语 "钻井液" 与操作上同义的提及 "钻井泥浆"、"钻井液" 一起演变。
PE: 随着时间的推移，"钻井液" 这一术语逐渐发展，与之操作上同义的还有 "钻井泥浆" 等表述。

In this example, the English source text primarily explains "drilling fluid". The machine system translates the second occurrence of "drilling fluid" again as 钻井液. While consistent with the preceding text, this feels repetitive in the Chinese context. The second occurrence mainly serves to emphasize its correspondence with synonymous terms rather than to redefine it. Therefore, during the post-editing, it is revised to 等表述, encompassing synonyms such as 钻井液 and 钻井泥浆. This approach avoids redundancy, preserves the original meaning, and results in a smoother, more comprehensible translation.

5.2. Syntactic Level

Problems at the syntactic level mainly include structural segmentation error, inflexible voice conversion and ambiguous reference. Based on these types of problems, the author summarizes the following specific post-editing methods.

5.2.1. Clarification of the Sentence Structure

Machine translation systems often struggle with complex sentences containing multiple layers of nesting and modification, frequently failing to accurately identify and translate modifying elements. During human post-editing, it is necessary to carefully analyze the sentence structure and refine the translation based on context and target language conventions to ensure both accuracy and fluency.

[Eg 5]
ST: Salt contamination plays a very important role in determining SP performance and can lead to a rapid degeneration of rheological properties and reduced tolerance to temperature of SP used in drilling fluids. (P18)
MT: 盐污染在确定 SP 性能中起着非常重要的作用，并且可以导致流变特性的快速退化和用于钻井液中的 SP 对温度的耐受性降低。
PE: 盐污染在确定 SP 性能中起着非常重要的作用，并且会导致钻井液中 SP 的流变性能迅速恶化，且耐温性降低。

The challenge in this sentence lies in determining whether the prepositional phrase "of SP used in drilling fluids" simply modifies "rheological properties" or "reduced tolerance to temperature" individually, or simultaneously modifies both phrases as a common modifier. By referring to the original text, it becomes clear that "of SP used in drilling fluids" modifies both phrases. The post-edited result reflects this relationship, enabling more accurate information

conveyance.

5.2.2. Voice Conversion

When processing texts, machine systems tend to overrely on grammatical rules and lexical matching while neglecting the influence of context on voice selection. When the voice in the source text contradicts the target language readers' reading conventions, machines often fail to make appropriate adjustments. During human post-editing, special attention should be paid to voice conversion, making flexible adaptations based on context and expressive needs to ensure translation accuracy and readability.

[Eg 6]
ST: Their size and chemical composition can be adjusted to provide properties for nearly all sub-surface functional objectives. (P2)
MT: 它们的尺寸和化学成分可以被调节，以提供几乎所有地下功能目标的特性。
PE: 其大小和化学成分均可调节，以满足几乎所有地下功能目标所需的特性。

The machine translation 可以被调节, while grammatically correct, does not align with the preferred style of Chinese technical texts. Chinese often avoids passive constructions, typically using active voice or adjusted word order for a more natural expression. The post-edited version 均可调节 results in a more concise and fluent translation that better conforms to Chinese conventions.

5.2.3. Identification of Reference

Machine systems often struggle to accurately comprehend referential relationships within source texts, particularly in complex contexts or lengthy sentences. Unclear references not only hinder readers' comprehension but may also lead to ambiguity or misinterpretation. During the human post-editing, special attention must be paid to referential relationships in the original text to ensure every pronoun or referential element in the translation has a clearly identifiable antecedent.

[Eg 7]
ST: Diluting the drilling fluid with water or another compatible fluid can help to reduce the concentration of incompatible additives and improve performance. (P17)
MT: 用水或另一兼容容流体稀释钻井液可有助于降低不兼容添加剂的浓度并改善性能。
PE: 用水或另一兼容流体稀释钻井液可有助于降低不兼容添加剂的浓度并改善钻井液性能。

While 改善性能 is a correct translation of "improve performance", the reference remains unclear. Readers cannot determine whether it refers to the performance of the drilling fluid or the drilling process. Contextual analysis confirms that it refers specifically to "the performance of the drilling fluid". Through the human post-editing, the addition of the qualifier 钻井液 eliminates the referential ambiguity present in the machine translation, resulting in a clearer, more precise expression that avoids potential misunderstanding.

5.3. Textual Level

Problems at the textual level mainly include ambiguous reference, poor cohesion, and semantic repetition. Based on these types of problems, the author summarizes the following specific post-editing methods.

5.3.1. Identification of Reference

Unclear reference is a common problem in translation at the textual level, particularly when dealing with pronouns or elliptical structures. If the referential relationship is ambiguous, readers may struggle to accurately understand the connections between different components of the sentence, potentially leading to misinterpretation or vague information transmission. During human post-editing, it is essential to identify the reference based on the contextual meaning, effectively enhancing the clarity and logical coherence of the translation.

[Eg 8]
ST: SPs may display a variety of molecular weights until they are purified. Various approaches used to determine SP molecular weight result in various averages. The number-average and weight-average molecular weights are the two most widely referred to. The molecular weight of the SP directly affects the magnitude of the intermolecular interaction forces. Therefore, the higher it is, the more difficult it is to dissolve the SP. (P6)
MT: SPs 可以显示多种分子量，直到它们被纯化。用于测定 SP 分子量的各种方法导致不同的平均值。数均分子量和重均分子量是

最广泛提及的两种。SP 的分子量直接影响分子间相互作用力的大小。因此，越高，SP 越难溶解。
PE: 在纯化之前，SPs 可能显示多种分子量。用于测定 SP 分子量的方法各异，所得的平均值也有所不同。数均分子量和重均分子量是最广泛提及的两种。SP 的分子量直接影响分子间相互作用力的大小。因此，分子量越高，SP 越难溶解。

The machine system directly translates the last sentence of the original text as 因此, 越高, SP 越难溶解, but fails to explain the pronoun "it", leaving readers confused. During the human post-editing, by analyzing the specific context, it is revised to 分子量越高, clearly identifying the referent of "it". This modification strengthens the internal coherence of the text, facilitating better comprehension for readers.

5.3.2. Addition of Logical Connectors

Cohesion is a key characteristic of paragraphs and texts, forming the core of discourse studies[62]. Poor cohesion can make a translation appear disjointed or even fragmented, hindering readers' understanding of the overall content. Adding logical connectors is an important strategy for addressing cohesion issues, making the translation more fluid and natural.

[Eg 9]
ST: Many monomers that are commonly used to synthesize polymers are extremely expensive, such as DMDAAC. Some monomers are inexpensive, such as AMPS, AM, and SSS. More effort is required to develop and utilize these lower-cost monomers in SP synthesis. (P37)
MT: 许多常用于合成聚合物的单体极其昂贵，例如 DMDAAC。一些单体是廉价的，例如 AMPS、AM 和 SSS。在 SP 合成中开发和利用这些低成本单体需要更多的努力。
PE: 许多常用于合成聚合物的单体极其昂贵，例如 DMDAAC。而有些单体则相对便宜，例如 AMPS、AM 和 SSS。因此，在合成 SP 时，需要加大力度开发和利用这些低成本单体。

The machine translation lacks tight inter-sentential cohesion, appearing abrupt. The first and second sentences lack a contrasting relationship, while the third sentence suddenly introduces the need for more effort without explaining its connection to the preceding text. During the human post-editing, the character 而 is added between the first and second sentences, and the logical connector 因此 is inserted before the third sentence. This adjustment clarifies the logic, improves textual coherence, and significantly enhances the quality and readability of the translation.

5.3.3. Appropriate Use of Pronouns

When the source text contains redundant information or repetitive expressions, literal translation may result in wordy and verbose output, reducing reading efficiency. During the post-editing, it is necessary to carefully review both the source and target texts to ensure concise and efficient information delivery. The appropriate use of pronouns can make the translation more concise while preserving the completeness of the original meaning.

[Eg 10]
ST: SPs are obtained primarily from petroleum products. Unlike natural and modified natural polymers, SPs tend to be built from relatively small molecules. SPs provide almost unlimited flexibility in their design. (P2)
MT: SPs 主要从石油产品中获得。与天然和改性天然聚合物不同，SP 往往由相对小的分子构建。SP 在设计上提供了几乎无限的灵活性。
PE: SPs 主要从石油产品中获得，与天然和改性天然聚合物不同，它往往由相对小的分子构建而成，在设计上提供了几乎无限的灵活性。

In the machine translation, the three clauses repeatedly use "SPs" as the subject, appearing mechanical and redundant, which reduces the information density of the discourse. During the human post-editing, they are consolidated into a single sentence, replacing the repeated "SPs" with the pronoun 它. This approach maintains the subject consistency (the full form is retained in the first clause to ensure terminological clarity) while using the anaphoric function of 它 to eliminate the redundant reference. This treatment results in more natural sentence cohesion, more coherent and concise expression, and improves comprehensibility.

5.4. Symbolic Level

Problems at the symbolic level mainly include three types of symbol errors, namely data unit symbols, punc-

tuation marks, and format symbols. Based on these types of problems, the author summarizes the following specific post-editing methods.

5.4.1. Verification of Data Unit Symbols

Incorrect or inconsistent use of data unit symbols in texts may lead to misinterpretation of data by readers, thereby compromising the accuracy and reliability of the information. During post-editing, it is crucial to verify the accuracy and consistency of data unit symbols to prevent semantic deviation from the original text caused by such errors.

[Eg 11]
ST: Auxiliary treatment agents, such as 2 wt% organic clay, 1.5 wt% wetting agent, and 1.5 wt% CaO, were added sequentially, followed by the addition of 35 wt% and 85 wt% barite to create SBDF with two different densities. (P17)
MT: 依次加入辅助处理剂，如 2 重量%有机粘土、1.5 重量%润湿剂和 1.5 重量%CaO，然后加入 35 重量%和 85 重量%重晶石以产生具有两种不同密度的 SBDF。
PE：依次加入辅助处理剂，如 2 wt%有机粘土、1.5 wt%润湿剂和 1.5 wt%氧化钙，然后加入 35 wt%和 85 wt%重晶石，以产生具有两种不同密度的 SBDF。

The machine system translates “wt%” as 重量%, which is an unprofessional expression. Research indicates that “wt%” stands for “weight percent”, representing the weight proportion of a substance in a mixture. However, in the petrochemical field, the abbreviation “wt%” is conventionally retained and not translated as 重量%. Therefore, during the human post-editing, the professional abbreviation “wt%” is preserved.

5.4.2. Punctuation Correction

Punctuation marks are the most common symbols in various texts. Their misuse not only affects the aesthetic quality of the text but may also cause ambiguity in readers’ interpretation of sentences. During the post-editing, close attention should be paid to the punctuation marks in both the source and target texts, selecting those appropriate for the target language to avoid mixing Chinese and English punctuation, which could undermine the text’s professionalism.

[Eg 12]
ST: Polymerization consists of combining homogeneous (or heterogeneous) monomers with the subsequent formation of a new high-molecular weight substance - polymer (without releasing any by-products). (P7)
MT: 聚合包括将均相 (或非均相) 单体组合，随后形成新的高分子量物质-聚合物 (不释放任何副产物)。
PE: 聚合包括将均相（或非均相）单体组合，随后形成新的高分子量物质——聚合物（不释放任何副产物）。

In the example above, the machine translation retains English half-width parentheses, whereas Chinese typically uses full-width parentheses to maintain layout harmony and visual appeal. Similarly, using short dash “-” instead of a dash does not conform to Chinese typesetting standards. In Chinese, dashes are usually represented by two short dashes “——” to indicate a change in topic or tone, or to provide additional explanations for the preceding text. During the post-editing, the translator fully follows Chinese typesetting habits and correctly uses parentheses and dashes, making the entire sentence clearer and more standardized.

5.4.3. Unification of Format Symbols

Format symbol errors primarily involve issues related to symbol usage in text layout and formatting. Machine translation frequently encounters problems when handling such symbols. During the human post-editing, the format symbols in the translation should be aligned with the conventions of the target language to ensure smoother and more coherent output.

[Eg 13]
ST: (xi) surfactants such as fatty alcohol ether sulfate or alkyl ether sulfate. (P14)
MT: （ ）表面活性剂如脂肪醇醚硫酸盐或烷基醚硫酸盐。
PE: （十一）表面活性剂，如脂肪醇醚硫酸盐或烷基醚硫酸盐。

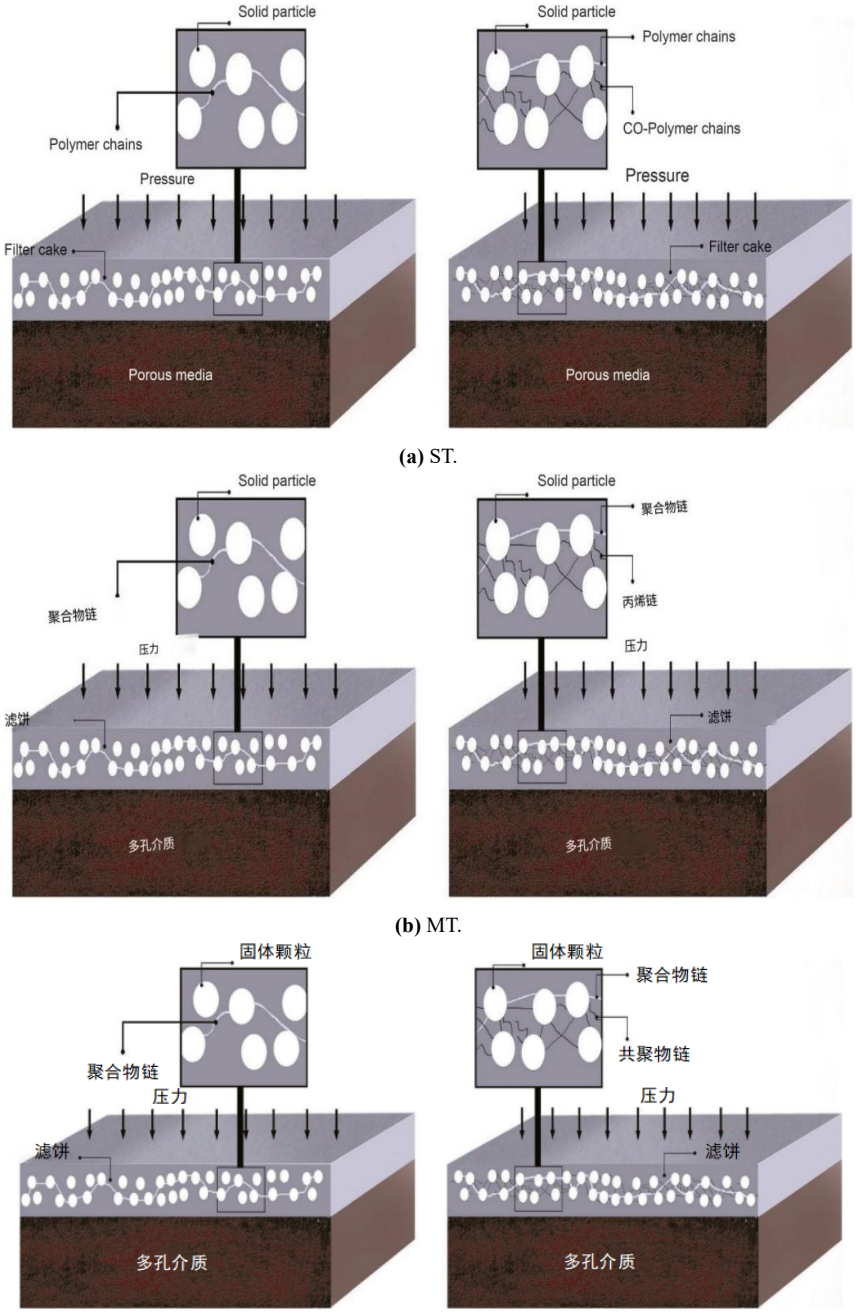
In this sentence, the machine translation omits the format symbol “xi”, leaving only a half-width space. When the original text uses Roman numeral identifiers, the translation should replace them with Chinese sequencing notation. Consequently, during the human post-editing, “(xi)” is re-

placed with （十—） , making the translated format more standardized.

5.5. Graphic Level

Although Trados is a powerful tool, it can only process plain text and cannot translate text embedded within images. Furthermore, the output from currently available image translation software cannot be directly post-edited. During the human post-editing, the translator first uses Photoshop to meticulously process the image, removing the original textual information. Subsequently, WPS software is used to accurately embed the post-edited text into the image, thereby generating the final edited graphic (see **Figure 1**).

[Eg 14]



(a) ST.

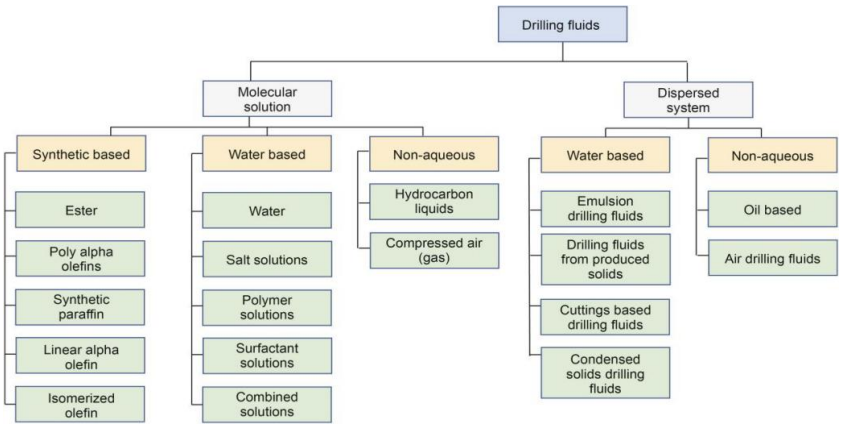
(b) MT.

(c) PE.

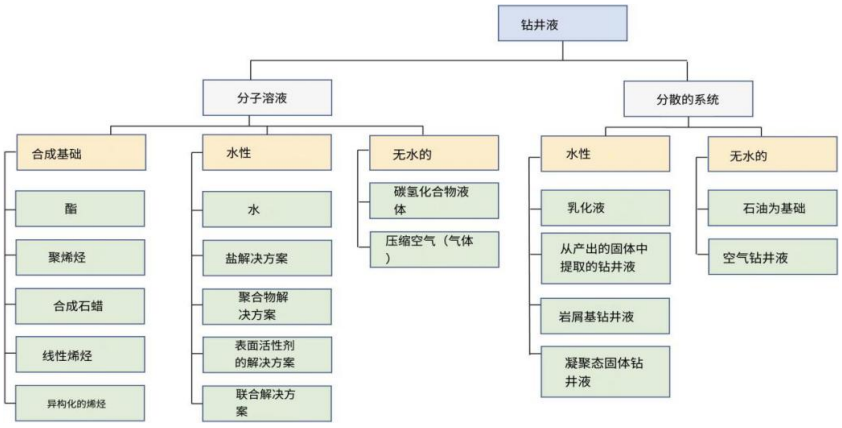
Figure 1. Comparison of ST, MT, and PT in Eg 14.

A comparison between the original image and the machine-translated version reveals three main problems with the machine output: first, partial content is omitted, resulting in incomplete information; second, it lacks aesthetic appeal, missing the artistic effects of the original; third, non-textual parts of the image are damaged, compromising its integrity. During the human post-editing, the translator not only completes the missing translations but also utilizes the professional image processing technique to enhance the visual quality and repair damaged sections, ensuring the translated image matches the original in both content and visual effect (see **Figure 2**).

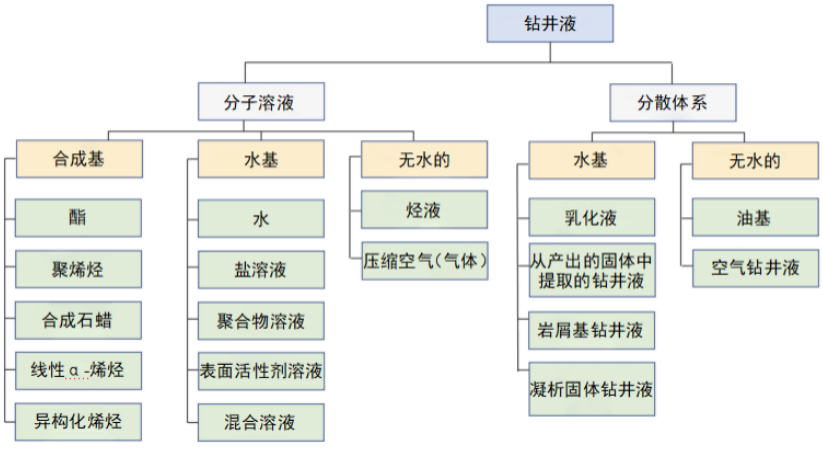
[Eg 15]



(a) ST.



(b) MT.



(c) PE.

Figure 2. Comparison of ST, MT, and PT in Eg 15.

When comparing the original and machine-translated images, the translator finds a key issue: the machine-translated one fails to keep the centered text alignment of the source and has some translation inaccuracies. The original has meticulously centered texts for balance and to show typographic precision. But the machine-translated version disrupts the visuals and may affect comprehension. So, the translator uses image editing software in post-editing to re-align texts and ensure accuracy, restoring style and improving appeal and readability, considering both translation quality and aesthetics.

6. Conclusions

Taking the Chinese translation project of excerpts from *Petroleum Science* as an example, this study combines concrete case analysis to systematically categorize machine translation errors at lexical, syntactic, textual, symbolic, and graphical levels, while proposing corresponding post-editing methods. The research finds that although machine translation has improved the efficiency of translating petroleum science and technology texts to some extent, significant limitations in translation quality remain, making post-editing indispensable. Translators must continuously enhance their translation proficiency to accurately identify errors in machine-generated translations and implement appropriate revisions. By adopting a human-machine collaboration approach, the ultimate goal is to consistently produce higher-quality translations.

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Q.Z. was responsible for writing the article and made revisions and polishing based on H.T.'s suggestions. Both authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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