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Product Requirement Information Modeling for the Life Cycle of the Port Hoisting Equipment

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Abstract

Port hoisting equipment is associated with numerous salient characteristics like loads variation, complicated product composition and higher safety and reliability requirements. In addition to it, requirements of multiple standards are needed to be met during the entire product life cycle. There is a need of clear and thorough definition of requirements vis-à-vis design of port hoisting equipment, and at each life cycle stage, development activities are to be carried out. This paper discusses the classification of the requirement information of the hoisting equipment and defines the requirement features as well. This study also establishes requirement information model for port hoisting equipment by SysML and elaborates the requirement information within relationship by means of an example.

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Keywords: Port hoisting equipment; life cycle; product requirement; information modeling

1. Introduction

Port hoisting equipment is a mechanism that moves vertically and horizontally within a certain range. It is often used in loading and unloading operations of bulk cargo or container at port [1]. It is subjected to various loads, including lifting load, weight load, etc. It has complex product composition including operating mechanism, steel structure, power unit and a control system. The requirements for safety and reliability are also very stringent i.e. it has to meet requirements of many standards, such as, design, test and electrical specification, and so on. At each stage of life cycle including design, manufacturing, assembly, sales, transportation, operation and maintenance many unique requirements are put forward. From the perspective of life cycle of the port hoisting equipment, defining a complete and clear requirement information and its relationship and establishing the requirement information model have an important influence on realization of the design. Moreover, it has also a strong influence upon the product development.

Dadfarnia analyzes a product requirement with the system engineering theory, which realizes the design of an ambulance patient compartment driven by requirement model [2]. Subhan discusses the important role of requirement analysis in software system development life cycle, and proposes a new software development method [3]. Baudry discusses the method of requirement analysis driven by model [4] and Chehida makes a security requirement analysis for network applications by UML(Unified Modeling Language) [5]. Also, Cao discusses the method of requirement modeling about the complex products of small batch or single-piece [6]. At home and abroad, the requirement analysis has been launched in many fields, but it has less been involved in the port hoisting equipment.

Systems Modeling Language (SysML) is a standard modeling language for system engineering, which can realize the requirement analysis, system design, function description, system verification etc. of engineering application system.

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Gotoh establishes the equipment model of an intelligent ceiling crane by SysML, which realizes the design driven by requirement model [7]. Karwowski establishes the model of knowledge management system by SysML [8] and Zeng establishes the overall design system of a satellite by SysML, which realizes the overall design of satellite driven by model [9].

This paper studies the construction of requirement information model from the perspective of life cycle process of the port hoisting equipment, analyses the diversified requirement of the port hoisting equipment, defines the feature and property of the requirement information associated with the life cycle process of the port hoisting equipment, and describes the relevant requirement information and its relationship by SysML.

2. Product requirement information associated with life cycle

Product requirement information is diverse, most of which is function related, structure related, standard related, execution process related and capability related. When there is more complex product, there should be higher requirement information. Furthermore, the requirement information is not independent; it usually interacts with each other and forms a network of requirement information. For instance, ambient temperature and relative humidity included in the requirement information of the port hoisting equipment, directly affects the selection of the material. While, as soon as the material is finalized, its density affects the weight of the product. Working speed, working range and lifting height makes an impact on the determination of the speed control scheme and logic control scheme of the port hoisting equipment.

Traditionally, requirement information is described by means of document, specification and data table, however, the connections among requirement information are hidden in the information, which makes it difficult for the designer to grasp it quickly. The traditional expression of requirement is limited to the information provided by the user only. But in such a case, flowing downstream stage of life cycle, some major requirements are often difficult to express. For example, the weight and size of assembly parts associated with transportation stage of the port hoisting equipment life cycle are the key requirement parameters, however they are usually delivered among the designers by experience merely, which makes the organization and transmission of the information lack of standardization and makes it easy to cause requirement information missing, so that it eventually affect the design quality. Because of the complex requirement information, a reasonable and standardized classification can make a contribution to a clear expression of the requirement information and its relationship.

In order to have a better organization, requirement information can be organized from the perspective of product life cycle stage, which can not only comprehensively define the requirement information, but also clearly express the corresponding relationships which are the design essentials between life cycle stage and requirement information. Therefore, the designer could understand the design essentials before product design, and several problems are solved at the early stage of product development cycle, which ensures the design quality and avoids much rework or waste. Table 1 presents the requirement information associated with port hoisting equipment life cycle and each one of which should be considered in the development process of port hoisting equipment.

Table 1. Main requirement information associated with stages of port hoisting equipment life cycle.

Life cycle stage	Main requirement information
Design stage	Capability, life in service, target product cost, geometric size, aesthetics/appearance, ergonomics, standards, and quality and reliability, etc.
Manufacturing stage	Material type, material properties, working space, wrench space, etc.
Assembly stage	Component location reference, the size of purchased parts, lifting point position, etc.
Sales stage	User funds, delivery period, etc.
Transportation stage	The weight of assembly parts, the size of assembly parts, etc.
Operation and maintenance stage	Relative humidity, ambient Temperature, wind speed, etc.

As shown in Table 1, the requirement information listed in the design phase, related to capability, structure and standards, is the baseline for design and is also the basic requirement information. Normally, among the requirements provided by the user, the ones related to material type and man-machine engineering, such as working space, wrench space, etc., which are not only converted into the information of the structure size and design parameters associated with design stage, but also considered as the requirement factors which should be taken into account for manufacturing process decision, affecting product manufacturing process.

Component location reference, the size of purchased parts and lifting-point position play an important role in equipment assembly stage, for example, an in-appropriate location reference may make it difficult to guarantee the coaxial degree of connectors which are axis related, which makes it hard for the connectors to turn. There is a direct constraint between product cost and requirement information such as user funds and supply period, and this constraint affects designer's selection decision. The weight and the size of assembly parts directly affects the transportation of the product, because, excessive weight or size may lead infeasible transportation. The information of ambient temperature, relative humidity, wind speed, is also the basic requirement information provided by the user, which limits the operating environment of the product, so it is classified as the requirement information associated with operation and maintenance stage.

Different product requirement information is related to each other. For example, relative humidity, ambient temperature and wind speed, has a direct impact on the selection of material type, however, material type and associated properties indirectly affect the weight of components. Moreover, the information of process and