A Study on the Development of Computer Aided Die Design System for Lead Frame of Semiconductor Chip

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ABSTRACT

This paper describes the development of computer-aided design of a very precise progressive die for lead frame of semiconductor chip. The approach to the system is based on knowledge-based rules. Knowledge for the system is formulated from plasticity theories, experimental results, and the empirical knowledge of field experts. This system has been written in AutoLISP using AutoCAD on a personal computer and the I-DEAS drafting programming Language on the I-DEAS master series drafting with on HP9000/715(64) workstation. Data exchange between AutoCAD and I-DEAS master series drafting is accomplished using DXF(drawing exchange format) and IGES(initial graphics exchange specification) files. This system is composed of six main modules, which are input and shape treatment, production feasibility check, strip layout, data conversion, die layout, and post processing modules Based on knowledge-based rules, the system considers several factors, such as V-notches, dimple, pad chamfer, spank, cavity punch, camber, coined area, cross bow, material and thickness of product, complexities of blank geometry and punch profiles, specifications of available presses, and the availability of standard parts. As forming processes and the die design system using 2D geometry recognition are integrated with the technology of process planning, die design, and CAE analysis, the standardization of die parts for lead frames requiring a high precision piercing process is possible. The die layout drawing generated by the die layout module is displayed in graphic form. The developed system makes it possible to design and manufacture lead frame of a semiconductor more efficiently.

Keywords: Die layout, Input and shape treatment, Knowledge-based rules, Lead frame, Production feasibility check, Strip layout

1. Introduction

The electronic industry has grown continuously owing to the investment in facilities to produce lead frames efficiently, and has become important. Lead frames, which are important metal products in the IC process and able to communicate as wire bonding with accuracies in micrometers are used in products from general computers to electronic products and toys and supports for semiconductor chip. In order to produce these products, standardization of die design is necessary because of trends in miniaturization, weight reduction, and time requirements in modern industry. Shear forming, by which parts with a desired shape are manufactured from sheet metal using a punch and a die, requires this kind of standardization for the compatibility and accuracy of components. However, generally, only experience and intuitional decisions have been used for production feasibility checks, strip layout, and die layout for forming by blanking or piercing. In order to solve this problem, the automation of computer-aided process planning for the designed product by formularising the experience of skilled engineers has been undertaken[1-3]. In 1971, Shaffer developed progressive die design using a computer(PDDC) system[4] and Fogg and Jaimson followed him by developing an improved PDDC[5] by considering other factors which have an effect on die design. A weak point of this system is that it is semi-automated and the processing time is too long. Shibata and Kunimoto developed a CAD/CAM system[6] for which the aim is the screen-output of blank layout and die layout. Nakahara and the others introduced a system for a progressive die design[7]. Choi et al. developed a compact and practical CAD system for the blanking or piercing of irregular shaped sheet metal products and stator and rotor parts[8-9].

In this study, a die layout module outputs the parts and the assembly of a die using the I-DEAS master series drafting software for a 32LD PLCC lead frame strip layout, and generates the drawing automatically using AutoCAD.

Automated strip layout, die layout of lead frames should result in quantifiable cost and time saving by improved standardization, and can provide a permanent and confidential source of expertise. Furthermore, such a system could serve as a valuable consultant for experts and as a dependable training aids for beginners.

2. Working principle of the die design system

2.1 Data treatment for process planning

When AutoCAD receives the geometric data of the product by direct user input of drawing files, the shape data and input condition are converted into a numerical data list which can be used in programs.

The procedures to be converted are as follows

-List composed of lines and arcs

(0.0 (Sp Ep) (Sp Ep) (Sp Ep)· · · · · (Sp Ep Cp) (Sp Ep Cp) · · · · · · ·)

-List composed of circles

(0.0 (Cp R) (Cp R) (Cp R)·)

Where, (Sp Ep) represents that the entity is a line, (Sp Ep Cp) an arc, (Cp R) a circle. Sp(Xs Ys Zs) is the starting point, Ep(Xe Ye Ze) the ending point, Cp(Xc Yc Zc) the center point of an arc or circle and R the radius of a circle.

In order to use these data in each sub-module, line and arcs are rearranged to form a closed loops in the clockwise direction.

(0.0 ((P1 P2) (P2 P3 PC1) (P3 P4)· · · · · · · · · · · · · (Pn-1 Pn Pcn) (Pn P1))
((q1 q2) (q2 q3) (q3 q4 qc1)· · · · · · · · · · · · · (qn-1 qn qcn) (qn q1))

Where Pn is not only the ending point of (Pn-1 Pn Pcn) (Pn P1) but also the starting point of (Pn P1) and the Pcn is the center point of the arc.

The point which has minimum value in x-coordinate in a closed loop is chosen as P1(x1 y1 z1). Based on the P1 Point, a closed P type loop is recognized in the clockwise direction

2.2 Data treatment for die design

The shape data obtained in the strip layout module using AutoCAD are converted into recognizable shape data in the die layout module using the I-DEAS master series drafting with a workstation, HP 9000/715(64).

The procedures to be converted are as follows.

- List composed of line

(Entity,[ViewNum],[LayerNum],[Color],[Weight],[Ltype],[Intell],{GroupName},[Xs],[Ys],[xf],[Yf])

- Arc composed of arc

(Entity,[ViewNum],[LayerNum],[Color],[Weight],[Ltype],[Intell],{GroupName},[Xc],[Yc],[Rad],[Sa],[Ia])

Where, "Entity" is entity number, "[ViewNum]" view-number(1-63) of entity number, "[LayerNum]" number of layer, "[Color]" color of display, "[Weight]" thickness of line, "[Ltype]" type of line, "[Intell]" "yes" or "no" of intelligent font, "[GroupName]" name of group, "[Xs]" x-coordinate of starting point, "[Ys]" y-coordinate of starting point, "[Xf]" x-coordinate of end point, "[Yf]" y-coordinate of end point, "[Xc]" x-coordinate of center point, "[Yc]" y-coordinate of center point, "[Rad]" radius of circle, "[Sa]" starting angle, and "[Ia]" is incremental angle.

In order to use these data in the die layout module, the data conversion module organizes closed loops for the entities composed of lines and arcs. The representation, which is a one-dimensional array, is as follows:

(Xs(1), Ys(1), Xf(1), Yf(1), Xc(1), Yc(1), Rad(1), Sa(1), Ia(1))

. . . .

(Xs(n), Ys(n), Xf(n), Yf(n), Xc(n), Yc(n), Rad(n), Sa(n), Ia(n))

Where, (n) is the numbers of entities, the initial values is zero in the case of a line. The concept of a symbol is introduced to ease the generation of the parts of the die. The procedures are as follows:

- Representation of die part
  ((Part_name1 Sb_num1 view_pt1 layer1 pt1_x pt1_y)· . . . .
  (Part_namen Sb_numn view_ptn layern ptn_x ptn_y))

Where, "(Part_namen)" is name of the nth part, "(Sb_numn)" number of symbol, "(view_ptn)" number of view point, "(layern)" number of layer, "(ptn_x)" x-coordinate of the part, and (ptn_y) is y-coordinate of the part.

3. Structure of the system

The system is composed of input and shape treatment, production feasibility check, strip layout, data conversion, die layout, and post process modules. It is accomplished in one operation and has the merit of being processed without interruption as each module holds the rule and database in common. It is easy to use, as dialogues are user-friendly with appropriate prompting statements for the various data required. The configuration and modular structure of the system can be seen in fig. 1 and fig. 2.

If a drawing of a lead frame product requiring very precise piercing operations is loaded in the developed system, the input module of the system automatically recognizes the drawing of the product and prompts for input data for the product. Results produced in the shape treatment module are transferred to the production feasibility check module which checks the distances between the internal shapes, corner and fillet radii and the minimum holes required for piercing. Data that is feasible in the production feasibility area are transferred to the strip layout module for automatically carrying out strip layout. Results from the strip layout module are transferred to the die layout module to generate parts and the assembly of the die set.

Result from the die layout module are transferred to the post processing module to generate working drawing of parts.

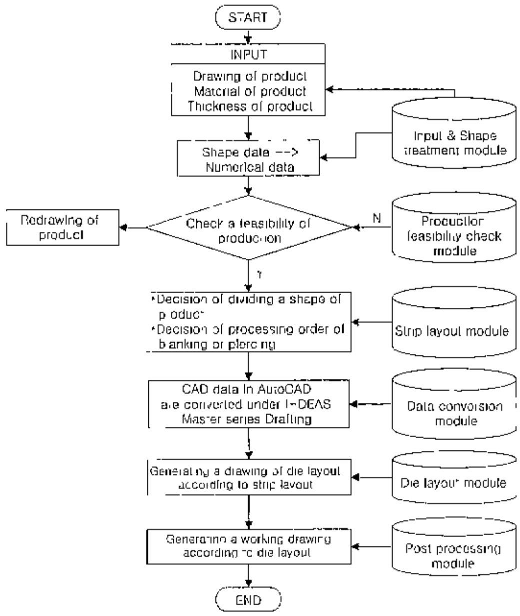

Fig. 1 Configuration of the die design system

The functional description of modules of the system is presented in detail as follows.

3.1 Input and shape treatment and production feasibility check modules

The user inputs material type, thickness, width, heat treatment condition, and the shape of the product into an AutoCAD drawing by hand or as an outputs drawing file on the screen, and the shape treatment module automatically reads information about the mechanical properties of the material from the database and converts the shape data into numerical data and stores it. Numerical data are used in each module of the system.

The production feasibility check module is the module that checks the production feasibility of the product with the blank information and shows geometric regions which are difficult or impossible to form by piercing. When checking the production feasibility for blanking or piercing of a blank, this module compares holes to be pierced, and the corner and fillet radius with criteria stored in the database. Therefore, this module shows feasible geometric regions.

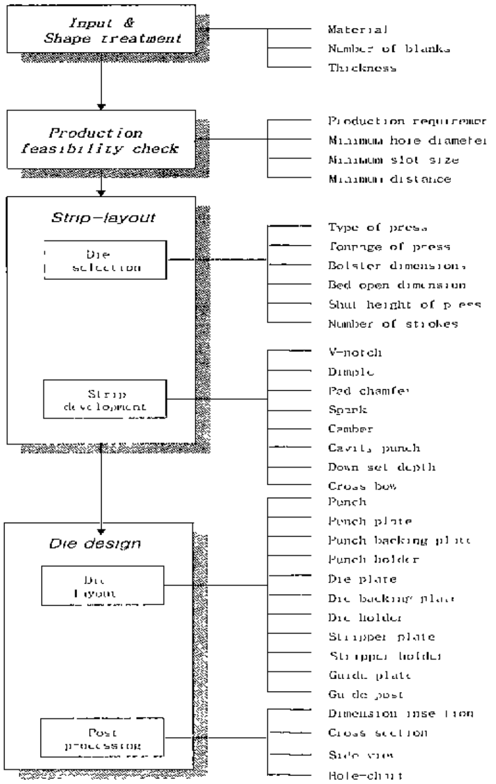

Fig. 2 Modular structure of the die design system

3.2 Strip layout and data conversion modules

The strip layout module, automatically derives punch profiles for the external area of the product and carries out piecing. Also, this module decides the order of the processes for progressive working based on factors influencing the strip layout of the lead frame for semiconductor. The factors are as follows.

a) V-notch: Prevention of bubbles and moisture
b) Dimple: Diffusion of heat through a flaw inside a die attached pad
c) Pad chamfer: Elimination of burr for a die pad
d) Spank: Compensation of internal and external lead after piercing
e) Cavity punch: Prevention of twist of lead
f) Camber: Curvature of the lead frame strip edge
g) Cross bow: Transverse bowing of lead frame
h) Down set depth: Intentional depression of the die attached pad

The data conversion module converts the shape data obtained in the strip layout module using AutoCAD into recognizable shape data in the die layout module using the I-DEAS master series drafting with a workstation, HP 9000/715(64). Data exchange of the system can be seen in fig. 3.

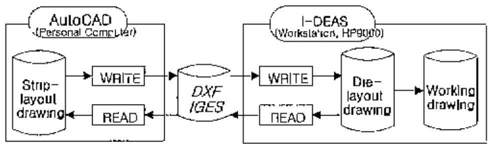

Fig. 3 Data exchange of the system

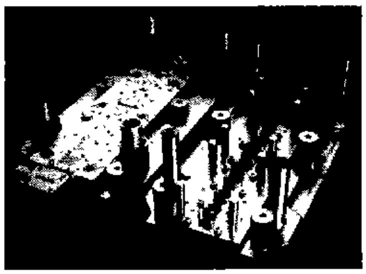

Fig. 4 Die set of lead frame, semiconductor

3.3 Die layout and post processing modules

The die layout module automatically designs the parts and assembly of the die to satisfy the rule design using the information on tool position according to the processes obtained in the strip layout module. The pattern of the die set of a lead frame is shown in fig. 4. Using data obtained from the die layout module, CNC and EDM programming are able to generate NC working data for the automatic machining of the working parts of the die in the post processing module.

4. Rule and database of the system

An automated system organizes the rule and database as process variables extracted from plasticity theories, relevant references and the empirical know- how of experts in blanking industries. Rules which organize empirical know-how and guide design, are based on decision tree of the form of "IF (conditions) THEN (actions)". According to the information on the condition part, the system calculates the action part and the results of the action part are the input to the next condition part.

4.1 Rule of strip layout

Rule 1) Generally in the case of existing notches, they are pierced at the first step of the processes.

Rule 2) If a V-notch, dimple, and pad chamfer exist, they are pierced at the first process.

Rule 3) When pilot pin holes, epoxy holes, and molding holes exist, if possible they are pierced at the first process.

Rule 4) If pilot pin hole exists, the size of hole should be greater than 3 times the thickness of product.

Rule 5) If holes to be pierced are close to each other, or are not related to the function, holes are distributed over many processes

Rule 6) As internal features which are related exist, the system being able to set a punch equipment, they are pierced preferentially.

Rule 7) If a pilot pin hole, epoxy hole, molding hole, V-notch, dimple, pad chamfer, internal lead cannot be pierced at the same time, the process order is as follows : dimple, V-notch, pad chamfer, pilot pin hole, epoxy hole, molding hole and then internal lead.

Rule 8) So as not to use a punch of an intricate shape, the shape of the blank is divided automatically into simple shapes.

Rule 9) After calculating the perimeter for each blank, first of all, the strip layout module decides the working order according to the size of the perimeter.

Rule 10) In each shape that is divided from the shape of the blank, the strip layout module decides the size of the die blank which is capable of enduring normal pressure produced by the thrust force.

Rule 11) Each of the succeeding die blanks is first pierced on its specified pitch according to the working order, and shifts to the next pitch if it overlaps.

Rule 12) The ratio of thrust force to blanking force is obtained from the database.

Rule 13) The normal pressure exerted by the thrust force is decided as follows.

$$P_{face} = \frac{F_d}{L_{shear} \times t \times BLR}$$

where, BLR : ratio of thickness of material to burnishing length

L_{shear} : summation of shear length(mm)

F_d : thrust force(kgf)

Rule 14) Outer diameter endured normal pressure by thrust force is decided as follows

$$d_o = \frac{d_i}{\sqrt{\frac{\sqrt{3}P_{face}}{m\sigma_y}\sqrt{2-\left(\frac{\sqrt{3}P_{face}}{m\sigma_y}\right)^2}-1}}$$

where, m : constant depending on yield criterion, $1 \le m \le 1.155$,

σ_y : yield strength of die(kgf/mm2)

d_i : inner diameter of die blank(mm)

d_o : outer diameter of die blank(mm)

Rule 15) Regrinding of die and punch is required after piercing from 600,000 to 700,000 strokes.

Rule 16) For a lead frame with over 16 pins, a spank process is required

Rule 17) A punch with a cavity is divided and if possible, cavity punch and cutting bar are operated together.

Rule 18) Note that in case of working together, the process of the cutting bar precedes that of the cavity punch.

Rule 19) In order to compensate for the distance between the leads and crossbow, an equalising process is required.

Rule 20) Feed error is within 1/100mm and location error 5/100mm.

Rule 21) All dimensions of lead frame are measured from dambar.

4.2 Rule of die layout

Rule 1) The center of pressure in a progressive die is calculated as follows.

$$x = \frac{\sum E_i x_i}{\sum E_i}$$
$$y = \frac{\sum E_i y_i}{\sum E_i}$$

where, E_i : shear length of each entity(mm)

x_i : centroid of x coordinates for each entity(mm)

y_i : centroid of y coordinates for each entity(mm)

Rule 2) Distance from edge of plate to center of sub guidepost is designed to be larger than 40mm.

Rule 3) Punch length is smaller than the criteria suggested in the following expression.

$$l \leq \sqrt{(2\Pi^2 EI/CP)}$$

where, l : punch length(mm)

E : elastic modulus(kgf/mm^2)

I : second moment of area(kgf/mm^4)

CP : safety factor

Rule 4) If any error at an equal pitch occurs, it is adjusted at the central position.

Rule 5) Length of pilot pin should be greater than three times the thickness of product.

Rule 6) Pilot pins are arranged as many as possible within the range that pitch of pilot pins is less than 35mm.

Rule 7) Positions of the knock pins and springs are arranged around the punch contour at equal pitch

Rule 8) Screws and dowels are located around the perimeter of the die block in a straight line at equal pitch.

4.3 Rules of post processing

Rule 1) In case that profile working is possible, partition of die is required. In case that partition of the die is impossible, die is manufactured by wire working.

Rule 2) If the dimensions of the die plate longer than 400mm, partition of the die plate is required.

Rule 3) The clearance between the partition die plates is designed to be 1mm.

Rule 4) The distance from the edge of the die pocket to that of the die plate is designed to be larger than 20mm and the distance between the pockets is designed to be larger than 20mm.

Rule 5) The cavity punch is designed more than 0.1mm away from die pad.

Rule 6) The cavity punch is designed to maintain the distance of 0.07mm from the die bar.

Rule 7) The single clearance between the stripper and the punch is designed to be 0.03mm.

Rule 8) The pilot pins are arranged as many as possible have pitches of less than 35mm.

Rule 9) The lifters are symmetrically arranged between the pilot pins.

Rule 10) Regrinding of die and punch is required after piercing from 600,000 to 700,000strokes.

Rule 11) The width of the guide plate is designed to be larger than 0.08mm in the direction of single clearance from that of the strip.

Rule 12) The distance between the springs of the stripper is designed to be greater than 40mm.

Rule 13) The distance between the corner of the pocket and the internal feature is designed to be 5-6mm.

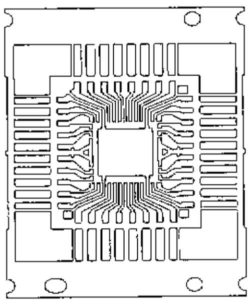

Fig. 5 The 32LD PLCC lead frame

5. Application and results of the system

When a lead frame for a semiconductor requiring a very precise piercing operation for progressive working is designed on the automated CAD system, the results obtained in each module are given in the following sections.

Table 1 The numerical list carried out in shape treatment module for the shape of the cavity punch of the 32LD PLCC lead frame, semiconductor

```
((45.7875 215.795 0.0) (45.7875 221.93 0.0))
((45.7875 221.93 0.0) (45.8114 221.973 0.0) (45.8375 221.93 0.0) (rev))
((45.8114 221.973 0.0) (46.1095 222.155 0.0))
((46.1095 222.155 0.0) (46.1355 222.162 0.0) (46.1355 222.112 0.0) (rev))
((46.1355 222.162 0.0) (46.4378 222.162 0.0))
((46.4378 222.162 0.0) (46.4851 222.129 0.0) (46.4378 222.112 0.0) (rev))
((46.4851 222.129 0.0) (46.6247 221.723 0.0))
((46.6247 221.723 0.0) (46.6275 221.706 0.0) (46.5775 221.706 0.0) (rev))
((46.6275 221.706 0.0) (46.6275 221.502 0.0))
((46.6275 221.502 0.0) (46.5275 221.402 0.0) (46.5275 221.502 0.0) (rev))
((46.5275 221.402 0.0) (46.3975 221.402 0.0))
((46.3975 221.402 0.0) (46.2975 221.302 0.0) (46.3975 221.302 0.0))
((46.2975 221.302 0.0) (46.2975 216.422 0.0))
((46.2975 216.422 0.0) (46.3975 216.322 0.0) (46.3975 216.422 0.0))
((46.3975 216.322 0.0) (46.5275 216.322 0.0))
((46.5275 216.322 0.0) (46.6275 216.222 0.0) (46.5275 216.222 0.0) (rev))
((46.6275 216.222 0.0) (46.6275 216.019 0.0))
((46.6275 216.019 0.0) (46.6247 216.002 0.0) (46.5775 216.019 0.0) (rev))
((46.6247 216.002 0.0) (46.4851 215.596 0.0))
((46.4851 215.596 0.0) (46.4378 215.562 0.0) (46.4378 215.612 0.0) (rev))
((46.4378 215.562 0.0) (46.1355 215.562 0.0))
((46.1355 215.562 0.0) (46.1095 215.57 0.0) (46.1355 215.612 0.0) (rev))
((46.1095 215.57 0.0) (45.8114 215.752 0.0))
((45.8114 215.752 0.0) (45.7875 215.795 0.0) (45.8375 215.795 0.0) (rev))
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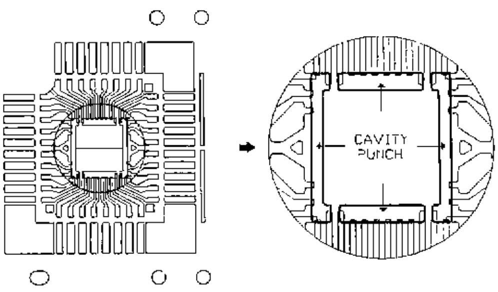

Fig. 6 Generation of the cavity punch of the 32LD PLCC lead frame in the shape treatment module

5.1 Application to the input and shape treat- ment and the production feasibility check modules

When a user inputs items demanded for the lead frame product as show in Fig. 5, the shape treatment module, being the recognized drawing of input shape, converts the numerical list into a list of closed loops to design each module. These lists are used to run the program in each module using the rule and database in common.

It extracts the list to design the cavity punch from the numerical data of the lead frame and automatically designs the cavity punch to prevent plastic deformation occurring in the end part of the internal lead. Fig. 6 shows the shape of the cavity punch generated automatically. The shape list of the cavity punch is shown in Table 1.

When the internal lead of the lead frame, 32LD PLCC, is applied to the production feasibility check module, the results of checking the corner radius of the product, the holes to be pierced, and the distance between the shapes of internal features are shown in Table 2 and Table 3. From these results, this system knows that the minimum distance between the shapes of internal features and the holes to be pierced are within the feasible area. This module, therefore, prevents errors which would occur in the actual workshop.

Table 2 Production feasibility check of corner and fillet radius for the 32LD PLCC lead frame with the thickness 0.254mm

Corner radius greater than criteria	
Minimum corner radius	: 0.5
Criteria	: 0.1275

Table 3 Production feasibility check of holes for the 32LD PLCC lead frame with the thickness 0.254mm

Min. Diameter of Circle Greater Than Criteri	
Minimum Diameter	: 1.25
Limits Diameter	: 0.2032
Min. Rectangular Distance G.T. Criteria	
Min. rectangular distance	: 0.256
Limit distance	: 0.1778

5.2 Application to the strip layout, the die layout, and the post processing modules

When the 32LD PLCC lead frame product is applied to the strip layout module, the results which are output by this module are shown in fig. 7. The strip layout module, by checking the interference of the outer diameter of the die blank and the thrust force, can carry out an automated strip layout to prevent the die from being broken. In the case of punches working on the external part of the product, the pilot pin hole, epoxy hole, external lead, moulding hole, and cutting bar, and shape of the product is the same as that of the punch, but in the case of complicated punches, the die pad, and internal lead, and punch profiles are divided automatically. When piercing internal leads, this module carries out progressive working considering the minimum distance so as not to interfere according to the size of the shear length. Plastic deformation occurring at the end part of the internal lead is required for designing the cavity punch to prevent such a deformation.

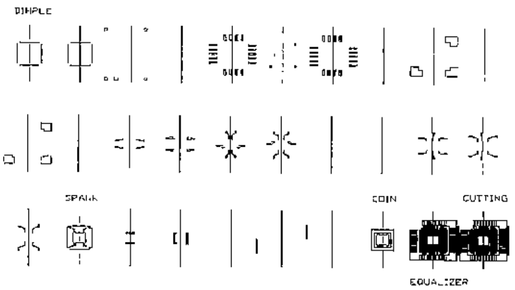

Fig. 7 An automatic strip layout drawing for the 32LD PLCC lead frame

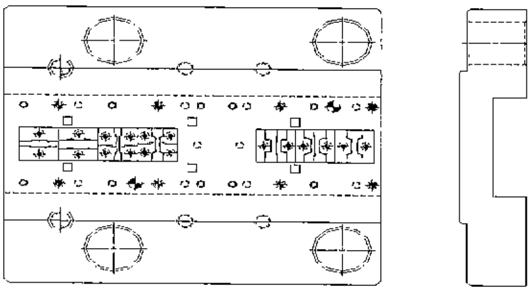

Fig. 8 A drawing of the die plate of internal leads generated in the die layout module

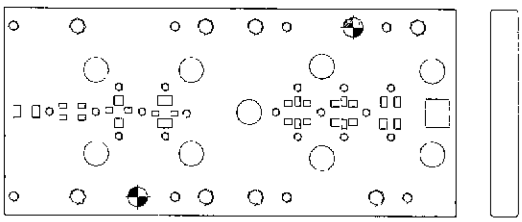

Fig. 9 A drawing of the punch plate of internal leads generated in the die layout module

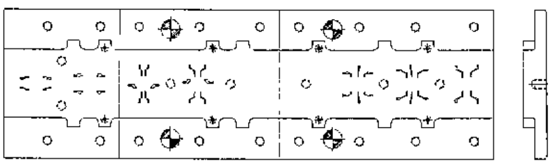

Fig. 10 A drawing of the stripper plate of internal leads generated in the die layout module

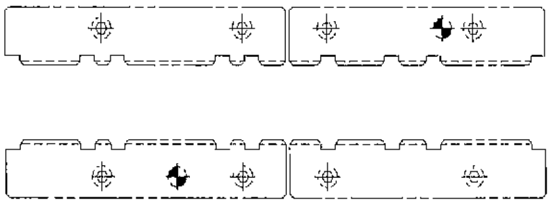

Fig. 11 A drawing of the guide plate of internal leads generated in the die layout module

The data conversion module converts the shape data of the strip layout drawing for the lead frame into recognizable shape data in order to use the I-DEAS master series drafting program. When the lead frame, 32LD PLCC, is applied to the die layout module, the parts and assembly of the die set are generated and can be seen in fig. 8 ~ 12.[3]

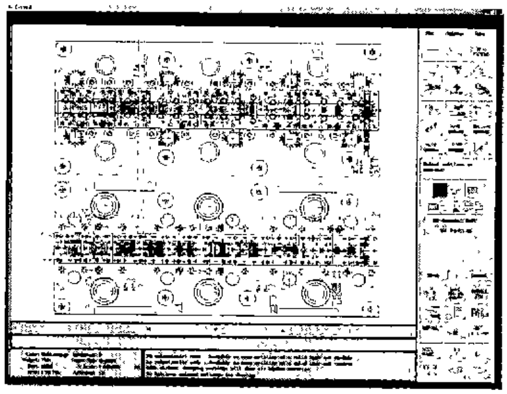

Fig. 12 A drawing of die set of the internal leads generated in the die layout module

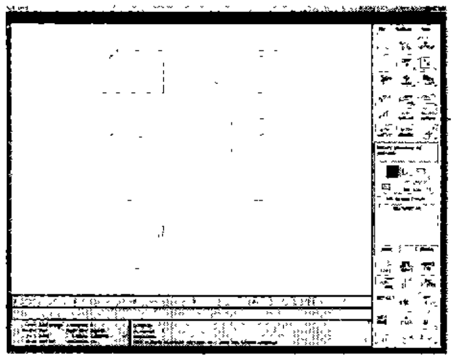

Fig. 13 Drawings of parting die of the internal leads

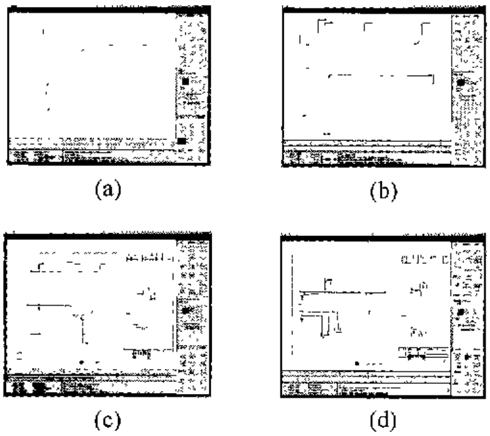

Fig. 14 Working drawings of the punch of the internal lead generated in the post processing module

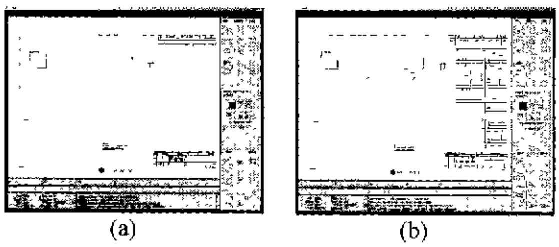

Fig. 15 Working drawings of the punch backing plate with the hole chart generated in the post processing module

The module reads standard parts from the database according to data obtained from the strip layout module, and for non-standard parts not stored in the database, and carries out the design. Therefore it generates the die layout drawing. Calculating the outer diameter under normal pressure of the die, and the clearance of geometric shape between of the die, and the clearance of geometric shape between die and punch, the center of pressure for the balance of forces, the number and arrangement of screws, and the number and arrangement of dowel pins, and the size of the dic block is decided by the following procedures. It calculates the "area of die layout" based on the length and width of the strip layout drawing. After calculating these data of the dic plate, the dimensions of the die set are standardized to those of the die set stored in the database. Also, based on the dimensions of the standardized die set, the thickness of the die plate and stripper plate, the minimum distances from the edge of die plate to the dowel pin and to the bolt, are obtained from the database. The diameters of the dowel pin and the fastener, and the diameters of the sub-guide and main-guide posts are obtained from the database. It checks success or failure by buckling of a punch. In the internal lead of the lead frame, the dimensions to be pierced are the same as those of the punch and the dimensions to be blanked, as those of the die. After all the die blanks are arrayed, moments are calculated from the position and center of gravity of each shape in order to determine the balance force point. Matching this point to the center of die set produces a balanced pressing pressure and reduces the wear of the dic and punch. By quantifying the technique and experience in this workshop, this module can generate the best die layout drawing preventing from plastic deformation and defects.

Using data obtained from the die layout module, this module generates the working drawings with hole chart, dimensions, hatching, cross section, and side view.

The results which are output in this module are shown in Fig. 13 ~ 15.

6. Conclusions

The study developed as computer aided die design system for process planning and die design for lead frame products for semiconductor with very precise piercing operations.

The automated computer aided die design system has the following features.

1. The input and shape treatment module, by recognizing the shape of the product input, convert a numerical random list of shape data into a numerical list of a closed loops to use easily in each module.
2. The production feasibility check module can check production feasibility for a lead frame product requiring very precise piercing operations.
3. Taking account of the outer diameter of the die blank under normal pressure for each shape of product, in the production feasibility check module, the shapes of the punch profiles were divided automatically for the external area.
4. The strip layout also checks the idle station between succeeding processes to prevent the die from being

broken and generates the strip layout drawing automatically.

5. The die layout module can carry out automated die layout and generate parts and assembly drawings of the die set in graphic form.
6. The post processing module automatically generates working drawings of the parts.

This system quantifies techniques and experience needed in designing die sets and standardizes design rules for formulating procedures for design. It has the advantage that it can be used by a novice who may not have any knowledge of tool design. By realizing an automated system on AutoCAD for process planning and on I-DEAS for complicated die design, the system, linked with other CAM software, can automatically generate NC data so a CAD/CAM system for lead frame for semiconductors requiring very precise piercing operations may soon be developed.

Acknowledgement

This work was supported by the Korea Science and Engineering Foundation(KOSEF) through the engineering Research center for Net Shape and Die Manufacturing at Pusan National University

References

1. J. C. Choi, B. M. Kim, H. Y. Cho and Chul Kim, "A compact and practical CAD system for blanking or piercing of irregular-shaped sheet metal products and stator and rotor parts," International Journal of MACHINE TOOLS & MANUFACTURE, Vol. 38, pp. 931-963, 1998.
2. J. C. Choi, B. M. Kim, H. Y. Cho, Chul Kim and J. H. Kim, "An integrated CAD system for the blanking of irregular-shaped sheet metal products," Journal of Materials Processing Technology, Vol. 83, pp. 84-97, 1998.
3. J. C. Choi, C. Kim and J. H. Yoon, "An automated CAD system for progressive working of irregular shaped metal products and lead frame for semiconductor," International Journal of Advanced Manufacturing Technology, Vol. 16, pp. 624-634, 2000.
4. G. Schaffer, "Computer design of progressive dies," Am. Mach, Vol. 22, pp. 73-75, 1971.
5. B. Fogg and Jaimeson, "The influencing factors in optimizing press tool die layouts and a solution using computer aids," CIRP Annals, Vol. 24, pp. 429-434, 1975.
6. Y. Shibata and Y. Kunimoto, "Sheet metal CAD/CAM system," Bull. Jpn. Soc. Prec. eng., Vol. 15, pp. 219-224, 1981.
7. S. Nakahara, T. Kojima, S. Tamura, A. Funimo, S. Choichiro and T. Mukumuru, "Computer progressive die design," Proceedings of 19th MTDR conference, pp. 171-176, 1978.
8. Y.K.D.V. Prasad and S. Somasundaram, "CADDS : An automated die design system for sheet-metal blanking," Computing & control engineering journal, pp. 185-191, 1992.
9. F. Strasser, "The secret of successful press tool design," Tooling, February, 1976.