

## Theoretical Study of Quick Design Modification of the Auto CAD-based Serialization of Products

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**Abstract:** Based on the analysis of the need for serialization of products, a theoretical model of an interactive dimension-driven quick design modification has been built to realize Auto CAD-based quick design modification. A classified parameter storing mechanism has been made through the analysis of the property of designing parameters. A quick drawing module has been built by making use of the parameterized drawing principle. Based on the analysis of the properties of the drawing entities, a parameter identification principle has been set up by making use of “Entity Types” and “Entity Handles”, and a dimension-driven based, automatic drawing generation with variable dimensions and an interactive quick design platform has been further built, and this platform can be used to quickly draw the finalized designs and to modify the design based on the dimension-driven variable specifications so that the deficiency of “dimensions cannot drive drawings” in Auto CAD system has been solved, that the designing efficiency in realizing the promotion of the individualization and serialization of products in small quantities has been effectively increased, and that a theoretical support has been given for the construction of CAD system of this kind of products. *Copyright © 2013 IFSA.*

**Keywords:** Auto CAD, Serialization of products, Design modification, Dimension-driven, Parameterization.

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### 1. Introduction

At present, 2-D drawings are still the main carriers of the information of products due to the limit of the manufacturing technology and the level of equipment. According to statistics, about 80 % of the engineering drawings are finished in 2-D designs [1]. Small serialization of products shares the same structure and technology [2]. The focus of the design is to calculate the dimensions of the drawings and to make quick drawings according to the selected type of the products and its specifications, or to make quick modifications on the original drawings so that they can be quickly put into production [3].

Auto CAD system is one of the widely applied CAD systems [4], which does not have great

advantages over other systems in terms of the quick design of the serialization of products due to its lack of dimension-driven drawing functions [5]. The quick generation of the drawings with the appointed specifications and the quick modification in terms of dimension of the original designs are the common problems that designers are faced up with, and these problems are also the targets that need to be solved in the construction of the CAD platform.

The drawings generated by the Auto CAD system are supported by complete drawings and their data, and an exact mapping relationship has been built [6], and at the same time, this system also provides plenty of secondary developing tools, which have effective supports for the operation of the bottom layer data of drawings and quick design

modifications. On the basis of the analysis of the need for design of the serialization of products, a theoretical model with a feature of an interactive dimension-driven quick designing has been put forward in this paper. After further study, the classified data storing mechanism of the products has been given, and a parameterization drawing principle and an interactive quick drawing-and-dimension targeted design modification model have been established so that the need for quick designing of the serialization of products with variable specifications in small quantities has been thus met.

## 2. The Analysis of the Need for Serialization of Products

The types of the products are the main parameters in determining the working principle of

the products and forms of the structure, and the specifications are the main parameters used to distinguish the dimensions of the products of the same type. For the details of the relationship of types and specifications, see Fig. 1. The designing of the serialization of products with variable specifications mainly refers to the modification of the dimension values so as to change the dimension of the drawings, but the change of the product structure takes up only a tiny proportion [7]. Therefore, designers' key interest is the change of the dimensions of the products due to the difference in specifications of the products. Besides, shorter time of delivery also calls for shorter designing cycles than other practices, which is, too, the major feature of the designing of the serialization of products. In order to fully utilize the technological resources of the existing products, the product designing process shown in Fig. 2 is often used in the actual engineering.

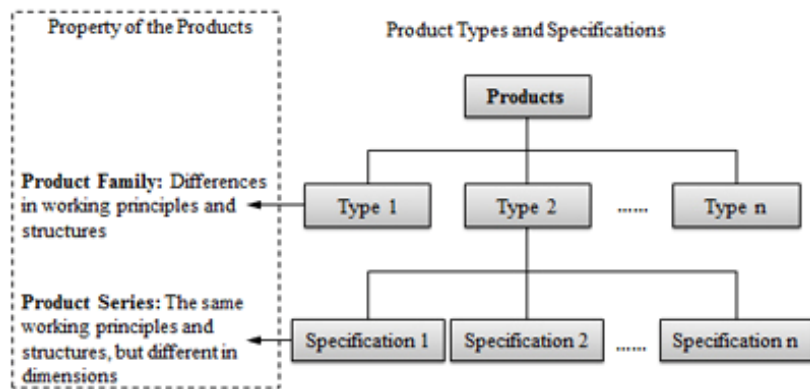


Fig. 1. The schema of the relationship among product types, specifications and the constitution of serialization of products.

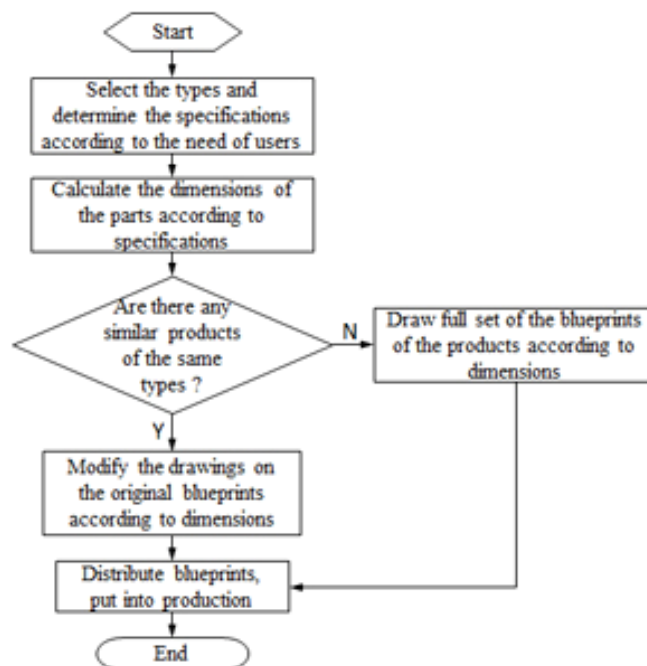


Fig. 2. The designing process of the serialization of products.

The above analysis shows that the shortening of the delivery cycle of the products is the core interest of enterprises [8]. The “quick drawing” and “quick modification” are the main requirements of the designing of the serialization of products for the purpose of the shortening of product designing cycles at the maximum degree. The focus that designers care most is the change of the dimensions of the products, so the optimal mode of “quick drawing” is to input the parameters of the products by means of CAD auto drawing functions, that’s the fulfillment of “parameterized drawing”; the optimal mode of fulfilling the “quick modification” is to drive the change of the dimensions of the drawings interactively, that’s the “interactive dimension-driven drawing”.

### 3. Dimension-driven Quick Design Modification of Theoretical Model

The designing method of the dimension-driven 2-D parameterized drawings differs from other existing ones [9], whose arithmetic is more efficient, easier to achieve, relatively smaller in amount of programming and more transplantable

[10]. Learned from the analysis of the need for serialization of products, the main functions to be realized in the “Dimension-driven quick modification of the designing theory” include:

1) Achievement of the “parameterized automatic drawing “of the finalized products: the input of the dimensions of the determined products can automatically finish the drawing.

2) Achievement of the “quick modification” of the existing drawings: the new drawing, whose data is in conformity with the one inputted, can be made on the existing drawing by means of choosing the dimensions to be modified, inputting new values and redrawing the graphs, and that’s the achievement of the quick modification of the products with variable specifications.

Therefore, sourced from the designing data, with the cores of “parameterize drawing principle” and “quick design modification principle”, this “dimension-driven quick design modification theory” can help designers to finish the designing of the products with original specifications or the designing of the products with variable dimensions. For such purpose, a theoretical model of the dimension-driven quick design modification has been built as shown in Fig. 3.

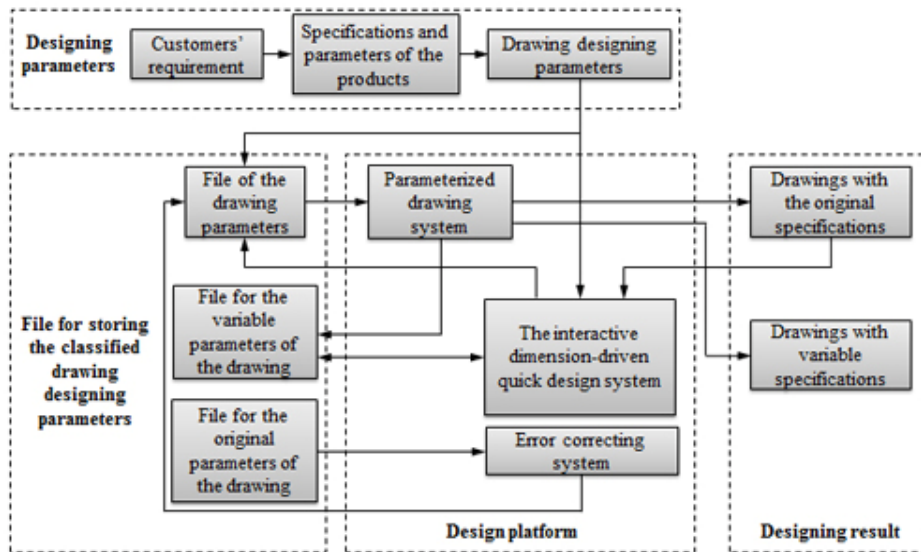


Fig. 3. The theoretical model of the dimension-driven quick design modification.

## 4. Research of the Dimension-driven Quick Design Modification Theory

### 4.1. Parameter Storing Principle

In order to strengthen the flexibility and transplantability, “file for the parameters of the drawing”, “file for the variable parameters of the drawing” and “file for the original parameters of the drawing” have been built in “the theoretical model of the dimension-driven quick design

modification”, and these files are used to store driving parameters and process parameters according to their classifications.

#### 4.1.1. Storing Methods and Storing Formats of the Driving Parameters

“Driving parameters” are the source data that is used to drive the geometric models to automatically calculate the drawing parameters, which are stored

in “file for parameters of the drawing” and in “file for the original parameters of the drawing”. See details of the sources and destinations of the data from Table 1.

When Auto LISP is used as the developing tool (hereinafter called “the tool”), it is suggested that the driving parameters should be stored in the format of “list”, and each parameter exclusively stands a line. See the storing format:

$$(X Y "X")$$

among which, *X*-Parameter identifier, such as *d1*; *Y*-Parameter value, such as 20; “*X*”-Parameter name, such as “*d1*”.

#### 4.1.2. Storing Methods and Storing Formats of the Process Parameters

From the product designing principle, we learn that the driving parameters are divided into “fixed driving parameters” and “variable driving parameters”, whose properties can be seen from Table 2.

During the process of dimension-driven design modification, the background marking method for “Variable driving parameters” is set up to ensure that designers can only modify the values of the “Variable driving parameters”. When the parameterized drawing is in operation, the entity data, which has the property of “only” and “fixed” and is available for modification, will be drawn, and marked as the “Variable driving parameters”, and then entered into the “file for the variable parameters of the drawing”. When the interactive quick design modification is in operation, the system reads for the modifiability

used to compare dimensions. Therefore, the process data is the dimension marking data, both of which change only once during the designing cycle.

Auto CAD drawings are mainly composed of the structured container of the data bank object [11]. We learn from the analysis of the DXF file in the ASCII format that the data of the drawing entity is stored in the form of “group codes” and “group values”. Listed in Table 3 are the data of “group codes” and “group values” in the important part of the dimension entities.

The entity handle is the only identifier distributed to each of the drawing entities, whose value is unique, and fixed during the life cycle of the drawing, and it is the only effective access to drawing entities in the drawing data bank. So, the “handle” of the dimension entity can be selected to be the marking data of the “variable driving parameters”. In the drawing data, the “handle” of the dimension entity is stored in the format of “dotted pair” [12], whose format can be seen in statement (1), and the data marking format stored in “the file for the variable parameters of the drawing” can be seen in statement (2).

$$(5 . "3E7") \tag{1}$$

among which the element “5” on the left is the group code, indicating that the element on the right is the “handle”; the element “3E7” on the right is the value of the “handle”.

$$(Y "X") \tag{2}$$

among which *Y*-the value of the handle, such as “3E7”; “*X*”-name of the parameter, represented with the character string, such as “*d1*”.

**Table 1.** Storing information of the “file for parameters of the drawing” and in the “file for the original parameters of the drawing”.

Types of parameter files	Sources of the data	Destination of the data
File for the variable parameters of the drawing	Initially manual input of the original designing parameters	Read by parameterized drawing modules, automatically draw “drawings with the original specifications”
	Modified product designing parameters entered through interactive quick design modification module	Read by parameterized drawing modules, automatically generate “drawings with variable specifications”
File for the original parameters of the drawing	Manual input of the original designing parameters	Read by error correcting system, cover the data in the “file for the parameters of the drawing”

**Table 2.** Properties of “fixed driving parameters” and “variable driving parameters”.

Types of parameters	Properties of parameters
Fixed driving parameters	No modification to the products in the interactive quick design modification is needed if these products with different specifications but with the same dimensions of the same values.
Variable driving parameters	Modification to the products in the interactive quick design modification is needed if these products with both different specifications and the dimensions of the different values.

Table 3. "Group codes" and "group values" in the important part of the dimension entities.

Group codes	Meaning of the group codes	Group values
0	Type of entity (character string, fixed)	Indicating that the type of the entity is dimension
5	Entity handle (A string of hexadecimal digits, fixed)	3FF: handle of this dimension (entity data)
8	Name of the layer on which the entity stands (fixed)	0: this dimension stands on layer 0 ( entity data)
10	Value of coordinate X of the point (starting point and center of the circle etc.)	400.0 (entity data)
20	Value of coordinate Y of the point (starting point and center of the circle etc.)	120.0 (entity data)
30	Value of coordinate Z of the point (starting point and center of the circle etc.)	0.0 (entity data)
40-48	Values of distance, radius, height etc.( value of the Double-precision floating-point)	300.0: the measured value of the dimension ( entity data)

## 4.2. Principle of the Parameterized Drawing

### 4.2.1. Model of the Parameterized Drawing Principle

The “parameterized designing”, according to the performance parameters of the parts, is a kind of designing methods of determining its geometric shapes [13]. The parameterization provides ways for the variability and reusability of the model of the products so that users can make modifications on the original model drawings conveniently so as to generate series of products, and consequently, the production efficiency has been greatly improved [14]. In the theoretical model of the dimension-driven quick design modification, the functions of the parameterized drawing principle include:

1) Automatically finish the "drawings with the original specifications": stored in the file for the

variable parameters of the drawing at the moment is the data of the original specifications of the product. The drawings with the original specifications which have been drawn are the objects which the interactive quick design system is set to modify.

2) Automatically finish the “drawings with variable specifications”: presently stored in the “file for parameters of the drawing” are the modified data of the new products by means of “the interactive quick design system”.

3) Generate dimension identifying data: either the “drawings with the original specifications” or the “drawings with variable specifications” is drawn, when dimensions are marked, the dimension entity handle, which is to be modified, is allowed to be entered into the “file for the variable parameters of the drawing” for identifying the type of dimensions when the modification is going on. See the model of the parameterized drawing principle in Fig. 4.

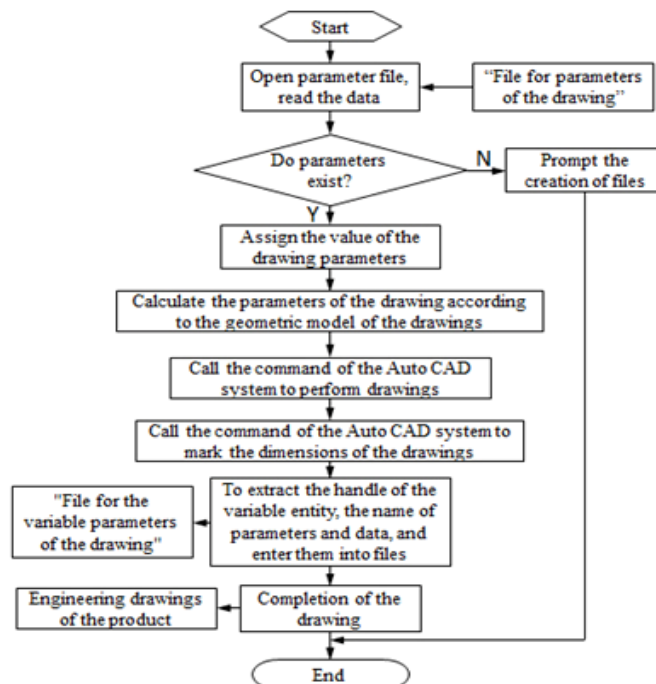


Fig. 4. The model of the parameterized drawing principle.

#### 4.2.2. Construction of the Geometric Model of the Drawing

The geometric model of the drawing is composed of geometric information and topological information. The geometric information shows the coordinates of the drawing entities, while the topological information represents the quantity of the entities and their geometric relationships [15]. The purpose of the construction of the geometric models is to determine the composition of the entities of the drawings, the properties of the entities, the parameters and their geometric and mathematical relationships and so on. Refer to Fig. 5 for the basic process of the construction of the geometric models of the drawings.

#### 4.2.3. Extraction of the Identifying Data of the Variable Parameters

When an applied programme is under development with Auto LISP, the function of the "Command" can be used to call the command of

Auto CAD [16]. See the sentence format if the dimension marking command is called statement (3), closely followed by the sentence with the data of the handle of the dimensional entity. See the format in statement (4).

(Command "DIM" "Subcommand" <  
Command running parameters> /r) (3)

among which: *Command*-function called by the command of Auto LISP; *DIM*-dimension marking command; "Subcommand"-name of the dimension marking subcommand, followed by <*Command running parameter*>, the data needed to run the subcommand.

(assoc 5 (entget (entlast))) (4)

among which *entlast*-the name of the graphic entity finally drawn; *entget*-the data of the graphic entity obtained; *assoc 5*-search for the point to list containing group code "5" from the data of the drawing of the entity, and the element on the right on the table is the handle of the entity.

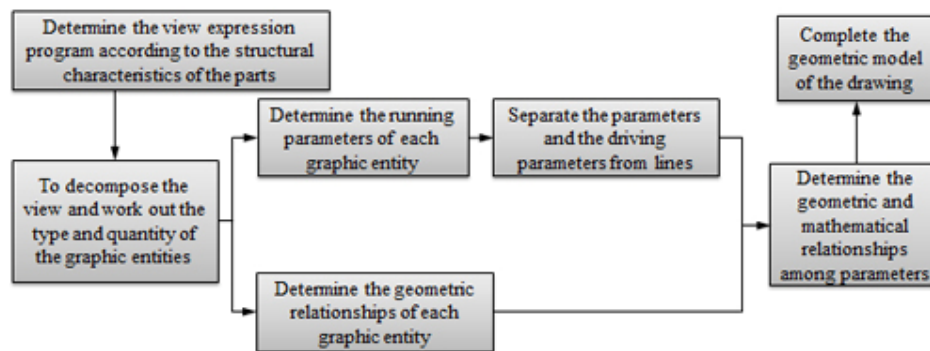


Fig. 5. Basic process of constructing the geometric model of the graph.

### 4.3. Interactive Dimension-driven Quick Design Modification Principle

#### 4.3.1. Model of the Interactive Dimension-driven Quick Design Modification Principle

Interactive dimension-driven quick design modification is the core of the dimension-driven quick design modification principle, and its functions include:

1) Modify the variable parameters of the drawing interactively: support the way of choosing the dimension entity with the cross cursor to enter new values of the dimension. At the same time, it has functions of identifying types of entities and variable parameters.

2) Generate new "file for the parameters of the drawing": a new set of the parameters of the

products with new specifications will be generated after the entry of the dimensions into the "file for the parameters of the drawing".

3) Fulfill the drawings of the products with new specifications according to the new parameters automatically.

See model of the interactive dimension-driven quick design modification principle in Fig. 6.

#### 4.3.2. Identification of the Dimensions and the Marking of Modifications

To ensure that the entity that has been selected is the dimension entity: in order to increase the fault tolerance of the system, the function of "identifying types of entities" is particularly set up: judge the types of the entity selected by obtaining the group value in correspondence with the group

code "0" of the data of the entity drawing. See statement (5) for the sentence format.

(= "DIMENSION" (cdr (assoc 0 (entget (entlast)))))) (5)

This sentence format is a condition for judgment, among which "DIMENSION" is the code of the type of the dimension entity, and (cdr (assoc 0 (entget (entlast)))) is the group value in correspondence with the one from the group code "0" drawn, that's the code for the type of the dimension entity.

It is guaranteed that the dimension selected is one that is modifiable: the dimension can be modified if the handle of the dimension entity

selected is the same as the one stored in the file for the drawing with the variable parameters after comparison. The method of extracting the handle of the dimension entity is the same as statement (4).

Marked modified dimensions: the colour of the dimension will change after the modification. See sentence format in statement (6).

(command "change" point coordinates "" "p" "c" "number of the colour" "" /r) (6)

The modification of the colour of the dimensions called from the sentence format is done with the CHANGE command of the Auto CAD system. For example, when "the number of colour =1", the colour will be modified into red.

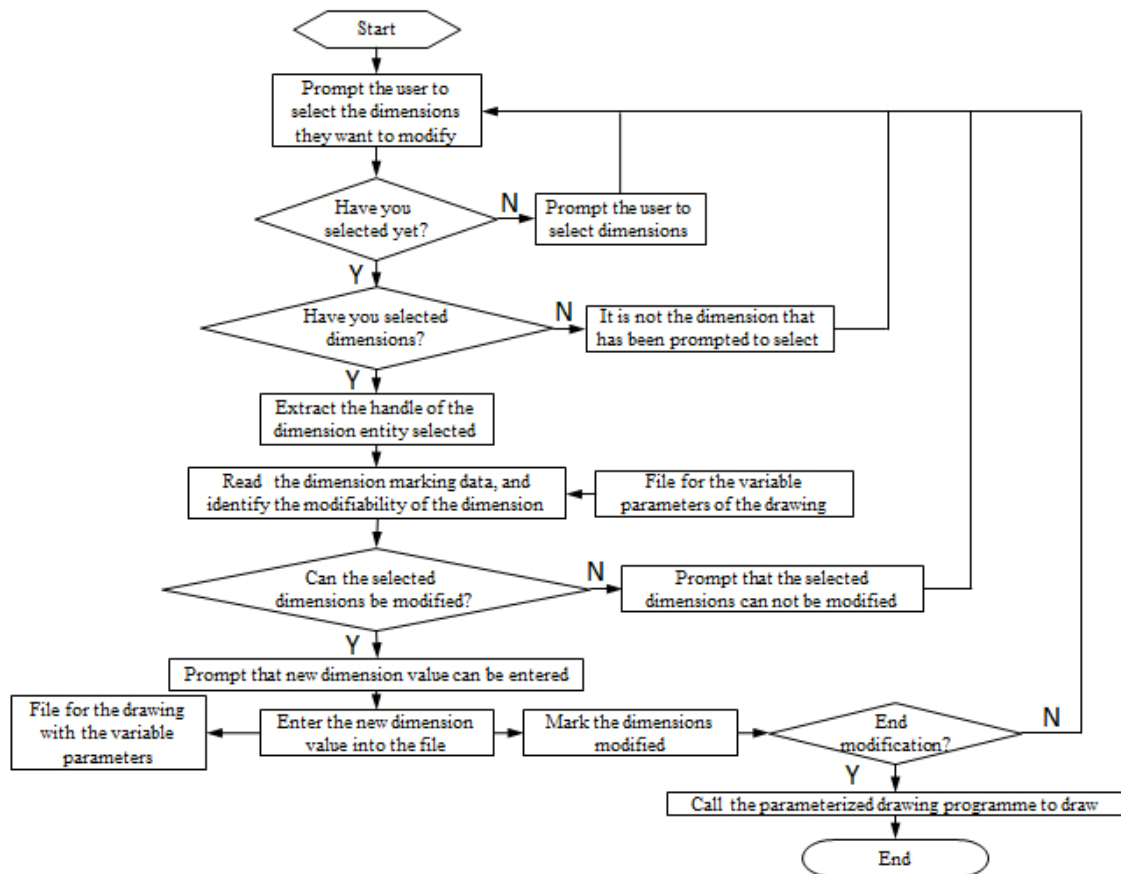


Fig. 6. Model of the interactive dimension-driven quick design modification principle.

## 5. Conclusion

The interactive dimension-driven quick design modification theory has been put forward in connection with the individualized features of the serialization of products in small quantities. Based on this theory, the designing efficiency has been greatly increased by the change of the dimensions which automatically drive the change of the drawings when the dimensions of the drawings are the objects of the modification. This theory has also

met the requirement for the change of the specifications of the serialization of products and obtained the following achievements:

1) The theoretical model of the interactive dimension-driven quick design modification, which is in conformity with the requirement of the serialization of products in small quantities has been put forward, and based on this model, the designing parameter storing mechanism, parameterized drawing principle and the interactive quick design modification principle have been

constructed. An effective means of quickly modifying serialization of products has been found so as to offer a theoretical support for the construction of the CAD platform for the enterprises' serialization of products in small quantities.

2) The designing parameter classification storing mechanism has been constructed, and the platform model on which the core modules are independent from each other, and intercommunications can be done through data files. Besides, the degree of difficulties in developing the system platform has been reduced, and the flexibility and transplantability of the theoretical model have been strengthened.

3) The marking mechanism of the entity identifying and the product's variable driving parameters has been originally created. In this theory, the method of marking the product's variable driving parameters by making use of the handle and identifying entities with the data of the entity types has also been proposed. This method has provided the designers with the interactive user interface, which is in line with the designing habit so as to both increase the fault tolerance and meet the dimension-focused requirement in the designing of the serialization of products.

4) The designing parameter storing format, means of accessing to dimension entity data, means of calling command from Auto CAD and the method of comparing the process data have been given with the developing tool of Auto LISP.

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