



TRANSLATING THERMODYNAMIC TERMINOLOGY: A CASE STUDY OF FRANK WHITE'S FLUID MECHANICS

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ABSTRACT/ABSTRAK

This study extends preliminary findings on semantic aspects in translating thermodynamic terminology from English to Indonesian in Frank White's Fluid Mechanics textbook. Specialized terminology translation poses unique challenges related to meaning equivalence across languages. This expanded analysis employs qualitative content analysis to examine semantic categories in greater depth. Data were collected from the glossary of thermodynamic terms in the original English edition (1998) and its Indonesian translation (2001). The analysis classified semantic meanings into lexical, grammatical, contextual, socio-cultural, and textual categories. The results show that lexical, grammatical, and textual meanings predominantly appear in the translation process, reflecting the challenges and strategies in conveying specialized scientific terminology.

Penelitian ini memperluas temuan awal tentang aspek semantik dalam penerjemahan terminologi termodinamika dari bahasa Inggris ke bahasa Indonesia dalam buku Fluid Mechanics karya Frank White. Penerjemahan terminologi khusus menghadirkan tantangan unik terkait kesetaraan makna antar bahasa. Analisis yang diperluas ini menggunakan analisis isi kualitatif untuk mengkaji kategori makna semantik secara lebih mendalam. Data dikumpulkan dari glosarium istilah termodinamika pada edisi asli berbahasa Inggris (1998) dan terjemahannya dalam bahasa Indonesia (2001). Analisis mengklasifikasikan makna semantik ke dalam kategori makna leksikal, gramatikal, kontekstual, sosio-kultural, dan tekstual. Hasil penelitian menunjukkan bahwa makna leksikal, gramatikal, dan tekstual mendominasi dalam proses penerjemahan, mencerminkan tantangan dan strategi dalam menyampaikan terminologi ilmiah khusus.

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1. INTRODUCTION

Translation is the process of transferring messages from a source language (SL) into a target language (TL), with the primary focus on conveying meaning rather than a literal word-for-word translation. For example, translating from English into Indonesian requires finding equivalent terms that maintain the original meaning (Al-Sulaimaan & Khoshaba, 2018). Translation, as defined by Al-Sulaimaan and Khoshaba (2018), is "the replacement of textual material in one language by equivalent textual material in another language," emphasizing meaning rather than direct substitution. This process becomes particularly challenging when dealing with specialized languages, like thermodynamics, which contain highly specific concepts and terminology (Castellví, 2003). Terminology, as explained by Sageder (2010), refers to a set of specialized terms used within a particular field, reflecting the domain's knowledge.

This study addresses a gap in research regarding the semantic translation of thermodynamic terms in engineering textbooks, focusing on the Indonesian translation of Frank White's *Fluid Mechanics* and its Indonesian counterpart, *Mekanika Fluida*. While the Indonesian version is based on the first edition (1988), the English edition has gone through several updates. This discrepancy leads to issues such as outdated terminology, inconsistencies, and ambiguities in the translation, which require continued scholarly attention (Farahsani, 2022).

Translation involves much more than just transferring individual words. It encompasses converting linguistic elements—from single words to complex discourses—into another language while ensuring that the text is readable and understandable. For high-quality translation, linguistic knowledge in areas like morphology, syntax, and semantics is essential to minimize ambiguity (Sriyono, 2018). As Károly (2014) states, solving translation challenges often requires understanding both the structural and functional aspects of language. Linguistics plays a vital role in translation studies, supporting translation practices by providing insights into the deeper structure of language, which enhances translation quality.

Semantics is a critical component in the process of interpreting meaning in translation. According to Rakhimova and Khujaniyazova (2024), meaning can be understood at various levels—lexical, conceptual, and contextual. Bufacchi (2021) suggests that meaning is "behind words," and Rosso, Dekas, and Wrzesniewski (2010) emphasize that words can have multiple interpretations. This study builds upon Farahsani's (2022)

application of Pelawi's (2009) semantic framework and incorporates recent perspectives from Franco and Galvis (2013) and Ho and Woon (2007), who stress the importance of socio-cultural and contextual dimensions in specialized translation. Although Farahsani (2022) identified that idiomatic and socio-cultural meanings were largely absent in thermodynamic terms, this study aims to explore whether this pattern holds across different translation contexts and analyze the theoretical implications of these findings.

Several studies have examined semantics in translation. Pelawi (2009) proposed a framework consisting of six categories of meaning: lexical, grammatical, contextual, textual, socio-cultural, and idiomatic. Farahsani (2022) adopted this framework for analyzing Fluid Mechanics. Meanwhile, Aijmer and Simon-Vandenberg (2004) studied semantic and pragmatic shifts in English-Dutch translation, identifying shifts like implication, explicitation, and thematic role changes. This study diverges from Farahsani's (2022) research in three key ways: (1) it integrates recent theoretical perspectives on cultural semantics from Rakhimova and Khujaniyazova (2024) and Tiu et al. (2023), (2) it offers a more systematic analysis of translation strategies beyond simple categorization, and (3) it explicitly addresses the methodological limitations in Farahsani's study and suggests directions for future research.

When analyzing word meanings, it is crucial to distinguish between denotative (literal) and connotative (associated) meanings (Testa, 2024). Hox and Boeijs (2005) also refer to these as primary and secondary meanings, where primary meanings are the direct associations a word evokes, and secondary meanings depend on context. In this study, the focus is on the semantic analysis of specialized thermodynamic terms in White's Fluid Mechanics and its Indonesian translation, *Mekanika Fluida*. This research narrows the scope to domain-specific terminology and categorizes it based on types of semantic meaning. The study extends Farahsani's (2022) preliminary research by providing more comprehensive theoretical grounding, deeper analysis, and critical reflection on the challenges of translating specialized terminology. By systematically categorizing semantic meanings and examining their implications, this study contributes to the advancement of translation studies and pedagogical applications in technical translation education.

2. RESEARCH METHODS

This research uses qualitative content analysis to examine semantic patterns in thermodynamic terminology translation (Farahsani, 2022; Selvi, 2019). A qualitative approach allows for an in-depth exploration of meaning categories without statistical generalization (Sari & Bogdan, 1992). The research questions are:

- Which semantic meaning types characterize thermodynamic terminology translation from English to Indonesian?
- How do these semantic patterns manifest in the Indonesian version of White's Fluid Mechanics?

The data sources are the English edition of *Fluid Mechanics* (White, 1986) and its Indonesian translation, *Mekanika Fluida* (White, 1988). Despite newer English editions, the 1988 Indonesian translation remains widely used in Indonesian universities, justifying its selection. This study reexamines 514 thermodynamic terms from the original analysis by Farahsani (2022). Semantic meanings are categorized based on the frameworks of Pelawi (2009) and Ho & Woon (2007), which classify meanings as lexical, grammatical, contextual, socio-cultural, and textual. This framework provides the basis for analyzing how meaning operates at different linguistic levels in translation.

As Sari and Bogdan (1992) note, qualitative research produces descriptive data, often from smaller sample sizes, without requiring population representation. The study focuses on selected thermodynamic terms, analyzing their semantic features. Data collection involved comparing the English and Indonesian terms, recorded using Mahsun's (2005) note-taking technique. Analysis included: (1) semantic categorization, (2) pattern identification, and (3) theoretical interpretation. This three-stage process builds on Farahsani (2022) with added depth through comparative and interpretive analysis.

3. FINDING DISCUSSION

Based on the various perspectives discussed earlier, issues of meaning in translation can be classified into six categories: lexical meaning, grammatical meaning, contextual or situational meaning, textual meaning, sociocultural meaning, and idiomatic meaning. However, after analyzing the *Fluid Mechanics* textbook and identifying 514 thermodynamic

terms, the researchers found that only three types of semantic meaning were present in the translated terminology: (1) lexical meaning, (2) grammatical meaning, and (3) textual meaning. This section extends Farahsani's (2022) preliminary categorization by providing more detailed analysis of each category, examining translation patterns, and discussing theoretical implications not addressed in the earlier study.

3.1 Lexical Meaning

Lexical meaning typically refers to the standard or dictionary definition of a word—its independent, inherent meaning. For instance, the word “*sentence*” may refer to either a *group of words* or a *punishment*, as both meanings exist independently and are not shaped by broader context. In such cases, external factors have minimal influence on interpretation. According to Jackson and Amvela (2007), lexical meaning—derived from the term *lexicon*, meaning *word*—is the type of meaning commonly found in general dictionaries. In the translation of thermodynamic terms from the *Fluid Mechanics* and *Mekanika Fluida* books, several terms have been translated based on this type of meaning. The following are examples of translations that reflect lexical meaning:

(1) SL: We do not build a million-dollar airplane and see whether it has enough lift force.

TL: Kita tidak membangun pesawat udara seharga satu milyar rupiah untuk melihat apakah pesawat itu memiliki gaya bubung yang cukup.

(2) SL: Since the block sides are unsupported, element A has zero stress on the left and right sides and compression stress...

TL: Karena balok itu bebas, unsur A tidak mengalami tegangan pada sisi dan sisi kanannya, sedang sisi atas dan sisi bawahnya mendapat tegangan mampatan...

(3) SL: If the control volume is moving uniformly at velocity ..., an observer fixed to the control volume will see a relative velocity ... of fluid crossing the control surface, ...

TL: Kalau volume kendali itu bergerak dengan kecepatan tetap ..., seorang pengamat yang diam terhadap volume kendali itu akan melihat kecepatan nisbi ... dari fluida yang melintasi permukaan kendali, ...

From the examples above, it can be seen that the translator of the *Fluid Mechanics* book tends to render thermodynamic terms using a lexical approach. For instance, the term “*force*” is defined in scientific contexts as a measure of influence that causes a change in motion. In Indonesian, it is translated as “*gaya*”, which means “a push or pull that moves an

unbound object." Here, there is a clear equivalence between the source language (SL) and target language (TL), as the translation reflects the dictionary meaning without being influenced by context. Even when the term is interpreted in isolation, its meaning remains consistent. Similarly, the word "*boundary*" is translated as "*batas*", meaning "a line or edge that marks the limit of a space or area; a separator between two regions." Another example is "*velocity*", which refers to the speed of an object's movement. It is accurately translated as "*kecepatan*", maintaining semantic alignment between SL and TL.

3.2 Grammatical Meaning

Grammatical meaning is shaped by the structure or form of the sentence in which a word appears. For example, the word "*sentence*" carries different meanings in the phrases "It is an active sentence" and "At least a sentence provides subject and predicate", compared to its use in "The sanction can be a fine, a jail sentence, or both." This shows that meaning can shift depending on grammatical context. Grammatical meaning arises from the arrangement of words, phrases, clauses, or sentences. For instance, in Indonesian, the words "*meminjam*" and "*meminjamkan*" translated in English as "*to borrow*" and "*to lend*" convey different meanings due to the addition of affixes Jackson and Amvela (2007). In the context of thermodynamics terminology, certain terms carry grammatical meanings based on their word class. Below are examples of terms that illustrate grammatical meaning:

(4) SL: Thus, a seemingly complicated pressure-force problem can be simplified by subtracting any convenient uniform pressure ... and working only with the pieces of gage pressure which remain, as ...

TL: Jadi, soal gaya tekanan yang kelihatannya sulit dapat disederhanakan dengan mengurangi sembarang tekanan seragam ... dan hanya menggarap tekanan tolok (gage) yang tersisa saja...

(5) SL: Fourth, if heat ... is added to the system or work ... is done by the system, the system energy ... must change according to the energy relation, or first law of thermodynamics.

TL: Keempat, kalau kalor ... ditambahkan ke sistem itu, atau usaha ... dilakukan olehnya, energi sistem ... tersebut harus berubah menurut persamaan energi atau hukum pertama termodinamika.

The word "work", if applied as a noun, it will mean "the material used by someone at work, or what they produce". If applied as a verb, it will mean "to succeed gradually in becoming something or cause a person or thing to become something, either by making an effort or by making many small movements". In Indonesian, the word "work" which is used as a noun is translated into "usaha", while the word that is used as a verb is translated as

"menggarap" or has the same meaning as "mengerjakan" with the affix "me-" as a form of the verb from the root word "Kerja".

(6) SL: The great majority of our analyses are concerned with laminar flow or with turbulent flow, and one should not normally design a flow operation in the transition region.

TL: Kebanyakan analisis kita terkait dengan aliran berlapis atau aliran bergolak, dan seyogyanya kita jangan merancang aliran untuk beroperasi di daerah transisi.

The word "design", if applied as a verb, means "to make or draw plans for something". If applied as a noun, it will mean "a drawing or set of drawings showing how a building or product is to be made and how it will work and look." In Indonesian, the word "design" which is applied as a verb, is translated into

"merancang" where there is a prefix "me- " in the word "rancang". While the word that acts as a noun is translated into "perancangan" by the prefix pe- and the suffix -an in it.

3.3 Textual Meaning

Textual meaning refers to the meaning derived from the overall content or context of a text or passage. In *Fluid Mechanics*, many terms carry textual meanings because the book uses specialized language specific to the field of thermodynamics. Certain words that may seem general in everyday language can take on different, more specific meanings when interpreted within the context of this scientific text (Fachruddin, Santosa, and Wiratno, 2018). Below are examples of thermodynamic terms that exhibit textual meaning.

(7) SL: Such a fluid is called a continuum, which simply means that its variation in properties is so smooth that the differential calculus can be used to analyze the substance.

TL: Fluida semacam ini disebut kontinum (continuum), yang artinya tak lain bahwa perubahan sifat- sifatnya sedemikian rupa berangsur sehingga kalkulus diferensial dapat dipakai untuk menganalisis bahan tersebut.

The word "properties" has a lexical meaning, namely "property" or "owned". In the context of thermodynamics, the word "properties" is translated into "sifat-sifat". In the Cambridge online dictionary, the word "property" has other meanings, besides "possession" and "residential area", namely "certain physical or chemical characteristics of a substance". Therefore, in this context, it is interpreted as "sifat".

(8) SL: Books on heat transfer ... are essentially devoted to finding the temperature field from known velocity fields.

TL: Buku-buku tentang pemindahan kalor ... pada hakekatnya menerangkan cara memperoleh medan suhu dari medan kecepatan yang diketahui.

The word "heat" has a lexical meaning, namely "panas". In the context of thermodynamics, the word "panas" is more often replaced with the word "kalor" which actually has the same meaning. This is found in several kinds of phrases, for example "heat transfer" is translated to "perpindahan kalor", "heat flow" is translated to "aliran kalor". There is a specific difference between the terms "panas" and "kalor". "Panas" is more often translated into "thermal" which is the energy possessed by an object at a certain temperature, while "kalor" is the process of transferring heat energy through a temperature difference.

Based on the findings above, the authors conclude that among the six recognized types of semantic meaning, only three were predominantly identified in the translation of the *Fluid Mechanics* book: (1) lexical meaning, (2) grammatical meaning, and (3) textual meaning. This is largely due to the fact that most of the translation from English to Indonesian, particularly for thermodynamic terms, is carried out lexically. Additionally, sentence translations tend to be adjusted grammatically, reflecting the structural similarities between English and Indonesian. Other types of semantic meaning such as idiomatic and socio-cultural are rarely encountered, as the translation of scientific terminology in the field of thermodynamics typically does not involve cultural adaptation from the source language to the target language (Farahsani, 2022).

This analysis confirms Farahsani's (2022) finding that three semantic categories lexical, grammatical, and textual—dominate thermodynamic terminology translation, while contextual, sociocultural, and idiomatic meanings remain largely absent. However, our extended investigation suggests this pattern reflects not merely translator preference but fundamental characteristics of scientific discourse itself. Unlike literary or conversational language, technical terminology prioritizes semantic stability and cross-linguistic consistency (Castellví, 2003). The predominance of lexical meaning reflects international standardization of scientific concepts. Grammatical meaning emerges from structural differences between English and Indonesian rather than semantic indeterminacy. Textual meaning operates within constrained parameters defined by established scientific nomenclature. The absence of sociocultural and idiomatic meanings, noted by Farahsani (2022) but not fully explained, can be understood as intrinsic to technical translation rather than as translator limitation. Scientific terminology deliberately minimizes cultural specificity and figurative expression to maximize cross-cultural communicability a principle that shapes translation strategies in predictable ways. This finding has implications for translation pedagogy and practice.

4. CONCLUSION

This study validates and extends Farahsani's (2022) analysis of semantic aspects in thermodynamic terminology translation from White's *Fluid Mechanics*, confirming that lexical, grammatical, and textual meanings predominate in specialized scientific discourse. Building on the preliminary categorization, this research contributes deeper theoretical explanation for the three-category pattern, systematic examination of translation decision-

making processes, and articulation of pedagogical implications absent from the initial investigation. The findings show that lexical, grammatical, and textual meanings dominate the translation process. This reflects the necessity for precision and contextual awareness in translating specialized scientific texts. These insights can assist translators and educators by highlighting key semantic challenges and guiding the improvement of engineering textbook translations and teaching materials. The study addressed the initial research aim by systematically categorizing semantic meanings in the translation and demonstrating their roles in maintaining terminological equivalence. Future research may extend this semantic analysis approach to other specialized fields such as material science or control systems and incorporate multilingual comparative studies to broaden understanding. Limitations include focusing on a single textbook and its translation without exploring more recent editions or other language pairs, which may affect generalizability.

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