International Journal of Computer and Information Technology (ISSN: 2279 – 0764)
Volume 04 – Issue 02, March 2015

Evaluation of Shape Representation Methods in STEP for Korean Industry

Hyun Chan Lee
Industrial Engineering Department
Hongik University
Seoul, Republic of Korea
Email: hclee [AT] hongik.ac.kr

Abstract-**The international standard STEP stands for standard for exchange of product model data. It represents ISO 10303. In the STEP, common shape representation is supported by various part groups. In this paper, four major part groups are investigated. The first part group is part 40's, the integrated generic resources, which provide the fundamental framework for shape representation. The second part group is part 500's, the AIC (Application Interpreted Constructs), which provide common shape representation for APs (Application Protocol). The third part group is part 50's and 100's, the parametrics, which provide the representation schemes for variational geometric design and history-based parametric design. The fourth part group is the rest of STEP parts which are involved in shape representation such as AP 203. In this paper, these part groups are summarized in terms of common shape representation supports and relationship among these parts are analyzed. Finally, based on the analysis, future works in these fields in Korea are proposed.**

Keywords-STEP(ISO 10303); shape representation; product model data exchange; neutral format.

I. INTRODUCTION

International Standard STEP (STandard for Exchange of Product model data, ISO 10303) defines the neutral file formats to exchange product model data among various systems [27]. STEP includes a lot of documents, but it is well structured. The main purpose of this study on the common shape representation parts in STEP is to thoroughly analyze the representation methods of product attributes and shapes. For this purpose, first, we put together various shape representation parts in STEP, and then compare the parts to clarify the similarities and differences of the parts. As a result of the comparison, we will suggest a guideline for using STEP in Korean industry practices.

Common resources for shape representation in STEP can be classified into the following 4 categories.

- Integrated generic resources: Parts for representing general product shapes and structures, which includes parts 42, 43, and 44.
- AIC(Application Interpreted Constructs): Shape representation methods are defined by AIC parts, which are numbered in 500s.
- Parametric design methodology: Various parametric design methods are defined in Integrated Resources, which include parts 55, 108, 111, and 112.
- Other shape representation related parts: Above mentioned shape representation related parts are included in Common Resources in STEP. The other part which connects the shape representation methods to industrial applications is AP (Application Protocol) 203.

The four categories are structured in hierarchy as the basics in lower area and more application oriented one in higher area as shown in Figure 1. In this paper, we analyze and discuss the four categories from lower to higher areas. In Section II, the first basic category, integrated generic resources, is explained. In Section III, shape representation methods classified as AIC are compared based on the representation objects. In Section IV, parametric representation methods are explained along with parts that support the methods. This category is more closely related to industrial design practices and productivity. In Section V, AP 203 Edition 2 is explained in terms of industrial application of the shape representation methods. In Section VI, how the categories are related and complement each other. In Section 7, how the common shape representation methods can be applied to Korean industries to increase product design and management productivity.

II. INTEGRATED GENERIC RESOURCES PARTS

In STEP, a single product data model is developed to accommodate common requirements from various industries. The basic resources for the product data model are defined in parts included in integrated resource classes. The integrated resources are documented in several parts. They are classified into two groups as follows:

- Integrated generic resources (parts 41~99) define components of application independent conceptual product data model. For example, part 42 geometric and topological representation defines context independent standard representation of object shapes.

- Integrated application resources (parts 101~199) support requirements of specific application groups by expanding common resources. For example, part 101 draughting includes or uses engineering draft and defines common data requirement of all applications.

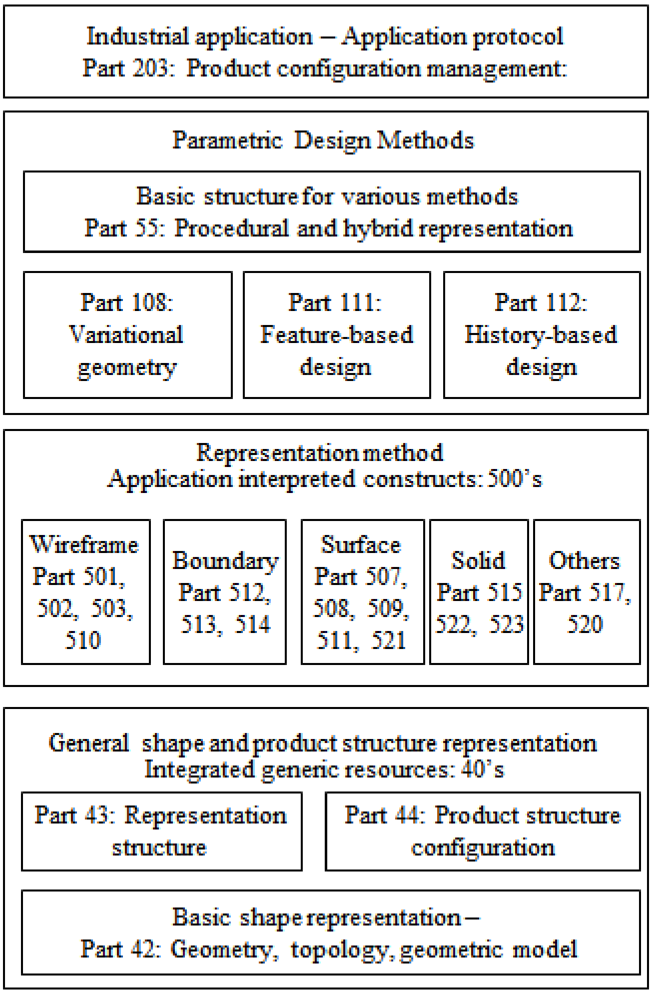

Figure 1. Parts structure for common shape representation

Integrated resources provide standard definitions for STEP AP (Application Protocol) developers. However, it does not mean direct implementation. The mechanism is similar to a group of function library in programming language which programmers use. Integrated resources define reusable components. The components are intended to be modified in AP depend on a specific requirement of the AP. Among parts in integrated generic resources, common shape representation related parts are part 42 [2], part 43 [3], and part 44 [4]. The basic concepts and contents of the parts are as follows:

- Part 42: Geometric and topological representation specifies resources for the explicit geometric and topological representation of product shapes. Application scope is determined by requirements for the explicit representation of the ideal product models. Geometry and topology can be used independently and widely used by various aspects of geometric shape models. This part also specifies concepts of representation in geometric application of representation elements.

- Part 43: Representation structures describe overall structure of representation and obviously geometric representation is special case of them. They are used in describing representation for connecting entities into collection. Relationships among collections can be also described.

- Part 44: Product structure configuration specifies basic resources required for product structure and configuration management during product development. Product structure configuration information is important in various product development steps, such as requirement analysis, initial product concept, product schematics, engineering analysis, detailed product design, manufacturing engineering, etc. Product structure configuration information is important in controlling versions of the same product due to changes during product development.

In part 42, representation methods for geometry, topology, and geometric models are defined. The relationships among such methods are structured in part 43. Once components are defined, how the components are combined to form a product is defined in part 44.

III. APPLICATION INTERPRETED CONSTRUCTS (AIC)

In STEP, if two or more AP have the same shape requirement, AIC can be initiated and support the APs. The common shape components are defined in the initiated AIC. The part number of AIC starts from 501. AIC include more shape representation methods oriented definitions than integrated generic resources. The shape representation methods are traditionally developed in geometry research groups.

In this section, AIC parts are compared according to the shape representation methods. The shape representation methods include wireframe representation, boundary representation, surface modeling, and solid modeling. The similarities and differences of the AICs in each representation method are analyzed.

A. *Wireframe related AIC parts*

Wireframe representation method represents the shapes using wires and it is traditional method to represent shapes. In the AIC, four different wireframe methods are defined as follows:

- AIC 501: Edge-based wireframe [10],
- AIC 502: Shell-based wireframe [11],

- AIC 503: Geometrically bounded 2D (two-dimensional) wireframe [12],
- AIC 510: Geometrically bounded wireframe [16].

AIC 502 uses the same geometric elements as AIC 501, but AIC 502 uses more topological elements, such as vertex_shell, wire_shell, and path on their vertex and edge topological elements such as edge_cureve, edge_loop, vertex_loop, and vertex_point. The scopes of four AIC parts representing wireframe models are compared in Table I.

TABLE I. Scope comparison among 4 AICs representing wireframe models

<table>
<tr><th>AIC 501</th><th>AIC 502</th><th>AIC 503</th><th>AIC 510</th></tr>
<tr><td colspan="2">• Representation of wireframe models described by graphs consisting of vertices and edges intersecting their own vertices
• Points defined in 3D coordinate space
• Curves including b-spline defined in 3D coordinate space
• Representation of one wireframe model or group of wireframe models</td><td rowspan="2">• Points defined in 2D coordinate space
• Trimmed curves by a point and a curve defined in 2D coordinate space
• Self-intersecting curves defined in 2D coordinate space
• Group representation of one or more wireframe models</td><td rowspan="2">• Structure of points and curves in 3D Euclidean coordinate space
• Use of wireframe structure for shape representation
• Composition of representations to form representation group</td></tr>
<tr><td>• Representation of wireframe models of set of one or more connected edges which are not overlap or intersect other than their vertices or edges</td><td>• Representation of wireframe models of one or more shells which are not overlap or intersect other than their vertices or edges</td></tr>
</table>

B. Boundary representation related AIC parts

Boundary representation (B-rep) method represents a shape using boundary elements such as vertex, edge, and face. This method is most commonly used in industry. In the AIC, three different boundary representation methods are defined as follows:

- AIC 512: Faceted boundary representation [18],
- AIC 513: Elementary boundary representation [19],
- AIC 514: Advanced boundary representation [20].

The scopes of three AIC parts representing boundary models are compared in Table II.

TABLE III. Scope comparison among 3 AICs representing boundary models

<table>
<tr><th>AIC 512</th><th>AIC 513</th><th>AIC 514</th></tr>
<tr><td colspan="3">• 3D geometry, B-reps, unbounded geometry, geometric transformations
• Use topology to bound geometric entities</td></tr>
<tr><td>• B-rep models
• Faceted B-reps
• Polyloops</td><td>• The definition of an elementary b-rep shape representation, this is a representation composed of one or more manifold_solid_breps each of which is defined with elementary geometry and complete explicit topology
• The definition of the unbounded geometry of curves and surfaces used in the definition of the faces of such a B-rep model
• The definition of the topological structure of a B-rep model
• Elementary curves, these are lines or conics
• Elementary surfaces
• Polylines</td><td>• B-rep models
• B-spline curves and surfaces
• Elementary curves, conics
• Polylines, pcurves, twisted curves, surface curves
• Elementary surfaces, sculptured surfaces, swept surfaces</td></tr>
</table>

C. Surface modeling related AIC parts

Surface representation method provide tools to represent free-form surfaces. In the AIC, five different surface models are defined as follows:

- AIC 507: Geometrically bounded surface [13],
- AIC 508: Non-manifold surface [14],
- AIC 509: Manifold surface [15],
- AIC 511: Topologically bounded surface [17],
- AIC 521: Manifold subsurface [22].

The scopes of five AIC parts representing surface models are compared in Table III.

D. Solid modeling related AIC parts

Solid representation method defines a shape using three-dimensional solids. In the AIC, three different solid models are defined as follows:

- AIC 515: CSG: Constructive Solid Geometry [21],
- AIC 522: Machining features [23],
- AIC 523: Curve swept solid [24].

The scopes of three AIC parts representing solid models are compared in Table IV.

TABLE IIIII. Scope comparison among 5 AICs representing surface models

<table>
<tr><th>AIC 507</th><th>AIC 508</th><th>AIC 509</th><th>AIC 511</th><th>AIC 521</th></tr>
<tr><td colspan="4">• The elementary curves line, circle, ellipse, parabola, and hyperbola
• The elementary surfaces plane, cylinder, cone, torus, and sphere
• Polylines that consist of at least three points
• Swept surfaces created by rotation or linear extrusion of a curve</td><td rowspan="2">• Advanced faces
• Subset of connected faces
• Mapping
• Open shells
• Relationships among domains of topological objects
• Subedges
• Subfaces
• Bounded geometry having related topological boundary</td></tr>
<tr><td colspan="3">• 3D point and curves
• Points defined in the parameter space of curves or surfaces,
• Curves defined in the parameter space of surfaces
• Intersection curves
• Replication of curves, surfaces, and surface models
• 3D offsets of curves and surfaces</td><td>• B-spline curves and surfaces
• Conic curves
• Pcurve
• Sculptured surfaces
• Surface curves represented by pcurve
• Twisted curves
• Unbounded geometry</td></tr>
<tr><td rowspan="2">• Trimming of curves and surfaces
• Composition of curves and surfaces</td><td colspan="2">• Sculptured curves and surfaces
• Trimming of curves and surfaces using topological entities
• Composition of curves and surfaces using topological entities</td><td colspan="2" rowspan="2">• 3D geometry
• Geometric transformation
• Use of topology for limiting geometric entities</td></tr>
<tr><td>• Non-manifolds</td><td>• 2-manifolds</td></tr>
</table>

TABLE IV. Scope comparison among 3 AICs representing solid models

AIC 515	AIC 522	AIC 523
• Solid primitives • Regularised boolean operations of union, intersection, and difference on solid primitives, manifold • Brep and other solids • Extruded_face_solids and swept_face_solids to define new primitive shapes • Boolean results generated by applying operators to solids	• Features that are to be manufactured by either milling or turning processes • Machining features for defining shapes necessary for manufacturing • Machining feature definition elements necessary for creating machining features • Shape representations necessary for creating machining features • Features that can be replicated in patterns • Implicit representation of machining features through selection of standard parameters	• 3D geometry • Directrix curves • Swept area solids • Swept disk solids • Surface curve swept area solids • Use of B-spline surfaces to define a ruled surface for the purpose of defining a swept solid • Planar areas with explicit geometric bounds

IV. PARAMETRIC SHAPE REPRESENTATION RELATED PARTS

The major purpose of the parametrics group in STEP is to implement representation methods for procedural design attributes, i.e. design intents [25]. The parametric related parts in STEP add functions of representing procedural design history to the existing explicit shape representation capability of STEP. STEP part 108 [6] enables parametric design using variational geometry method by adding constraint relationships among shape elements. However this method requires strong solver to solve the relationship equations simultaneously. It becomes more difficult to get a solution as the number of the equations grows.

To solve such problem, STEP part 55 [5] is provided, which enables procedural and hybrid representation model. The part 55 provides a method to identify the sequence of design operations. The method enables construction history based design. The receiving CAD system simply re-executes the received design sequence from the sending system to construct the exchanged product model. Therefore this method does not need strong solvers. During the reconstruction, the receiving CAD system can generate explicit models so that the new model is compatible with the existing shapes.

The commands for procedural operations based on STEP part 55 are defined in part 112 [8] and part 111 [7]. The part 112 defined 2D sketch commands based on the MP (Macro-Parametric) concept and the part 111 defines construction history features. The part 112 and part 111 provide commands to be used in practical operations for procedural models. The relationships among Parts related to parametric shape representation are given in Figure 2.

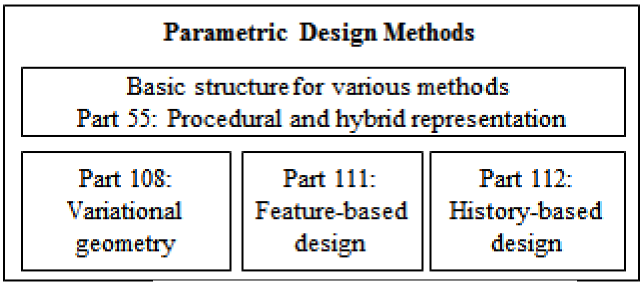

Figure 2. Parts structure for parametric design methods

V. OTHER SHAPE REPRESENTATION RELATED PARTS

The purpose of the part AP 203 [9] is to guide the usage of shape representation methods in application protocols. AP 203 guides information management of overall product model, and the major portion of the product information is shape information. This AP is supported by almost all CAD systems. In this section, we investigate the important features of the AP 203, especially focused on shape representation aspects.

AP 203 specifies usage of product data satisfying in the context of industrial requirements for exchanging design data of 3D mechanical parts and assembly components. To represent components of products, organizations are using various computer based application systems. The items includes in the product definition are specifications of product shape, specifications of product configuration, application of multiple definitions to a specific configuration, etc. Such data exist in more than one application systems in an organization. The integration of data which define the shapes of products including the data related to configuration is essential to establish organization's capability to define products without redundancy in various application systems. To communicate each other through the design definition of products, an organization shall be able to share the product data with partners, vendors, customers, etc.

Major activities included in AP 203 are as follows:

- Identification of product related to organizational customers and identification of components of product,
- Shape description of product components,
- Documents on formal change and release of product design,
- Product history including formal procedures of initiation, change, and release,
- Identification of approved supplier for product or product design.

AP 203 edition 2 is expanded to provide more representation capabilities than edition 1 by accommodating EXPRESS language edition 2, synchronizing AP 214, and adapting PDM (Product Data Management) concepts. The added representation capabilities are as follows.

- PDM: By allowing exchange of assembly and PDM information, facilitate the exchange of knowledge among CAD (Computer-Aided Design), CAM (Computer-Aided Manufacturing), and CAE (Computer-Aided Engineering) systems. It also reduces design costs by transferring complete product model data among systems,
- Geometric validation property: Adding capability for user to evaluate whether the data exchange is successful or not through exchanging physical properties such as volume, surface area, center of gravity, etc.,
- Geometric presentation: Adding geometric presentation structure including color, layer, and group. I.e. adding capability to assign color and position information to objects in different layers of a model,
- 3D associate characters: Providing capability to display character information on 3D models,
- Geometric dimensioning and tolerance: Providing capability to exchange dimensioning and tolerance information as constraints on shapes of the product,
- CSG: Providing capability to exchange design construction history using solid modeling primitives including cube, cylinder, cone, sphere, complex swept solid, etc.
- Addition of work management capability,
- Improvement of document management structure,
- Referencing formally most advanced edition of all other parts in STEP.

VI. RELATIONSHIP AMONG PARTS

In the introduction section, we already showed the basic structure of STEP related to general shape representation as Figure 1. Based on the figure, we sequentially analyze the related parts. In this section, we restructure the parts in the context of STEP development history and application of the parts.

The shape representation in STEP is the basics of product models and the main focus of the STEP in the early development stages. Therefore parts 40s which are resources for product model definition was developed from the beginning of STEP development. Part 41 does not include detailed contents on the shape representation because this part is the framework for overall product model data [1]. On the other hand, the next three parts 42, 43, and 44 include basics of the shape representation.

Part 42 consists of representations of geometry and topology which are the basic components of product shapes and the basics of geometric representation methods which are the combinations of geometry and topology. This part includes basics on the shape representation in the STEP, and the most shape representations in the STEP are rooted to this part. Such basic shape representations are defined by product parts or geometric or topological elements. They are put together to form an integrated product using relationships of the coordinate systems of the parts and elements. Part 43 defines the representation structure of the integrated product. This completes the shape representation of an integrated product. The assembled parts form a product, and the structure is referred as BOM (Bill Of Material). The BOM is defined in part 44. The three parts of integrated generic resources provide basic tools for product shape representation.

Even if basic shape representation methods are defined in integrated generic resources, they define the methods based on the geometric and topological elements rather than traditionally used representation methods. In addition, shape representation methods are differently used by industry because the methods are differently interpreted in different industry. To cope with such differences and to increase the usage of the methods in APs, AICs are developed. Each AIC define a self-completed representation method which is used by more than 2 APs. As above mentioned, part 42 provides a basic representation framework for geometric models. Each AIC specifies a representation method and segments the method into several specialized methods based on application areas.

The basic shape representation methods provided by AICs are wireframe representation, boundary representation, surface modeling, solid modeling, and other draft related methods. However, there can be slight differences depending on industry, wireframe representation methods are specialized into 4 sub-categories as given in section III.A. Similarly other methods are also specialized into 3~5 subcategories as given in section III.

The shape representation methods explained above can be classified as explicit methods, i.e. the methods can be applied to completely determined shapes. However, the shapes can be changed according to the situations. Therefore, parametric representation methods are included in STEP. The framework for the parametric representation is given in part 55, which defines the procedural and hybrid representation for various methods. This part is included in integrated generic resources. The procedural and hybrid representation enables parametric shape representation of the products.

Under the framework of part 55, three design methods are implemented in STEP. The first one is part 101, which specifies a design method using variational geometry. In this method, relationships among geometric elements are represented as mathematical constraints. By solving the constraints simultaneously, the final shape is determined. New shapes can be generated by change one or more constraints. The second one is part 111, which specifies feature-based design method, which is adapted by most CAD systems. In this method, featured are defined and put into a feature library, and the features are combined using set operators to form a shape. New shapes can be generated by change one or more dimensional sizes of the used features. The third one is part 112, which specifies macro-parametric method. In this method, the shapes are defined by series of commands. By executing the commands, the final shape can be obtained. New shapes can be generated by change one or more commands. However, this method is limited to use 2D sketch commands. These parametric representation methods can increase designers' productivity tremendously.

The above mentioned shape representation methods can be used in the industrial fields through APs. AP 203 specifies product configuration management for all industrial products. Therefore AP 203 is located in the top of the shape representation framework as given in Figure 3.

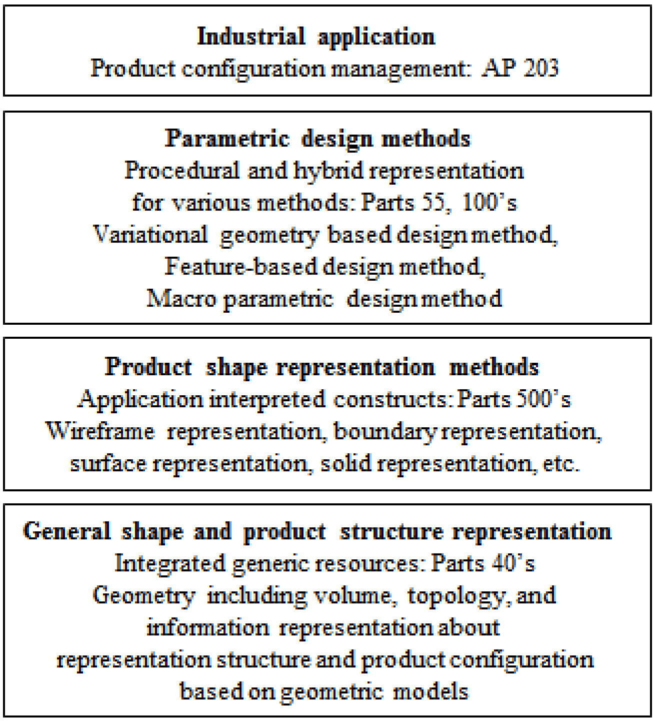

Figure 3. Relationships among parts for common shape representation

VII. APPLICATION GUIDELINE FOR KOREAN INDUSTRY

General shape representation methods are structured in the previous sections. The introduced parts are already processed to become international standards. Based on the international process, the parts are mostly adapted as KS (Korean Standard). However, the usage of the standards is not widely reported. The reason for the slow adaptation is due to the complexity of the STEP. The analysis and comparison of the shape representation methods in this paper will help the wide use of STEP in Korea industry.

The application of STEP to specific industry can be accelerated by AP of the industry. However, shape representation methods are closely relate to CAD system. Whether a certain CAD system adapt the STEP depends on the widely used practices in the industry. Since the Korean companies are heavy users of commercially available CAD systems, they can push the vendor to adapt STEP for more flexible shape representation. Especially parametric representation methods are very useful in increasing productivity of the designers.

STEP is not the only international standard for product shape representation. Depending on the international development on standards, several standards are available for a certain industry. For example, three international standards can be used in process plant industry as given in Figure 4 [26]. GPM(Generic product model) is a nuclear plant oriented specialized standard mostly used by Japanese nuclear plant industry. ISO 15926 is an international standard for process plant industry. It uses the STEP models for the shape representation and added more features for increasing flexibility in shape representation based on plant industry requirements. By combining STEP and ISO 15926, process plant industry has well adapted newly arose technical problems in plant configuration management.

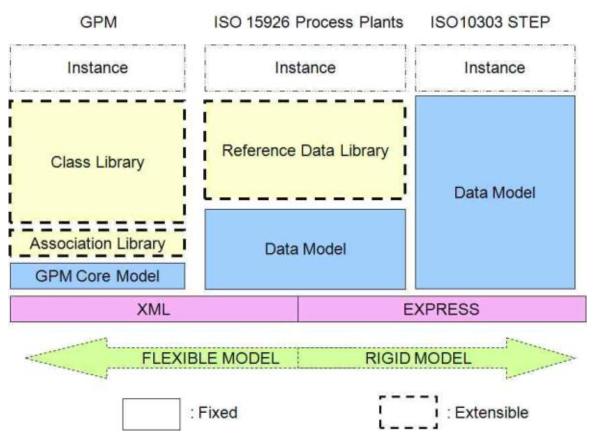

Figure 4. Comparison of neutral formats for process plant industry

As the example of process plant industry shows, each industry has its own direction for the future. Korean companies have to participate more aggressively in making international standards in their industry. Introduced STEP shape representation in this paper can be the basis for the further development of other international standards.

ACKNOWLEDGMENT

This work was partially supported by KEPCO E&C Research Fund (CC000-13-2081) and also partially supported by 2013 Hongik University Research Fund.

REFERENCES

[1] ISO 10303-41: Industrial automation systems and integration - Product data representation and exchange – Part 41: Integrated generic resources: Fundamentals of product description and support.

[2] ISO 10303-42: Industrial automation systems and integration - Product data representation and exchange – Part 42: Integrated generic resources: Geometric and topological representation.

[3] ISO 10303-43: Industrial automation systems and integration - Product data representation and exchange – Part 43: Integrated generic resources: Representation structures.

[4] ISO 10303-44: Industrial automation systems and integration - Product data representation and exchange – Part 44: Integrated generic resource: Procedural structure configuration..

[5] ISO 10303-55: Industrial automation systems and integration - Product data representation and exchange – Part 55: Integrated generic resource: Procedural and hybrid representation.

[6] ISO 10303-108: Industrial automation systems and integration - product data representation and exchange - Part 108: integrated application resource: parameterization and constraints for explicit geometric product models.

[7] ISO 10303-111: Industrial automation systems and integration - Product data representation and exchange: Part 111: Integrated application resource: Construction history features.

[8] ISO 10303-112: Industrial automation systems and integration - Product data representation and exchange: Part 112: Integrated application resource: Modeling commands for the exchange of procedurally represented 2D CAD models.

[9] ISO 10303-203: Industrial automation systems and integration - Product data representation and exchange: Part 203: Application protocol: Configuration controlled design.

[10] ISO 10303-501: Industrial automation systems and integration - Product data representation and exchange: Part 501: Application interpreted construct: Edge-based wireframe.

[11] ISO 10303-502: Industrial automation systems and integration - Product data representation and exchange: Part 502: Application interpreted construct: Shell-based wireframe.

[12] ISO 10303-503: Industrial automation systems and integration - Product data representation and exchange: Part 503: Application interpreted construct: Geometrically bounded 2d wireframe.

[13] ISO 10303-507: Industrial automation systems and integration - Product data representation and exchange: Part 507: Application interpreted construct: Geometrically bounded surface.

[14] ISO 10303-508: Industrial automation systems and integration - Product data representation and exchange: Part 508: Application interpreted construct: Non-manifold surface.

[15] ISO 10303-509: Industrial automation systems and integration - Product data representation and exchange: Part 509: Application interpreted construct: 2-manifold surface.

[16] ISO 10303-510: Industrial automation systems and integration - Product data representation and exchange: Part 510: Application interpreted construct: Geometrically bounded wireframe.

[17] ISO 10303-511: Industrial automation systems and integration - Product data representation and exchange: Part 511: Application interpreted construct: Topologically bounded surface.

[18] ISO 10303-512: Industrial automation systems and integration - Product data representation and exchange: Part 512: Application interpreted construct: Faceted boundary representation.

[19] ISO 10303-513: Industrial automation systems and integration - Product data representation and exchange: Part 513: Application interpreted construct: Elementary boundary representation.

[20] ISO 10303-514: Industrial automation systems and integration - Product data representation and exchange: Part 514: Application interpreted construct: Advanced boundary representation.

[21] ISO 10303-515: Industrial automation systems and integration - Product data representation and exchange: Part 515: Application interpreted construct: Constructive solid geometry.

[22] ISO 10303-521: Industrial automation systems and integration - Product data representation and exchange: Part 521: Application interpreted construct: Manifold subsurface.

[23] ISO 10303-522: Industrial automation systems and integration - Product data representation and exchange: Part 522: Application interpreted construct: Machining features.

[24] ISO 10303-523: Industrial automation systems and integration - Product data representation and exchange: Part 523: Application interpreted construct: Curve swept solid.

[25] Hyun Chan Lee, "Strategies for Using STEP in Parametric Design," International Journal of Computer and Information Technology, Vol. 2, No. 4, pp. 549-556, July 2013.

[26] Duhwan Mun, Jinsang Hwang, Soonhung Han, Hiroshi Seki, Jeongsam Yang, "Sharing product data of nuclear power plants across their lifecycles by utilizing a neutral model", Annals of Nuclear Energy, Vol. 35, No. 2, pp. 175-186, 2008.

[27] S. H. Han, H. C. Lee, STEP for Digital Manufacturing (Korean), Internet version, ISBN No: 8445-056-1 93560, Sigma Press, http://kstep.or.kr/kstep_introduction/step_book/toc.htm, May 2000.

[28] STEP Application handbook [Available online: http://www.isg-scra.org/STEP/]

[29] PDES, Inc., http://pdesinc.aticorp.org/

[30] STEPml, http://www.stepml.org/

[31] STEPnet, http://www.stepnet.org

[32] Internation Industry STEP Center, http://isc.aticorp.org/

[33] EuroSTEP, http://www.eurostep.com/

[34] Association GOSET, http://www.goset.asso.fr/

[35] Korea STEP Center, http://www.kstep.or.kr/