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A COMPUTER-AIDED DRAWING CHECK SYSTEM
(PART 1: Drawing Check of Dimensions and Mis-Writings)

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Abstract: This paper is concerned with a computer-aided supporting system to a systematic check of mechanical drawings.

The problems treated in this paper are limited to the checking of the omissions and mis-writings of dimensioning in the mechanical drawings made by a CAD system.

A drawing check system has been made up on a personal computer with Basic and Pascal. The feasibility of the proposed drawing check system is confirmed for omissions and mis-writings of dimensioning in mechanical drawings.

1. Introduction

Recently Computer-Aided Design (CAD) systems have rapidly been improved and the number of the mechanical drawings by applying CAD systems has been increasing remarkably. However the examination of these mechanical drawings has still been put in man power[1].

The present situation of the drawing check [2, 3] is as follows. The check heavily depends on the experience and sense of a drawing checker. The results of drawing check are very much influenced by the checker's physical and mental conditions. Though many experts are required to perform the efficient and systematic drawing check, there still remain many problems related to human error.

Therefore, it is very important that the methodology of drawing check is established for efficient and systematic checking. The works of drawing check need various expert knowledges with regard to design, fabricating, drafting, and so on. However some parts of the drawing check may be finished by the use of only simple knowledges. These checking may be replaced by the automatic drawing check applying the computer-aided system. By developing such a system we can decrease in number of experts who engage in drawing check and can perform the checking works efficiently and systematically.

There are a few studies on computer-aided drawing check system. Saitoh, et al.[4] have developed a drawing check system for drawing exercises in a university, based on the concept of Artificial Intelligence. The system compares the total number of line segments and projection points of an object drawing with those of a reference drawing. This system needs the complete reference drawing, therefore the method may not be suited for a practical use. For automatic dimensioning, Minagawa, et al.[5] treated a problem of dimensioning of drawings by means of 3 dimension solid geometry and graph theory. A method of automatic dimensioning has also been studied by using the relational rules of dimensioning by Imamura, et al.[6].

As the preliminary steps, the problem treated in this paper is limited to the checking work of omissions and mis-writings of dimensioning in mechanical drawings made by a CAD system. There exist various kinds of drawing such as mechanical drawings, architecture design drawings, public work drawings, electric circuit drawings, etc. In this paper we treat part drawings for mechanical manufacturing as object drawings.

This paper consists of 6 sections. The second section introduces the classification and contents of drawing check in general. The third section presents the drawing check system developed, which can detect disagreements and omissions of dimensioning. The drawing check processes are described in the fourth section. In the next section some results by using the drawing check system are discussed. In the final section some concluding remarks are given.

2. Classification and Contents of Drawing Check

Generally speaking a drawing check is two aspects, i.e., (a) approving the design methods and their results and (b) checking the contents of the drawing with respect to the results of design. In this paper the aim of the drawing checks are restricted to the second one. The drawing check are classified into the followings with respect to geometrical descriptions, functional relation among the dimensions and manufacturing methods.

Drawing check of dimensions. A drawing check of dimensions examines if dimensions on a drawing (geometrical dimension) and filling-up dimensions on dimension lines are same or not, and if omissions in dimensioning exist or not. This check inspects the geometrical descriptions on a drawing.

Drawing check of combined dimensions. A drawing check of combined dimensions examines the compatibilities and the disagreements of combined dimensions among parts described in drawings. For example, it is checked up whether combined dimensions are compatible or not, whether fittings are proper or not, and whether disagreements on assemblings, jointings and movements exist or not.

Drawing check of working and surface symbols. A drawing check of working symbols and surface symbols examines the contents of a drawing from a manufacturing point of view. The contents to be examined are finish symbols, surface roughness symbols, chamfered symbols, surface treatment instructions and special processing instructions, etc.

Drawing check of material symbols. A drawing check of material symbols examines the disagreement between material symbols described in drawings and working materials.

Drawing check of limit dimensions. A drawing check of limit dimensions examines functional dimensions such as dimension tolerance, maximum limiting dimensions and minimum limiting dimensions. Sometimes limit dimensions imply the critical values of physical and chemical variables such as thickness, length, width, corrosion resistance, etc.

Drawing check of standards. A drawing check of standards examines whether the industrial or engineering standards referred in object drawings are proper or not. It further detects the disagreements between the contents described in the drawing and the reference standards.

The classification is rewritten and summarized to four steps in hierarchical point of view. The check points in each step are shown briefly.

First step.

a. disagreements of geometrical dimensions with filling-up dimensions
b. omissions of dimensioning
c. mistakes in drawing

Second step.

a. compatibility of drawings in third angle views
b. combinations of functional dimensions

Third step.

a. manufacturing methods
b. surface treatments and surface roughness
c. working materials
d. omissions of special remarks
e. correspondence of fitting dimensions

Fourth step.

a. industrial and engineering standards used in drawings
b. standardization of parts

The first step is the most elemental checking of drawings. The step corresponds to drawing check of dimensions stated above. The second step is for drawing check of combined dimensions. The third step concerns drawing check of manufacturing methods, surface symbols and limit dimensions. The fourth step is for drawing check of standards.

If we can make clear all the knowledges in each step and implement them to a computer, we can accomplish an automatic check system or a computer-aided checking system for drawings. However the knowledges of the drawing check are very complicated and have not be gained yet. Therefore, the problem treated here is limited to the part of the first step, i.e., disagreements of geometrical dimensions with corresponding filling-up dimensions and omissions of dimensioning.

3. Drawing Check System to Detect Disagreements and Omissions of Dimensioning

3.1 System Structure

The drawing check system considered here consists of three modules, i.e., data making module, data analyzing module and drawing data modifying module.

In this system it is assumed that the object drawing for checking is made by a CAD system. Therefore the drawing data to be checked are prepared in the specific form of the CAD system used. Next three modules of the checking system are described in detail as follows:

Data making module. This module analyzes the object drawing data which have been made by a CAD system. The drawing data consist of drawing information and dimensioning information. The former describes straight lines, circles, circular arcs, etc. The latter describes dimension lines, extension lines, leader outgoing lines, dimensions, chamfered dimensions, etc. In this module the drawing data are classified into line data, circle data, letter data and letter-coordinate data. Next, to handle these data easily, we make up four sequential files with respect to the drawing data.

Data analyzing module. This module uses the sequential file data which have been made at the data making module. The module examines the correspondence between the line or circle data and letter or letter-coordinate data in order to detect the disagreements in dimensioning. The module also examines relation among the dimension line data, letter data and letter-coordinate data in order to detect omissions in dimensioning. If the corresponding data exist in the sequential files, then the data are decided to be correct. If the corresponding data do not exist, then the system generates the corresponding correct data. This data are supplied to the checker.

Drawing modification module. In this module, a drawing checker modifies the object drawing by using the corresponding correct data described above. Two modes of drawing modification are considered. One is the direct modification in which a drawing checker modifies the object drawing directly referring to the output data. The other is the indirect modification in which the drawing checker adds the correct data to the object drawing data by means of operating the computer key board or mouse.

3.2 Equipments for a Drawing Check System

For developing a computer-aided drawing check system, we prepared a set of hardware systems which consist of a 16-bit personal computer, a hard disk drive, a mouse and a X-Y plotter. The main memory of the computer is 640 kirobytes(KB). Programming languages used are Basic and Pascal. The constructions of the drawing check system is tabulated in Table 1.

Table 1. Hardware of Drawing Check System

Equipment	Remarks
Personal computer	16bit, memory 640KB
Hard disk drive	memory 20 MB
CRT	
Input device	mouse , keyboard
Output device	X-Y plotter
Programming Language	Basic Pascal

The software of the drawing check has been coded for the personal computer system shown in Table 1, by using Basic and Pascal Languages. The process of the drawing check system is shown in Fig.1.

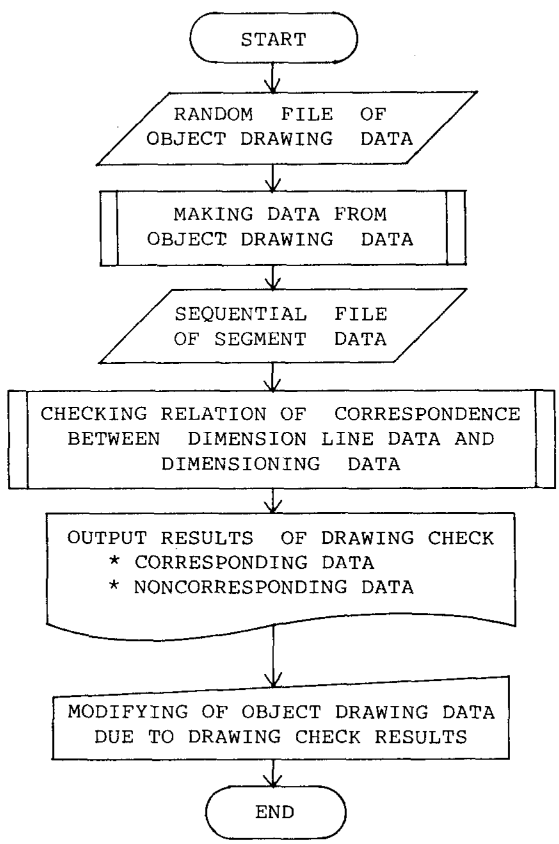


Fig.1 Process of Drawing Check

4. Drawing Check Process

The first procedure analyzes the mechanical drawing data given. This procedure corresponds to the data making module in section 3. An example of an output sequential file is shown in Table 2. In this table line data and circle data are indicated. The segment number 2011 indicates a visible outline, segment number 2013 a center line, and segment number 2031 a dimension line. Coordinates X1, Y1, X2 and Y2 are both end coordinates of a line segment. X-length and Y-length indicate length of a line in X-direction and Y-direction, respectively. In circle data, coordinates X and Y show the coordinates of a center point. Start and End of angle indicate the start and end angles of a circular arc. The circle data of number 2 show that the radius of the object circle is 20 mm and the circle is quardrant.

In the second procedure, the sequential file data of the first procedure are used to perform the drawing check. The drawing check is carried out as follows:

(1) A dimension line (a leader outgoing line) is picked up.
(2) Dimension figures corresponding to the dimension line (the leader outgoing line) are searched.
(3) If the corresponding dimension figures do not exist, then the result is printed out and the procedure restarts at step (1).
(4) If the dimension figures exist, the length of the line or the radius or diameter of the circular segment corresponding to the dimension figures is geometrically measured on the drawing. The value of the dimension figures and the length are compared.
(5) If they coincide in value, the corresponding data are correct.
(6) If not, the system generates a new corresponding data and the

Table 2. Line and Circle Data

Line Data

Number	Segment number	Coordinate(X1,X2) Coordinate(Y1,Y2)		X-Length Y-Length
1	2011	270 75	270 125	0 50
2	2011	270 125	330 125	60 0
3	2013	190 45	190 245	0 200
4	2013	125 160	240 160	115 0
5	2031	65.2 185	100 221	34.8 36
6	2031	154.6 141.3	225.4 178.7	70.8 37.4

Circle Data

Number	Segment number	Center coordinate		Radius	Angle	
		X	Y		Start	End
1	3011	100	185	50	90	180
2	3011	310	215	20	0	90
3	3011	190	160	40	0	360

results are printed out.

(7) If there is no dimension line or no leader outgoing line in the data, then this procedure is complete, else the procedure restarts at step (1).

This procedure corresponds to the data analyzing module described in section 3.

In the third procedure, the drawing checker modifies the original object drawing data taking account of the results of the second procedure. Two modification modes exist: one is to modify directly the original object drawing data and the other is to add new data to the original data.

5. Results of Drawing Check

To show the feasibility of the drawing check system developed here, some drawings have been checked by using this system. Figs. 2 to 5 indicate the drawings checked and their results.

The drawing of Fig.2(a) involves some mistakes of one mis-writing and two omittings in dimensioning. Dimension 230 is the mis-writing for dimension 170. In Fig.2(b), the first line of the list indicates the disagreement of the geometrical dimension with the filling-up dimension. The remaining two lines indicate the dimensioning omissions, they are dimension 85 in Y direction and R20 of inclined leader outgoing line, which are not described in the drawing. In this list, symbol XX, YY and XY denote horizontal, vertical and inclinational directions, respectively. The value R20 implies the radius of the circular arc of 20 mm.

In Fig.3(a), dimensioning figures of two holes and a chamfered dimension are not described. Fig.3(b) shows that the checking is complete.

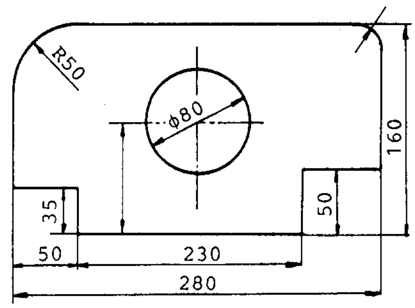
Fig.4(a) indicates the case where dimension figures of an one-sided dimension line is omitted. The dimension line crosses over a center line. The result of drawing check of Fig.4(b) shows the revised data of this drawing.

Finally, the drawing in Fig.5(a) involves three omissions of dimensioning which are a omission of a dimension of radius and omissions of two dimensions, in X and Y directions. Fig.5(b) indicate the similar results described above.

6. Concluding Remarks

In this paper, we gave emphasis to the necessity of introducing a computer-aided drawing check. We considered the features of the drawing check and indicated the hierarchical classification of the drawing check. We also indicated the main steps of the drawing check process.

For the limited problems, we developed a drawing check system which automatically finds out omissions in



(a) Object Drawing(1)

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CORRECT DIMENSION(XX) = 170(230)
CORRECT DIMENSION(YY) = 85
CORRECT DIMENSION(XY) = R20
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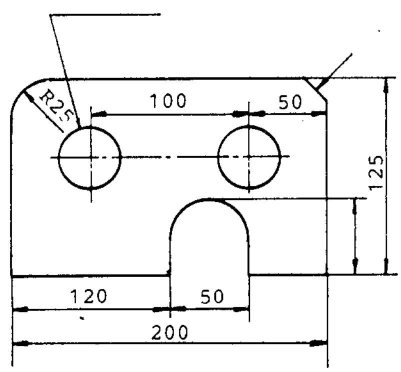
(b) Results of Drawing Check(1)

Fig.2 Drawing check (1)



(a) Object Drawing(2)

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CORRECT DIMENSION(EX) = 2-φ40
CORRECT DIMENSION(XX) = C15
CORRECT DIMENSION(YY) = 50
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(b) Results of Drawing Check(2)

Fig.3 Drawing check (2)

dimensioning and disagreement between geometrical dimensions and filling-up dimensions. By using this system we have performed drawing checks for some simple mechanical drawings. As a result, we are confirmed the followings.

(1) The drawing check system can automatically inspect the mechanical drawings in which a dimension line exists but dimension is not described.
(2) The system can inspect the mechanical drawings in which an geometrical dimension and a filling-up dimension disagree with each other.
(3) The system can inspect dimension lines described in all directions.

The problem treated in this paper corresponds to the first step of the drawing check process described in section 2. The second step is now under study, and will be presented in the coming paper.

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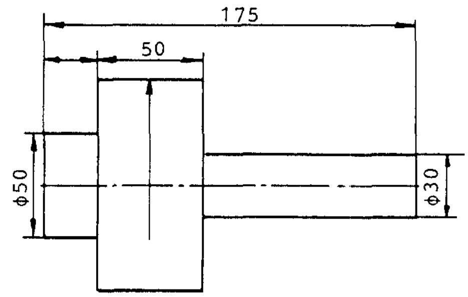
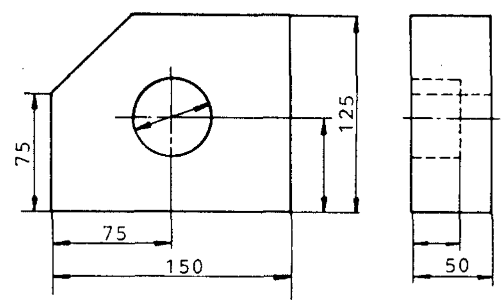


(a) Object Drawing(3)

CORRECT DIMENSION(XX) = 25
CORRECT DIMENSION(OY) = ϕ100

(b) Results of Drawing Check(3)

Fig.4 Drawing check (3)



(a) Object Drawing(4)

CORRECT DIMENSION(XX) = ϕ50
CORRECT DIMENSION(YY) = 60
CORRECT DIMENSION(XX) = 30

(b) Results of Drawing Check(4)

Fig.5 Drawing check (4)