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Modelling of Information for Additive Manufacture (AP242) and Comparative with Other Existing Models

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Abstract

With the advent of new technologies, there has been a revolution in recent decades that is not alien to companies. Nowadays, the organization of the company is subject to a series of information and/or qualities that are convenient to organize. In order that the information of a company can be used by other collaborating companies, some standards that allow communication have been created. The ISO 10303 standard, better known as STEP, is the international standard that is fulfilling this objective of standardizing the methods that allow what is called "interoperability". Very recently, different solutions are being articulated to those proposed ones in this study, aimed at providing solutions to the same problems, such as using the model based on STEP - NC. The purpose of this research is to develop a proposal that incorporates the AP242 standard (ISO 10303) in the information model for a manufacturing technique that is growing at great speed, known as "Additive Manufacturing"; for this purpose, the feasible project methodology is used, in addition to making a comparison with other existing models.

Keywords: modelling; information systems; ISO 10303; action protocols; AP242; STEP-NC; Additive Manufacturing.

1. Introduction

The use of the different possibilities and multiple alternatives offered by the new technological advances as a definitive support for the Additive Manufacturing (AM) process, crystallizes in the generation of new information models that enable the exchange of information between various systems and increases its importance when materializing a new design or final product that offers more and better products to society.

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At the same time, located at the gates of a new industrial revolution called industry 4.0, AM technologies are experiencing a rapid expansion after the search to improve and expand the applications in terms of performance, not only industrial profitability, but also the time of development of new projects or products. From this perspective, the approach principle for the new challenges proposed in the concept of industry 4.0, lies in how to use information to improve the process, properly determine resources, collaborate with systems and digitize all information to ensure knowledge. In this context, the exchange of information between various systems emerges as a research topic, since the modelling of information is often limited by barriers such as language, which is necessary for a system to send and/or receive information; another barrier is the structure or diagrams that must be adjusted in a logical, reasoned and, most importantly must be compatible for the system to work. In addition, the goal of the modelling of information for additive manufacturing is to ensure interoperability between operating systems through standardization of the type of information needed to manage that system throughout the life cycle of manufacturing a specific product. Based on the above considerations, there are different mechanisms to support the flow of information between each phase of a product's life cycle. The ISO 10303 standard also known as STEP (Standard for the Exchange of Product model data) provides a mechanism for organizing information. The standard defines the basic principles of data representation and information exchange used in ISO 10303 [1,3]. In this sense, taking into consideration the effect of ISO 1030 on the architecture and design of information systems for manufacturing, particularly in additive manufacturing, which requires the management of information on topologies, textures, materials, resistance, for which ISO 10303 generated the AP 242, which corresponds to an application protocol to manage 3D engineering and all the standardized information there is necessary for the generation of a product in three dimensions. That is why the implementation of this protocol in additive manufacturing becomes an important pillar to be taken into account when relating the different systems, i.e. the user, design and manufacture of the part.

For this purpose, this study proposes an information model that incorporates the ISO 10303 AP242 standard for the integration and preservation of product information generated with this technology, with the intention of providing a good organization of information that will facilitate decision making for an economic and industrial benefit. Therefore, the objective of incorporating this standard to the proposal of this study is to ensure interoperability between systems through the standardization of the type and form of data to administer a system throughout its life cycle [2].

2. Methodology

The research method is a project study that consists of gathering information for the description and analysis of the current situation, for the subsequent design of an information model for additive manufacturing that makes possible the integrated management of data and interoperability between CAD, CAPP/CAM and CNC systems.

From the description of the existing information models for additive manufacturing, the compatible variables of the modelling of information for additive manufacturing with the ISO 10303 AP242 standard were determined and the results obtained in previous works were compared with information models that incorporate the ISO 10303 standard for AM technology with the one proposed in this study. An information model for additive manufacturing was designed and it summarizes the best practices, according to weaknesses and/or strengths, similarities and/or differences [1,3,4,5].

The main advantage of the proposed model is that the various parties in the additive manufacturing process share a standard format, which ensures and guarantees complete and accurate information on the models and products generated, as well as feedback from all parties in the same model [2].

Similarly, the proposal represents an innovative effort to achieve interoperability among systems, finding common points between standards and multiple technological platforms involved. In this sense, this work presents the first approach of the conceptual and architectural level that involves the main aspects of the life cycle of additive manufacturing.

3. Results

When the analysis of the specific objectives and a review of the activities that led to their attainment is carried out, the following information is obtained:

1. When carrying out the bibliographic review related to information models for additive manufacturing, it leads to expressing that today's information models have greater strength and importance within industrial processes due to the globalization of the economy. In addition, these models offer very good organization of the industrial data information for AM, and also allow to verify that the questioned data is congruent with reality, facilitating the decision making for benefit at economic and industrial level; thanks to these models, the product can be defined, it is possible to carry out simulations of the manufacturing process, among others, in order to achieve the efficient creation of products.

2. The variables compatible with the modelling of information for additive manufacturing with the ISO 10303 AP242 standard were determined, and the most important aspects to consider are: the front-end design data, the product data management (PDM) or the necessary configuration control for a hardware system (similar to version control for software), the persistence of the model data in a file that guarantees the data to be accessible in the long term.

Therefore, the entity Module of the form was defined, by means of a normal connection, which expresses the data allusive to the computerized design. Likewise, this section considers the entity of the three-dimensional printing template under the context of additive manufacturing.

In addition, the segment of modelling of information for additive manufacturing corresponding to the User entity was detailed, specifying the organization to which it belongs and the role it plays in that organization, also considering certain access restrictions depending on the competent functions within the organization.

Likewise, the segment of the modelling of information corresponding to the Product entity was specified, which is associated to the user by a normal connection but also depends indirectly on the properties and geometry entities. In this way, the entities were defined: Product, Product Presentation, Presentation Restriction, Product Assembly, Assembly Restriction and Classification.

Under the ISO 10303 AP242 standard, AP 242 was considered for the management of extended 3D geometric dimensions and tolerances that include semantic data, 3D form quality, design of parametric/geometric 3D constraints, 3D kinematic assembly, sustainability information, digital rights access and management, mechatronics software, 3D electrical harness and 3D piping. This proposal included providing the model with a KBE component.

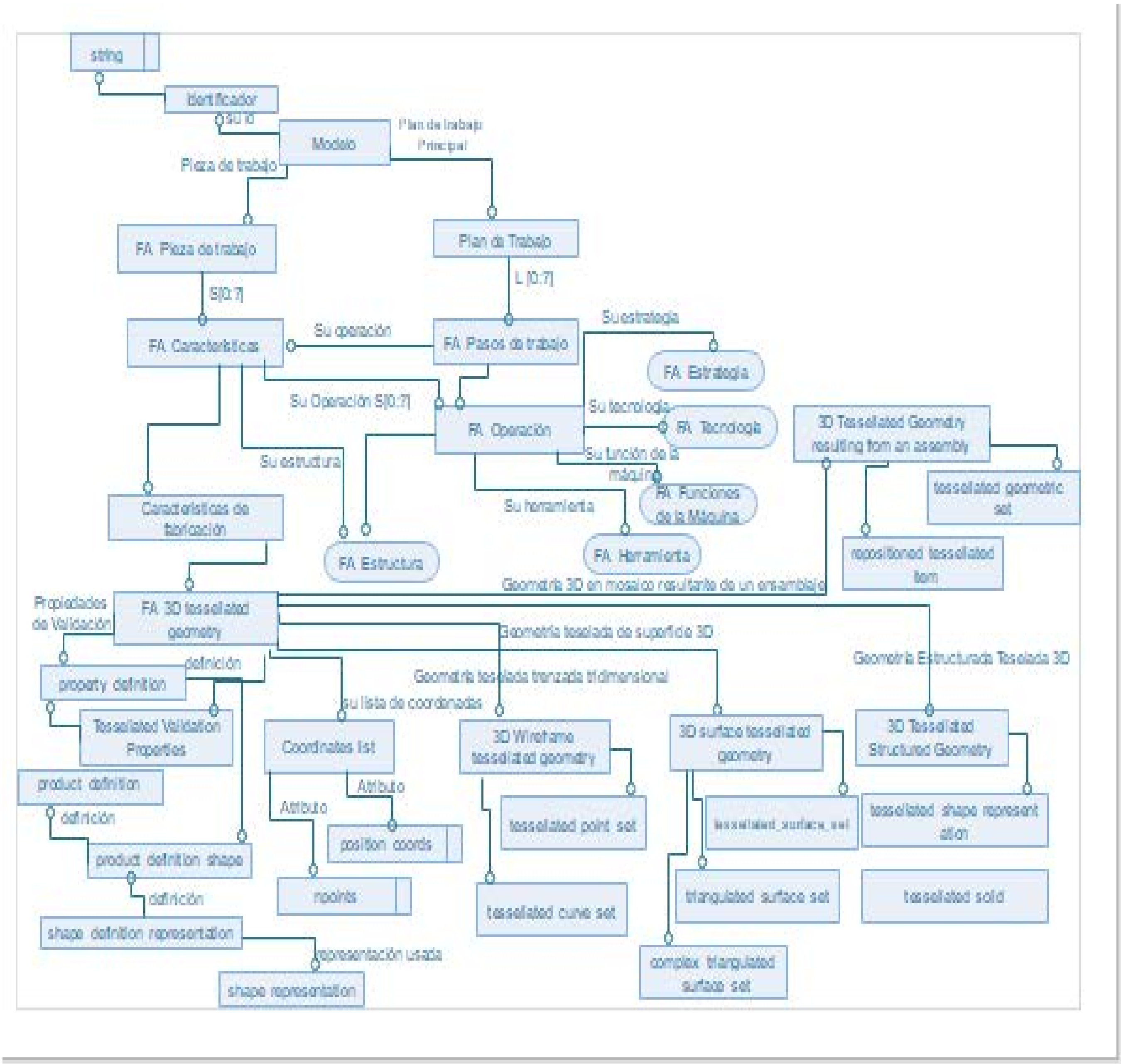

Figure 1: activity Model of referenced Application from the general data structure of ISO 1030 AP242

Source: own elaboration

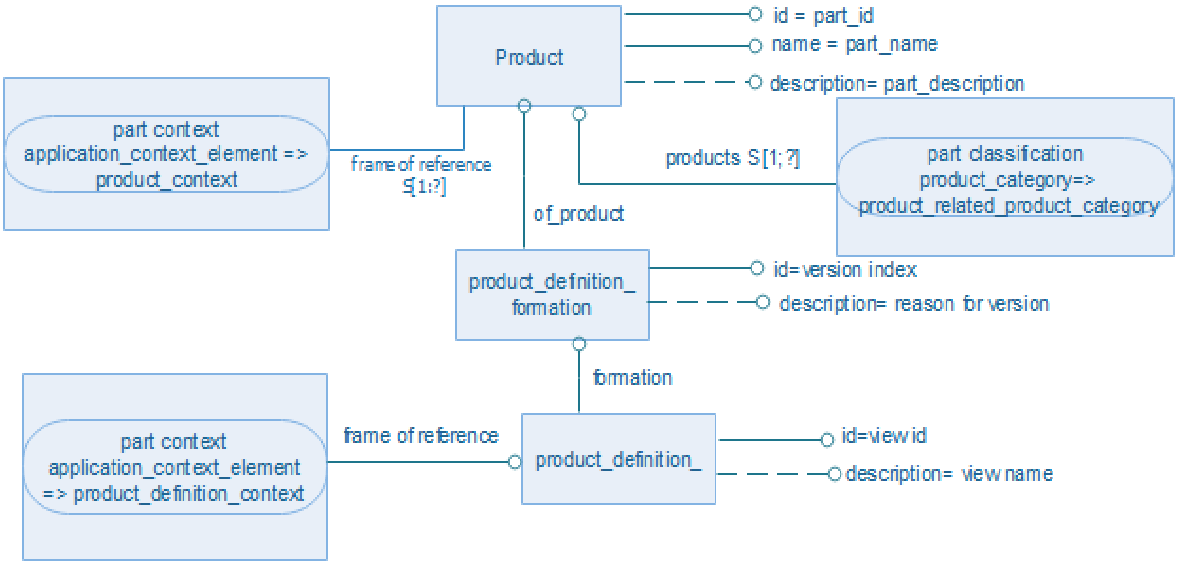

Figure 2: representation of the product structure in a STEP file

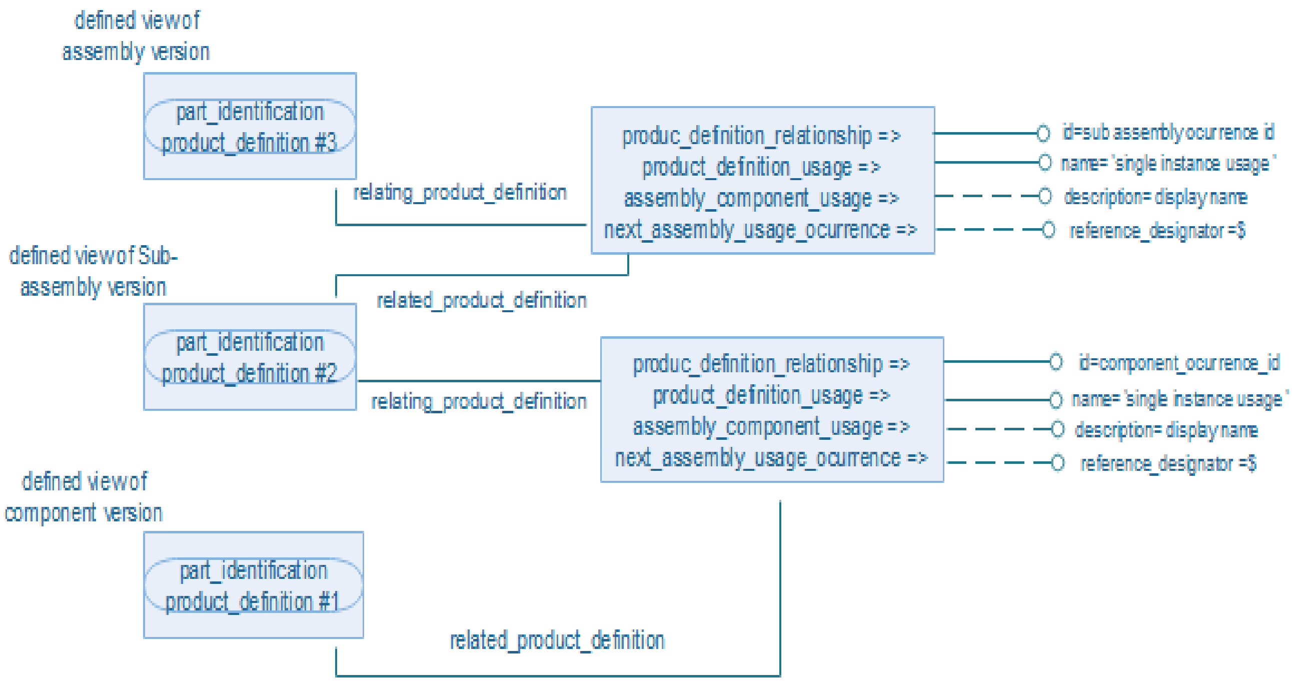

Figure 3: representation of the components that identify the product structure in a STEP file.

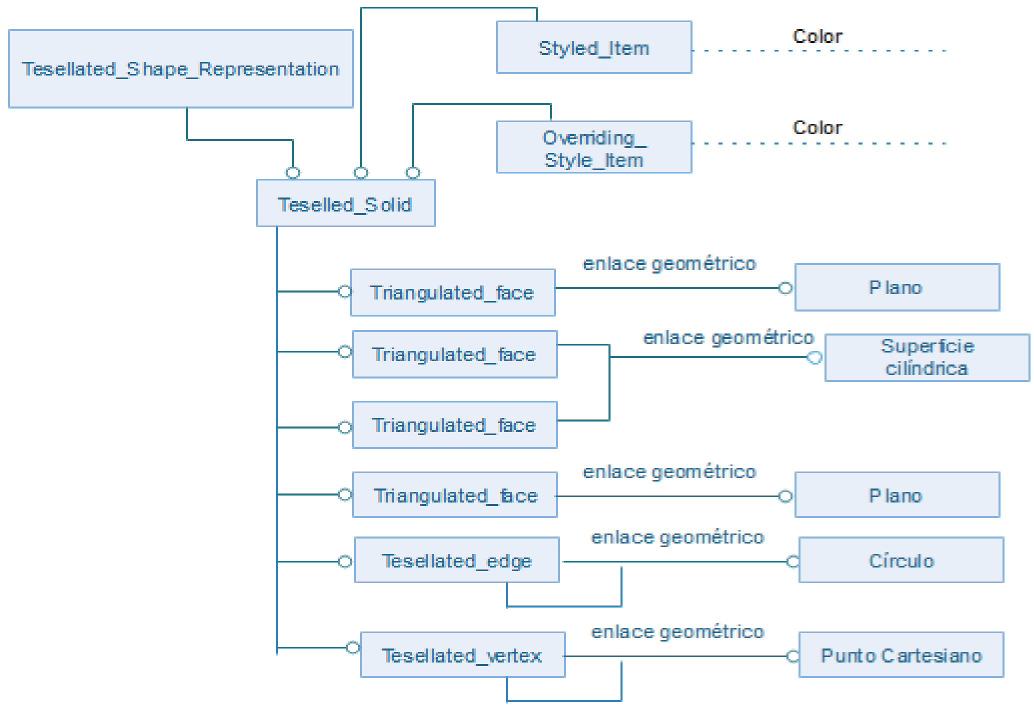

Figure 4: structured 3D tessellated geometry with exact geometry information ISO 10303 Part 42 AP242

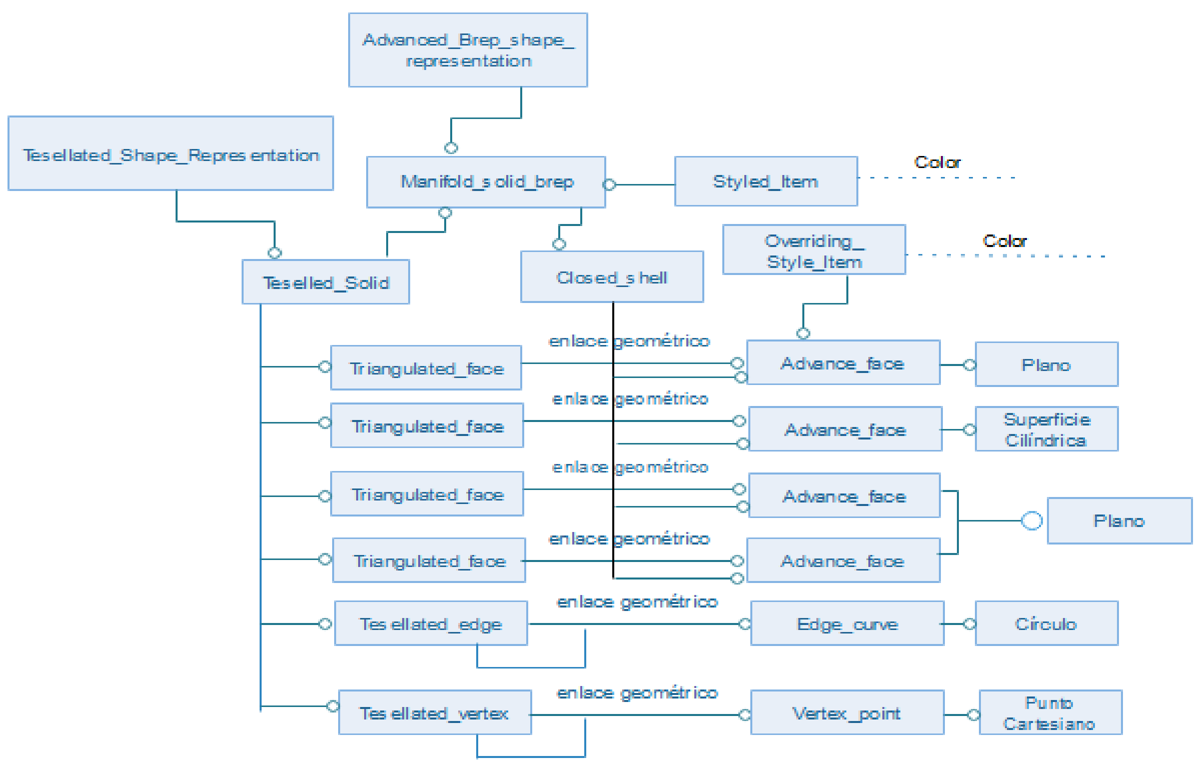

Figure 5: structured 3D tessellated geometry with exact geometry information BREP ISO 10303 AP242

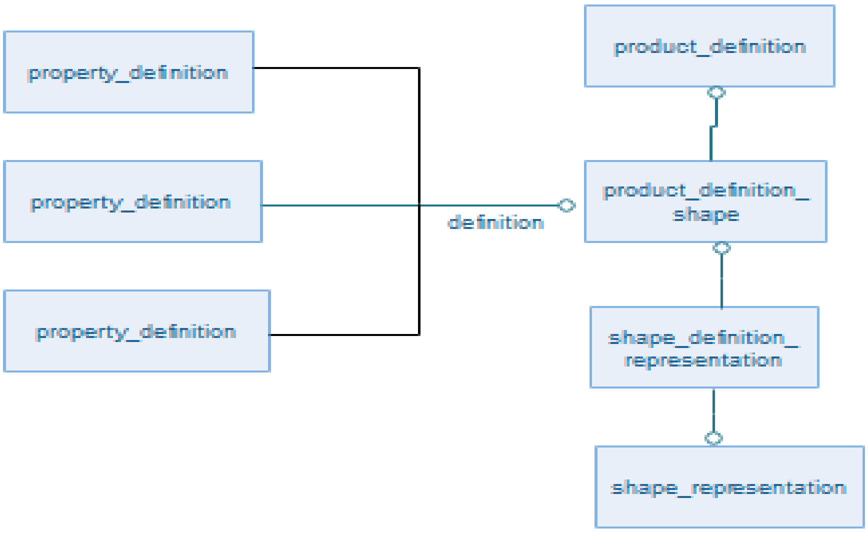

Figure 6: tessellated validation properties at part level

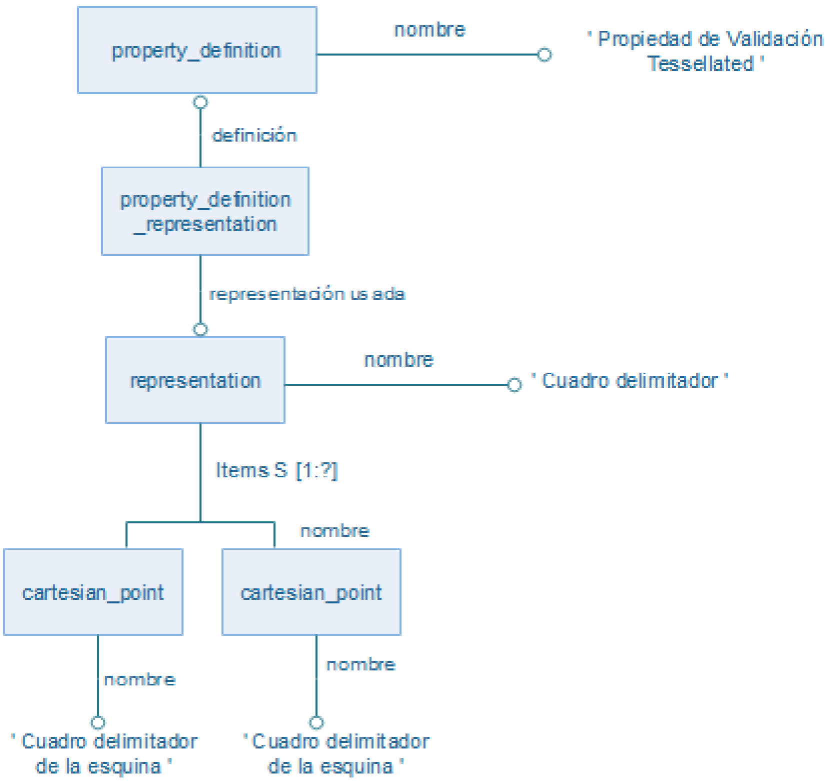

Figure 7: Tessellated validation property "Bounding box" ISO 10303 Part 21 AP242

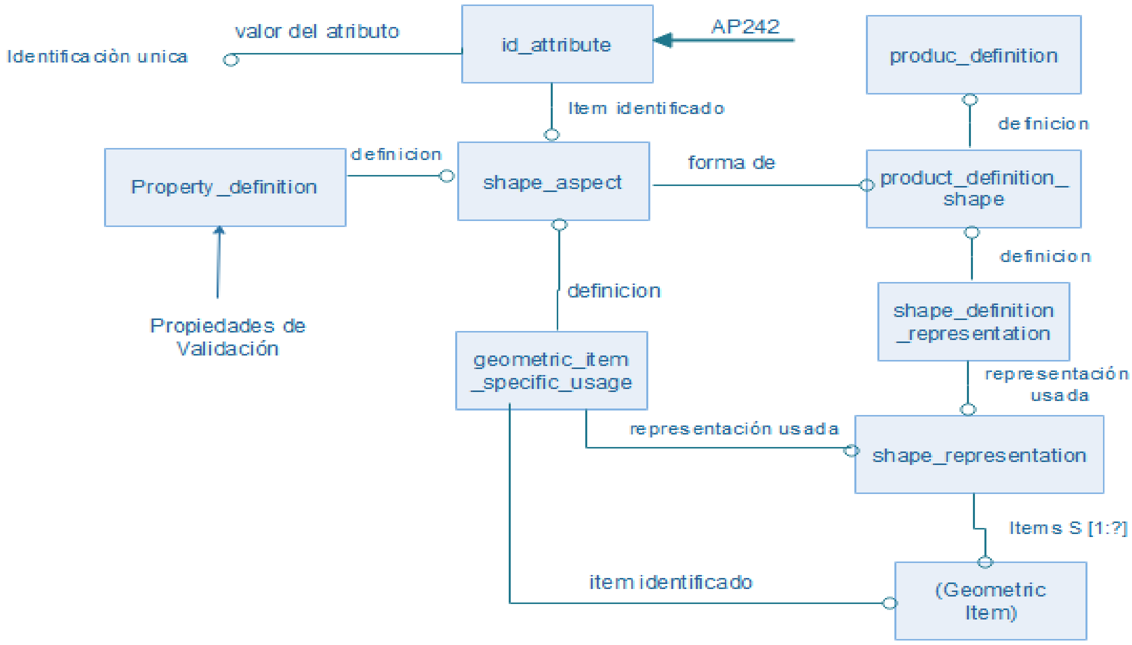

Figure 8: Validation properties at tessellated geometry level ISO 10303 AP242

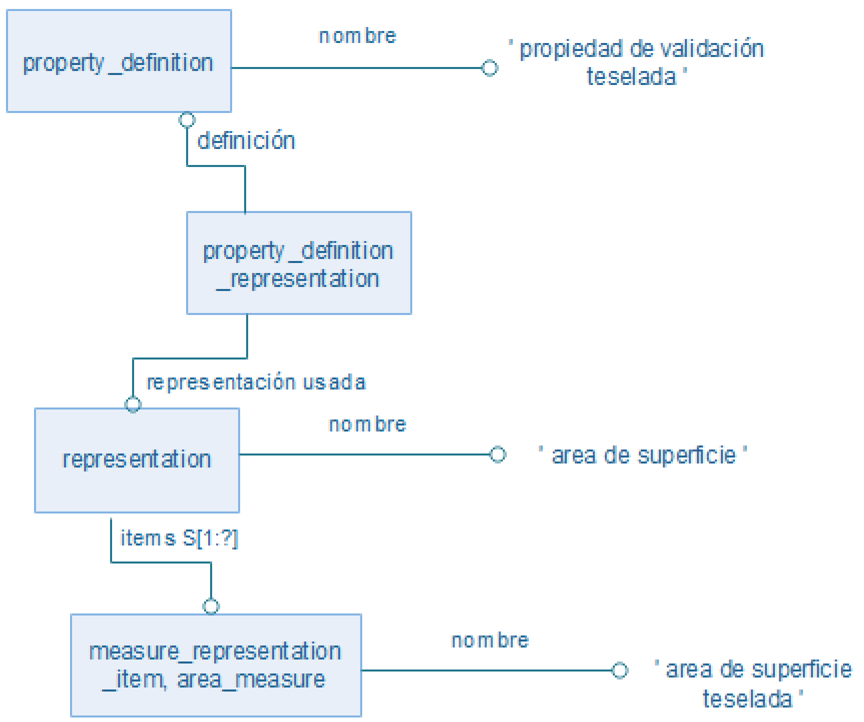

Figure 9: tessellated Validation Property "Tessellated Surface Area" ISO 10303 Part 21 AP242

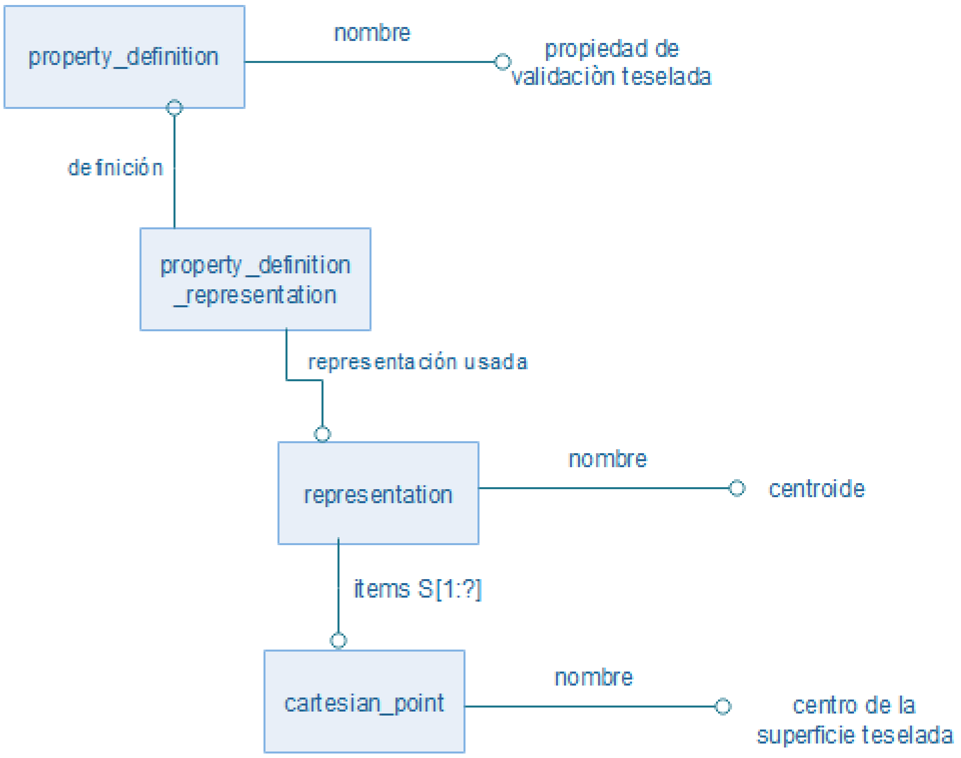

Figure 10: tessellated validation property "Central point tessellated surface". ISO 10303 Part 21 AP242

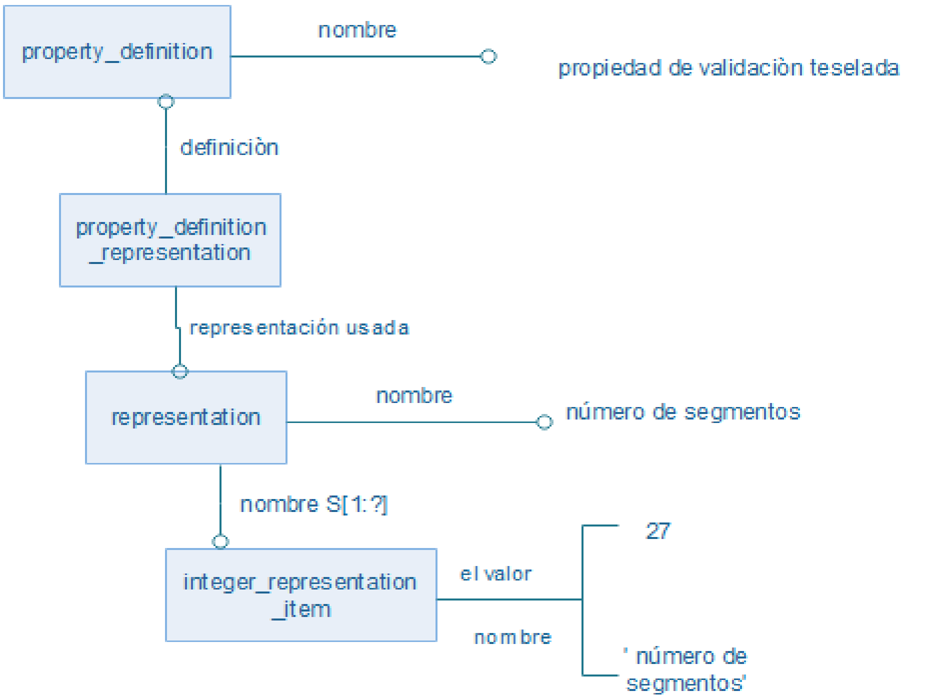

Figure 11: tessellated validation property "Number of segments" ISO 10303 Part 21 AP242

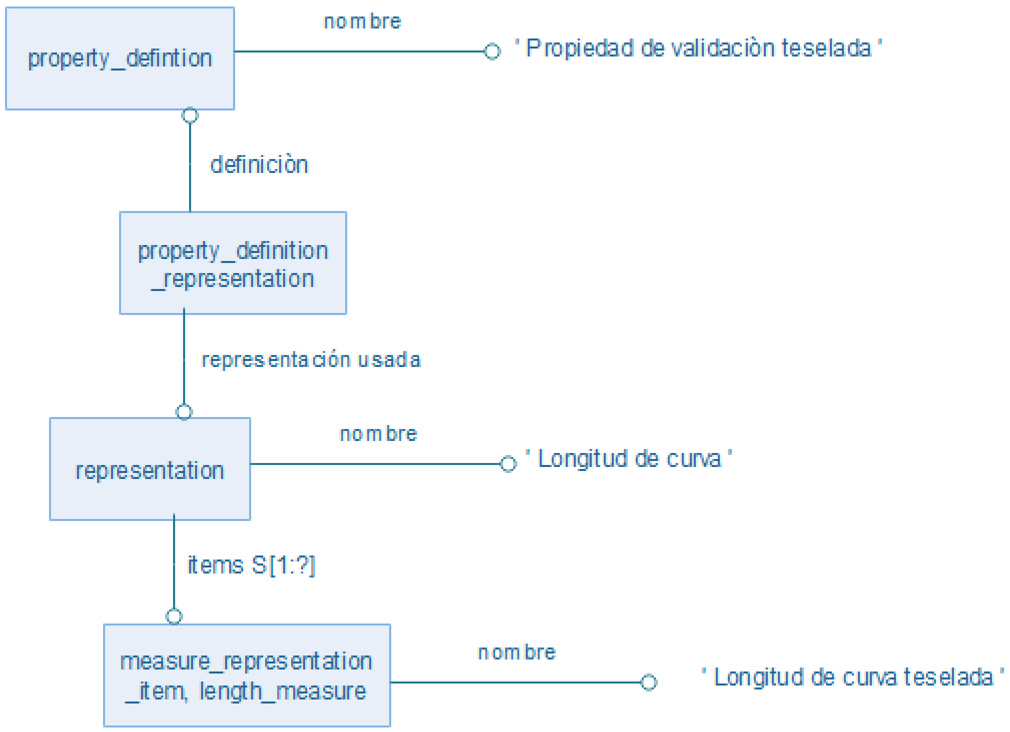

Figure 12: tessellated validation property "Length of the tessellated curve". ISO 10303 Part 21 AP242

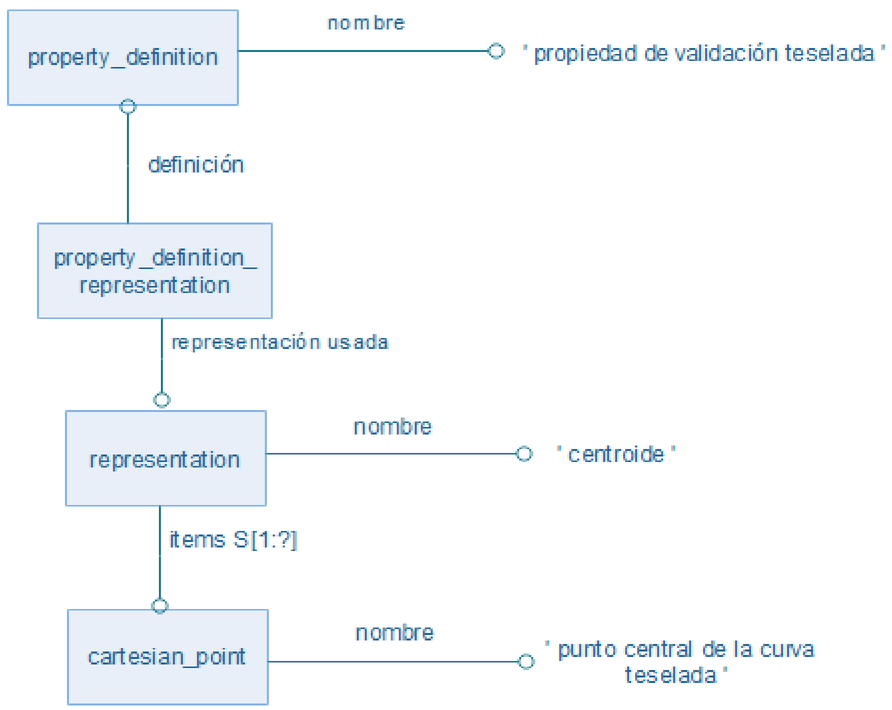

Figure 13: tessellated validation property "central point of the tessellated curve". ISO 10303 Part 21 AP242

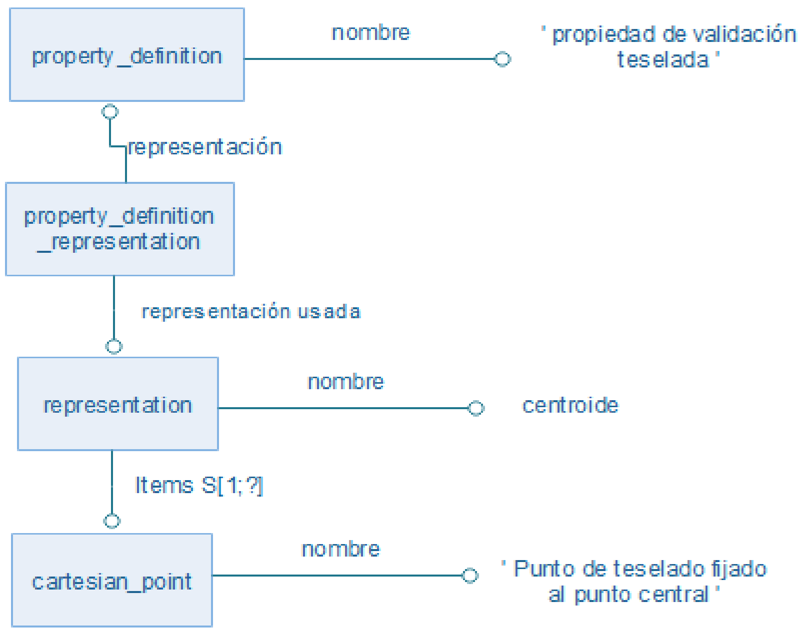

Figure 14: tessellated validation property "tessellated point fixed to the central point". ISO 10303 Part 21 AP242

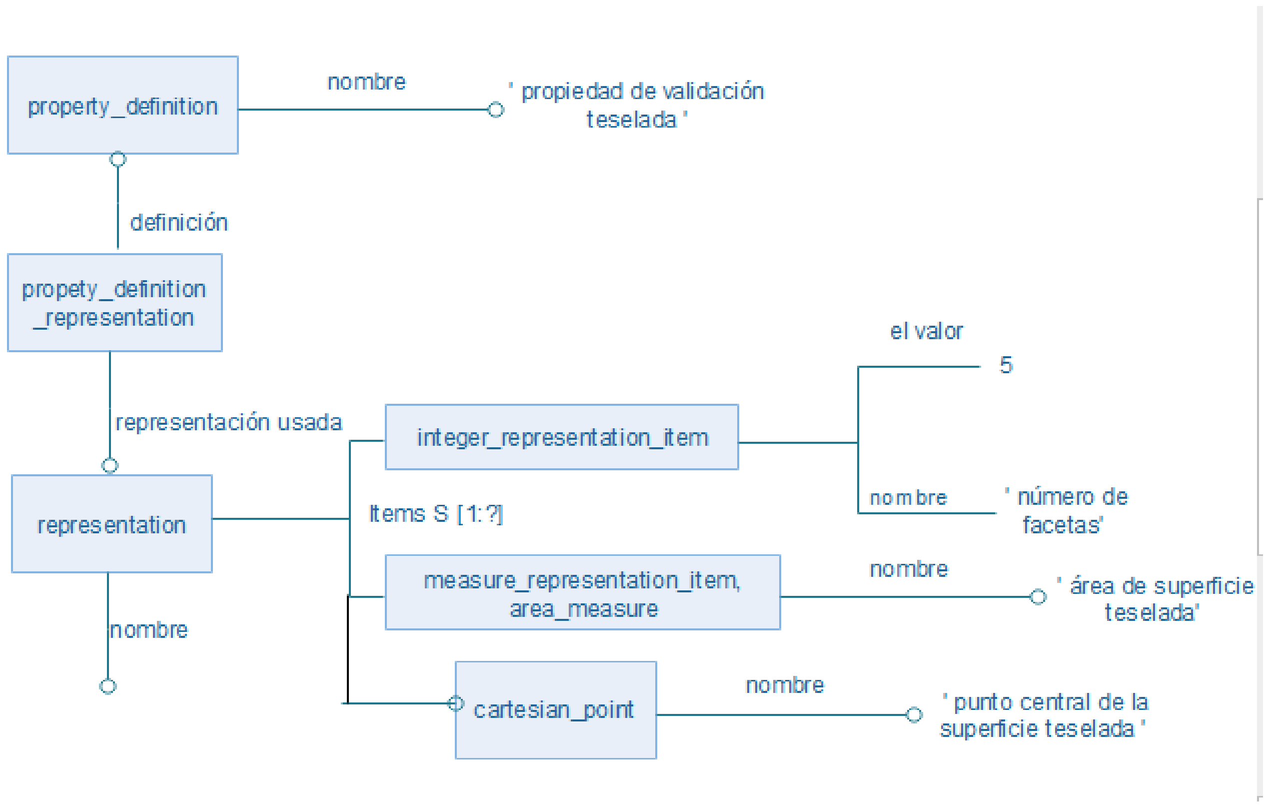

Figure 15: Combination of the number of facets, tessellated surface area and central point of the tessellated surface ISO 10303 AP242

4. Comparative with other models

By comparing the proposed model of this study with some existing ones, the following can be stated:

a) When comparing the model proposed in this study with the model presented by Rodríguez, Álvarez and Bonnard related to a model based on STEP - NC, it can be said that the proposed model is in line with the authors; it is considered as a key point that the information model for AM allows interoperability and the transparent flow of information since they play a preponderant role within AM [5].

b) The proposed model is related to an application protocol of STEP, specifically AP 242, characterized for 3D Engineering based on managed models, which makes it different from other models that have considered STEP AP219 for the exchange of dimensional inspection information and AP238 for the definition and exchange of product data, as well as another model that considers STEP-NC [1,3,4].

c) The model of this study, when considering STEP 10303 AP 242 when compared with other models, has positive considerations for electrical design in the following domains: 3D geometry, for example, improvements for 3D textures, tessellation of curves, 3D semantic representation, composite design and mechanical design (improvement for the machining function, additive manufacturing design information).

d) The proposed model, using STEP 10303 AP 242 (integrated ISO standard), with respect to other models will cover the interoperability capabilities of the product information for: Product data management, design based on 3D models with PMI (e.g. Dimensions and geometric tolerances), Mechanical, compound and electrical harness design. In addition, it considers definitions for three-dimensional geometry, assembly data and basic product information.

e) Additionally, the proposed information model has added value over others that do not consider it, by integrating a KBE repository that handles metadata from visualization applications, PDM systems, CAD applications and STEP files, in order to build a KBE for the common understanding of the processes and business objects of the additive manufacturing product life cycle.

5. Discussion and conclusion

The proposed information model has strengths in terms of interoperability and transparent information flow in AM as well as other developed models. It is also a strengthened model since it makes use of ISO 10303 - STEP AP 242 which is considered an integrated ISO standard that will cover the interoperability capabilities of product information.

Since the proposed model is based on the interoperability capacity of STEP files and using the elements already present within the programming resources defined by STEP, the model has the advantage and strength of adding new services focused on the flow of data and information to meet data exchange needs.

The model proposed in this study differs from other models already proposed, since it assumes the AP 242 that is specific for 3D Engineering based on managed models, unlike other proposals that have assumed the STEP 10303 standard but from the perspective of other application protocols [4,5].

Given that the proposal was developed under the market standard for the additive manufacturing ISO 10303 AP242 that uses the most extended neutral format, the future implementation of the model as a software product has a wide possibility of being used. Likewise, it is an active and continuously growing standard, which constantly generates numerous sub-standards for specific uses in various areas.

Likewise, the proposal contemplates transporting the best and largest amount of useful information possible to produce the best quality cuts, by integrating in a single format the information required by CAD and CAM systems. This is one reason why the model preserves the geometric information that helps overcome the inaccuracies generated by the diversity of formats in information exchange files.

We have to mention that the infinity of possibilities of development is the main advantage of the proposed model; to achieve that the different parties work sharing a standard format allows a considerable advantage, assured by the guarantee of having the complete and exact information, as well as the feedback of all the parties in the same model.

The proposed model has as a disadvantage the fact that it is not focused on any specific industry nor is it validated as such in any sector, therefore it is an unvalidated model.

The following lines of work resulting from this study are proposed:

1. Validate this proposal in a specific industrial context.

2. To be able to integrate the proposed model with another technology such as the Internet of things and augmented reality.

3. Make use of the model in hybrid manufacturing systems, where similar subtractive manufacturing models can be incorporated to complete the proposed modelling.

Special Thanks

I want to express my gratitude to everybody who has suffered my absence during my dedication to this research.

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