Modelling Definition in Mechanical Engineering Texts Viewed from SFL

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Abstract

Introductory textbooks for undergraduate students commonly accommodate numerous technical terms which are commonly in the form of abstract nouns. The technical terms naturally represent the knowledge of the discipline which serves to build the knowledge of the field. Unfortunately, the technical terms tend to use abstract words which require definition to understand them. Hence, understanding the construction of a definition will help the learners of the field understand the texts. Therefore, the purpose of this study was to investigate the construction of definitions appearing in technical terms appearing in disciplinary texts, like mechanical engineering textbooks. The qualitative data were collected from introductory textbooks of mechanical engineering. The results of analysis using Systemic Functional Linguistics (SFL) reveal several findings. First, the relational clauses constructing definition works on identifying the relational process. Second, the lexical verbs realizing the relational process tend to be from equative verbs, like be, call, define, know, or refer. Third, structurally the participant representing Value is realized by a nominal group whose Thing serves as Classifier and also has the element of Qualifier. Fourth, the Qualifier can be realized by prepositional phrase, non-finite clause, or finite clause. The last, functionally, the Qualifier may serve as Function, Properties, or Composition. These findings may be used for developing materials for academic reading and writing.

Keywords: technical terms, SFL, mechanical engineering, Qualifier, relational clause

Introduction

In the last few decades, Systemic Functional Linguistics (SFL) has been extensively used as an approach in language studies. SFL was employed to investigate texts of various contexts, such as business (Khramchenko, 2019; Nguyen & Oliver, 2015), engineering (Gardner & Xu, 2019; Khorina, 2018a, 2020a, 2020b; Khorina et al., 2022a; Nekrasova-Beker, 2019), health care (Matthiessen, 2013), law (Li & Wang, 2021; Pramoolsook & DaliMunte, 2020) to mention a few. These studies are in line with what stated by (Halliday, 1994) that SFL could be applied in any context in which a text is used. In other words, it is a comprehensive theory of grammar as claimed by (Halliday & Matthiessen, 2004, 2014) which can reveal the function of language in society and how society shape the language used.

Previous studies of engineering texts using SFL focusing on ideational meaning showed that the texts were strongly characterized by material process (Khorina, 2020a, 2020b) and relational process (Khorina, 2018a, 2018b; Khorina et al., 2022b). In mechanical engineering texts, both types of the material clauses were found serving to represent the the field. It is well known that mechanical engineering field refers to produce machine either by creating a new one or develop the old one (Wickert & Lewis, 2017). Furthermore, the studies also shows that engineering texts as a disciplinary texts are characterized by relational process as stated by (Martin, 1992). The process
may serve as the taxonomy of the knowledge, like classification and composition as stated by (Martin, 2004b). Khorina (2018a) found out that intensive relational clauses operating on attributive relational processes serve as classification, composition, and feature or properties which is in line with what Martin stated (2004b). Engineering knowledge also talks about how parts of a machine, for example, are assembled or structured. The structure can be represented by circumstantial clauses working on an attributive process as found by (Khorina et al., 2022a). However, the investigation of relational process representing definition seems to be rare as far as the writer’s concerned. Yet, according to (Martin, 2004b), the technical terms are commonly written in abstract nouns or phrases so they need to be elaborated to understand them, specially for those who are new in the field. Therefore, examining how definition is construed in engineering texts, like mechanical engineering texts will be essential to help learners build their knowledge of the field. The finding can also prevent them from being alienated from the texts (Halliday & Martin, 2004) since the main barrier to understanding science is the language itself (Wellington & Osborne, 2001), specifically understanding technical vocabulary like technical terms (Evans & Morrison, 2011).

**Theoretical Framework**

Systemic Functional Linguistics (SFL) is claimed as a comprehensive theory of grammar (Halliday & Matthiessen, 2004, 2014). SFL sees language as a function and a system which realizes the function. Language has three metafunctions as divided by (Halliday, 1994): ideational, interpersonal, and textual metafunction. The ideational metafunction refers to the function of language to construe ideas and experiences represented by the clause of representation. The clause works on the system of TRANSITIVITY having various processes. One of the processes is known as relational which is used to characterize and to identify. In scientific texts, both types of relational processes tend to occur dominantly expressing the taxonomy of knowledge, such as classification, composition, and feature/properties (Martin, 2004a) which is confirmed by Khorina (2018a) in engineering texts. The relational process can also function as definition which is necessary to elaborate to understand it (Martin, 2004b). Definition is commonly realized by an intensive relational clause operating on identifying process as exemplified by (Martin, 2004a) below.

**Precipitation** refers to **all forms of water which fall (precipitate) from the sky**.

<table>
<thead>
<tr>
<th>Term</th>
<th>process</th>
<th>definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>refers to all forms of water which fall</td>
<td>(precipitate) from the sky</td>
</tr>
</tbody>
</table>

The clause above represents the definition of the term being defined. It is an intensive relational clause working on identifying process. The term is realized by the nominal group but the definition is realized not only by nominal group but also by finite clause embedded to the main clause. This definition can be probed by using question “What is Precipitation?” The answer will be “**all forms of water which fall (precipitate) from the sky**”. Traditionally, it does not contain one clause but more than one known as clause complex. In SFL, the relation between these two clauses is known as hypotactic relation (Halliday & Matthiessen, 2004, 2014). The main clause is signified as α while the subordinate clause is symbolized as β as illustrated in Table 1. In terms of semantic relation, the subordinate clause or finite clause shows the expansion of the main clause which serves to elaborate the Thing preceded the relative conjunction which. The elaboration makes the Thing specific or it causes the Thing definite which is a characteristic of definition. Meanwhile, the main clause classified as intensive clause with identifying process has a role of classification. It can be
probed by question “What kind of form is precipitation?” The answer is all forms of water which is represented by Value realized by nominal group. If the finite clause does not exist, precipitation being discussed will not be clear or accurate or specific. This implies that the finite clause plays a critical role to make the Thing definite.

<table>
<thead>
<tr>
<th>Precipitation refers to all forms of water</th>
<th>which fall (precipitate) from the sky</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main clause</td>
<td>Subordinate clause</td>
</tr>
<tr>
<td>α</td>
<td>β</td>
</tr>
</tbody>
</table>

### Finite clause as elaboration

Subordinate clause in clause complex is commonly embedded to its main clause. They may have semantic relation of expansion which consists of elaboration, extension, and enhancement (Halliday & Matthiessen, 2004, 2014). In elaboration, according to (Halliday & Matthiessen, 2014: p.461) one clause elaborates on the meaning of another by further specifying or describing it. Furthermore, the secondary clause does not introduce a new element into the picture but rather provides a further characterization of one that is already there, restating it, clarifying it, refining it, or adding a descriptive attribute or comment (Halliday & Matthiessen, 2014: p.461). In other words, another clause serves to make the meaning of the first one definite or accurate.

### Method

This study aimed at modelling the definition in mechanical engineering texts. For this purpose, the qualitative data were collected from introductory textbooks of mechanical engineering. It is well-known that introductory textbooks are used to introduce new students to new knowledge and concept of the field and they use massive terms representing the knowledge and concept. Thus, two introductory textbooks of such were chosen. They are *An Introduction to Mechanical Engineering* written by Jonathan Wickert and Kemper Lewis in 2016 and *Mechanical Engineering Principles* (4th edition) written by John Bird and Carl Ross in 2020.

The data were selected based on some criteria as listed by (Martin, 2004a). First, the clause is an intensive clause with identifying relational processes realized by *be, call, define, know, or refer*. Then, the term being defined should be represented by Token while the definition is represented by Value. However, the clause may have a finite clause as in a clause complex having hypotactic relation and semantic relation. The finite clause or subordinate one serves as the expansion of the main clause giving information of elaboration specifically. The subordinate clause is marked by relative pronoun. Some samples taken from the data are as follows.

1) **Percentages are fractions having 100 as their denominator.**
2) **Tension is a force that tends to stretch a material.**

Next, the collected data were classified based on the structure and function of the finite clause (Khorina, 2018a, 2018b; Khorina et al., 2022c). Finally, the model of definition in mechanical engineering texts were formulated.
Results and Discussion

Results

Figure 2 shows that there are five lexical verbs which are used in relational clauses representing Definition. The lexical verbs are *associate*, *be*, *call*, *define*, *know*, *mean*, and *refer*. These findings confirm what was stated by Martin (2004a). Among them, the lexical verb *be* tends to be the highest frequently used followed by *call*, *define*, *know*, *associate*, *refer*, and *mean*.

![Figure 1. Lexical verbs used in relational clauses](image)

Furthermore, the data show that definition is realized by intensive clause of identifying relational process. The process may be realized by the lexical verbs as listed in Figure 1 which is in line with (Martin, 2004a). But the data also reveal that the clause belongs to clause complex with hypotactic relation between the main clause and the subordinate clause. In addition, they have semantic relation of elaboration since the subordinate or the nexus serve to expand the main clause by describing it (Halliday & Matthiessen, 2004, 2014). The subordinate clause may be realized either by non-finite or finite clause as illustrated in Figure 2.

![Figure 2. The structures of elaboration](image)
Discussion
This study is aimed at exploring how definition of a technical term is constructed in mechanical engineering texts. As stated by Martin (2004a), definition is represented in intensive relational clause working on identifying mode. It is characterized This study reveals that the identifying process of the intensive relational clauses serving as definition is realized by some the lexical verbs, such as associate, be, call, define, know, mean, and refer which align with what listed by Martin (2004a). The data show that the clauses serving as definition belong to clause complex. Consequently, the clauses consist of main and subordinate clause which have hypotactic relation. The subordinate clause is the expansion of the main clause having semantic relation of elaboration. But the elaboration can be realized either by non-finite or finite clause. The findings are discussed below.

Non-Finite Clause as elaboration
Clauses (1)-(4) are the samples of clauses as definition taken from the data. The clauses actually consist of two clauses: main and subordinate. The main clauses are intensive clauses working on attributive mode. But the subordinate clause has been downranked resulting in non-finite clause as seen in the table of analysis below. They serve as classification as seen in Table 2.

(1) Percentages are fractions having 100 as their denominator.
(2) A lamina is a thin flat sheet having uniform thickness.
(3) A clutch is an engineering device used for transferring motion from an engine to a gearbox or other machinery.
(4) A differential is a special type of planetary geartrain used in automobiles.

<table>
<thead>
<tr>
<th>Main clause</th>
<th>Subordinate clause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentages are fractions</td>
<td>having 100 as their denominator.</td>
</tr>
<tr>
<td>A lamina is a thin flat sheet</td>
<td>having uniform thickness.</td>
</tr>
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<td>A clutch is an engineering device</td>
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<tr>
<td>A differential is a special type of planetary geartrain</td>
<td>used in automobiles.</td>
</tr>
</tbody>
</table>

Table 2
Hypotactic and semantic relation between the clauses

<table>
<thead>
<tr>
<th>Intensive clause as classification</th>
<th>Non-finite clause as elaboration</th>
</tr>
</thead>
</table>

The main clause serves as function indicated by the type of relational process and the participants involved. It has attributive process realized by lexical verb be. Carrier is the participant representing term percentages, lamina, clutch, differential while attribute represents the thing that classified Carrier (the term). The nominal group realizing Attribute contain indefinite article instead of
definite one. Functioning as classification, the clauses can be probed by using interrogative sentence “What kind of ...(terms)”.

Table 3
Non-finite clause as elaboration realized by possessive clause

<table>
<thead>
<tr>
<th>Process</th>
<th>Attribute (properties)</th>
</tr>
</thead>
<tbody>
<tr>
<td>having</td>
<td>100 as their denominator</td>
</tr>
<tr>
<td>having</td>
<td>uniform thickness.</td>
</tr>
</tbody>
</table>

Verbal group Nominal group

However, by the presence of a non-finite clause, the intensive clause as classification becomes definite. The non-finite clause realized by possessive clause with attributive relational process elaborates the Thing in Attribute. The possessive clause serves as properties as indicated by (Khorina, 2018a) which describes the Thing in Attribute of intensive clause. As a result, it becomes definite. This can be probed by interrogative sentence “What properties do fractions have?” The answer is “Fractions have 100 as their denominator”. In other words, the non-finite clause describes (Khorina, 2018a) specifically the term percentage making the term definite. It can be formulated that the clause of definition can be: Term + Verb + Classifier + Elaboration (Properties) = intensive clause as classification + possessive clause (non-finite clause) as properties.

Table 4
Non-finite clause as elaboration realized by circumstantial clause

<table>
<thead>
<tr>
<th>Process</th>
<th>Attribute (function and location)</th>
</tr>
</thead>
<tbody>
<tr>
<td>used</td>
<td>for transferring motion from an engine to a gearbox or other machinery</td>
</tr>
<tr>
<td>used</td>
<td>in automobiles</td>
</tr>
</tbody>
</table>

Verbal group Nominal group

Non-finite clause may also serve as function. It is realized by circumstantial clause used for transferring motion from an engine to a gearbox or other machinery and relational process is realized by verbal group used. Attribute as circumstance is realized by prepositional group for transferring motion from an engine to a gearbox or other machinery and in automobiles. The circumstance may be assigned as function (3) as found by Khorina (2018b) and location (4). This can be probed by interrogative clause “What is an engineering device used for?” or “Where is a special type of planetary geartrain used?” The answer will be for transferring motion from an engine to a gearbox or other machinery and in automobiles. It can be seen that the presence of non-finite clause which elaborate the function and location of the Thing in Attribute cause it definite. This can be formulated as Term + Classifier + Function/Location or Intensive clause + Non-finite clause as Function/Location.
The findings also show that the clause complexes serving as definition also consist of the main clause and subordinate clause as a finite clause. Some samples from the data are listed below.

(5) Tension is a force that tends to stretch a material.
(6) Compression is a force that tends to squeeze or crush a material,
(7) Shear is a force that tends to slide one face of the material over an adjacent face.
(8) A thermometer is an instrument that measures temperature.
(9) Forging is forming process which is based on the principle of heating, impacting, and plastically deforming metal into a final shape.
(10) Torque is a moment that causes rotation of a shaft in a motor, engine, or gearbox.

Clauses (5)-(10) belongs to clause complexes having hypotactic relation (Tabel 5.) as stated by Halliday & Matthiessen (2004, 2014). The relation is indicated by the presence of the relative pronoun that/which links the main clause and the subordinate one. The main clause is realized by the intensive clause serving as classification like in (1)-(4) while the finite clause serves as an elaboration of the Thing in the nominal group realizing Attribute as seen in Table 5.

Table 5  
Hypotactic and semantic relation between the clauses

<table>
<thead>
<tr>
<th>Main clause</th>
<th>Subordinate clause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension is a force</td>
<td>that tends to stretch a material.</td>
</tr>
<tr>
<td>Compression is a force</td>
<td>that tends to squeeze or crush a material</td>
</tr>
<tr>
<td>Shear is a force</td>
<td>that tends to slide one face of the material over an adjacent face.</td>
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<td>which is based on the principle of heating, impacting, and plastically deforming metal into a final shape.</td>
</tr>
<tr>
<td>Torque is a moment</td>
<td>that causes rotation of a shaft in a motor, engine, or gearbox.</td>
</tr>
</tbody>
</table>

α β

All the main clauses serve as classification indicated by some characteristics. First, attributive relational process is realized by verbal group be (Halliday & Matthiessen, 2004, 2014). Attribute is realized by nominal groups with or without having indefinite article. The nominal groups refer to more general nouns or the relation between the Thing realizing Carrier and the one realizing Attribute is hyponymy relation – kind-whole relation. Attribute is commonly represented term used in the field or discipline of the text in which the clause is. The presence of finite clause elaborates the Thing in the main clause which causes it definite. The definiteness may be realized by relational clause, such as circumstantial clauses.
The circumstantial clause refers to a type of relational clauses which possesses circumstantial element (Halliday & Matthiessen, 2004, 2014). The circumstantial element may be manifested by relational process or by the participant representing Attribute. In this finding, it tends to be expressed by relational process realized by verbal group (5)-(10). But the Attribute may be realized by nominal group (9)-(10) or prepositional phrase (5)-(8). The circumstantial clause serves various roles, such as function, condition, and result.

Finite clause realizing circumstantial clause may serve as function (5)-(7). The circumstance is manifested by relational process and Attribute is realized by prepositional phrase. This can be probed by interrogative clause “What does a force tend to do?” The answer is “to stretch a material”. In this case the circumstantial element expresses purpose or function. This finding is in line with what found by Khorina (2018b). Also, in (9), the clause serves as function too while in (8), it serves as duration realized by prepositional group for very short periods of time. This can be probed by interrogative clause “How long...”. While in (10), Attribute is realized by nominal group serving as the circumstantial element of condition. This can be probed by interrogative clause “What is ... based on...?” Circumstantial clause also serves as result (11). The relational process is realized lexical verb cause which expresses circumstance. Whereas Attribute is realized by nominal group rotation of a shaft in a motor, engine, or gearbox. The nominal group has circumstantial element of result which can be probed by interrogative clause “What causes ...?” Various roles of finite clauses realized by circumstantial clauses make the Thing in the main clauses definite which is one characteristic of definition. This can be formulated as main clause (intensive relational clause as classification) + subordinate clause (circumstantial clause as function/duration/condition/result). It is implied that elaboration either in non-finite or finite clause play critical role in a clause serving as definition.

### Table 6
Non-finite clause as elaboration realized by circumstantial clause

<table>
<thead>
<tr>
<th>Relative pronoun</th>
<th>Process as circumstance</th>
<th>Attribute a (function/duration/condition/result)</th>
</tr>
</thead>
<tbody>
<tr>
<td>that</td>
<td>tends</td>
<td>to stretch a material.</td>
</tr>
<tr>
<td>that</td>
<td>tends</td>
<td>to squeeze or crush a material</td>
</tr>
<tr>
<td>that</td>
<td>tends</td>
<td>to slide one face of the material over an adjacent face.</td>
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<td>that</td>
<td>act</td>
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</tr>
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<td>which</td>
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<td>that</td>
<td>causes</td>
<td>rotation of a shaft in a motor, engine, or gearbox</td>
</tr>
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</table>

Subordinate conjunction: Verbal group | Nominal group/prepositional phrase
**Conclusion**

This paper discussed how definition of technical terms in mechanical engineering texts are defined. The definition is critical since it helps readers or learners of the field comprehend the knowledge of the field. As a result, understanding the structure of the definition is essential. This study found out that the definition is realized by clause complexes consisting of main clause and subordinate one. Consequently, the clauses have hypotactic relation in which subordinate clauses have semantic relation serving as elaboration. The main clauses are realized solely by intensive clauses while subordinate clauses are realized either by possessive clauses or by circumstantial clauses. The process in intensive clauses tends to be realized by several lexical verbs: *be, call, define, know,* and *refer* which are in line with (Martin, 2004a). Two types of clauses realize the subordinate clauses: non-finite and finite. Possessive clauses tend to be realized by possessive or circumstantial clauses. However, finite clauses are solely realized by circumstantial clauses. The clause containing definition can be formulated as follows: Intensive clause of classification + non-finite/finite clause (possessive/circumstantial clause) of function/properties/duration/condition/result. These findings have implications for teaching English for Academic or Specific Purposes. The grammatical formulae of definition may help learners read academic texts or write academic essays which are very important for their academic success.

**References**


