

## ***A Computerized Program To Allocate Datums For Rectangular Central Symmetrical And Non-Symmetrical Dies***

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### **Abstract**

*Due to the lack of planning engineers and their expertise in Iraqi enterprises to set up the manufacturing routes for the eng. parts like dies, where their works began with identifying and allocating references points to tolerancing and dimensioning the drawings. For this purpose an algorithm sets up and a program is built up under Visual Basic. The program is capable to identify and allocate (for eng. drawing) these reference points automatically using AutoCAD as input/ output interface. This leads to decrease time and efforts accomplished with accurate and precisions tolerancing and dimensioning calculations. The program can be developed in future to include complex and non-symmetrical shapes.*

*بناءً أسلوب برمجي لتحديد المواقع المرجعية لأجزاء القوالب المتماثلة وغير المتماثلة حول المركز*

### **الخلاصة**

*إن الحاجة ماسة لوضع هذا البرنامج وذلك لقلّة عدد وخبرة مهندسي التخطيط في المنشآت العراقية المختصين في وضع المسالك التكنولوجية للأجزاء الهندسية (كالقوالب) والتي تعتمد بالأساس على تحديد واختيار النقاط المرجعية المناسبة لوضع الأبعاد والقياسات كبداية لوضع المسلك التكنولوجي. تم وضع خوارزمية لذلك وباستخدام لغة البرمجة (Visual Basic). تم بناء برنامج حاسوبي لهذا الغرض بحيث يعمل البرنامج بالارتباط مع الحزمة البرمجية (AutoCAD) كمدخلات ومخرجات عن طريق تبادل البيانات باستخدام DXF. هذا البرنامج يقوم بتحديد واختيار هذه النقاط المرجعية بشكل أوتوماتيكي للرسومات الهندسية المستخلصة من الحزمة البرمجية (AutoCAD). أن تحديد هذه النقاط المرجعية يضمن سرعة إنجاز العمل و تقليل الجهد كما يضمن دقة احتساب التفاوتات والأبعاد المطلوبة لتنفيذ المسلك التكنولوجي، كما أن هذا البرنامج قابل للتطوير ليشمل أشكال أكثر تعقيداً وغير منتظمة مستقبلاً ليصبح حزمة برمجية جاهزة للاستخدام في منشآتنا الصناعية.*

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**Glossary:**

- CAD*: Computer Aided Design or Drawing.  
*CAM*: Computer Aided Manufacturing.  
*CIM*: Computer Integrated Manufacturing.  
*CAPP*: Computer Aided Process Planning.  
*CMPP*: Computer Managed Process Planning.  
*DXF*: Data Exchange (Format) File.

**1. Introduction:**

Datum or reference points, lines, planes and surfaces are an essential features in part drawing, process planning, manufacturing, and part inspection and quality control. Their affect appears quite clearly on machining cost and cycle time. For a given part / product design, multi manufacturing plans (routes) can be estimated by a process planner engineers due to their variation in knowledge, expertise and different firm environment.

The first step to set a plan is to allocate and identify references point (datums) to tolerancing and dimensioning the drawing. The aim of this research is to build a program to assist the planner engineer to put the process plan for rectangular die parts symmetrical and non-

symmetrical engineering drawings, this will ease to automate CAD, CAM and CAPP leading to implementing CIM.

**2. Datum definition:**

A datum is a theoretically exact point, axis, or plane derived from the true geometric counterpart of a specified datum feature. A datum is the origin from which the location or geometric characteristics of features of a part established <sup>[1]</sup>, (See appendix (A) for more definition terms).

Datums, based on their applications, can be classified into five categories <sup>[1]</sup> :

- 1- Design datums, which are datums used on part drawing for the purpose of dimensioning.
- 2- Setup datums, which are datums used to locate and setup the part on the workholder (fixture) or the machine table.
- 3- Operational datums, which are datums used to determine the way the machining cuts are taken.
- 4- Measuring datums, which are used for inspection purpose after machining.
- 5- Assembly datums, which are used to determine the position of the part in an assembly or the position of

an assembly on an assembly machine.

### **3. The role of datum in design:**

In drawing, reference plane may coincide with the front surface of the object, or it may cut through the object if the object is symmetrical, or the reference plane may coincide with the back surface of the object, or through any intermediate point of the object. The reference plane should be assumed in the position most convenient for transferring distances with respect to it. The advantage of the reference plane is that fewer measurements are required, since some points of the object lie in it [2]. (Figure 1) in drawing, it is expected to convey a complete description of every detail of a part. However, dimensioning is as important as the geometric information. And in manufacturing, a drawing without dimensions is worthless [3].

In dimensioning any drawing, the most important terms related to datum according to the American National Standards Institute are [3].

- To show the dimensions between points, lines, or surfaces that have a necessary and specific relation to each

other or that control the location of other components or mating parts.

- To select and arrange dimensions to avoid accumulations of tolerances that may permit various interpretations and cause unsatisfactory mating of parts and failure in use.

The basic location where most dimension lines originate is the reference location (datum). And for machining, the reference location provides the base from which all other measurement is taken [3]. This is also true as one step included in general design procedure [4] to set overall size limits with references to mounting upon an attachment to a machine.

Although manufactured products are all designed to have certain geometric shapes, but due to various uncontrollable factors, there are always geometric departures between the products and the design specifications. One important issue here is to judge and control the geometric quality of a product. In general, the geometric quality of a product is judged by how close the product is in compliance with geometric tolerances specified in the design [5].

Software needed to prepare the engineering drawing that done by the

designer's hand or with Computer Aided Design CAD, to design the manufacturing route. This step is an essential step toward automated process planning, which emerges as key factor in CAD/CAM integration leading to Computer Integrated Manufacturing CIM [6].

One Computer Aided Process Planning CAPP system, explained the need to datum and references in Computer Managed Process Planning CMPP, see figure (2). In Computer Managed Process Planning CMPP (developed by the United Technologies Research Center with some funding from U.S. Army) which applicable only to rotational parts - so the system has received limited in industrial environment, consist a process decision model (which consists a manufacturing logic) used some rules that specify how some reference surfaces are to be selected, depending on part information which includes final part shape, dimensions, tolerances, surface finish, geometric form conditions, material specifications, and surface treatments and/or coating [6].

#### **4. The general framework of the program:**

The general framework of the program includes sequential steps to allocate the suitable datum point for symmetrical and non-symmetrical geometrical parts (molding and punching dies). Figure (3) is a suggested framework.

##### **4.1. The extraction features proposal algorithm:**

Engineering features and elements for a part drawing must be identified which are lines, circles, and curves. The distinguishing of these features are done automatically by the program. The program is capable to read and identify the stored elements as Data Exchange Format DXF file, and figure (4) showed the proposal algorithm's flow chart.

##### **4.2. An algorithm to allocate the center of the geometrical drawing:**

For any symmetrical drawing, its boundaries must be identified and determine; the fourth surfaces or dimensions, right to left, and bottom to top. This done by drawing a dashed lines (center line) – vertical and horizontal lines, which divides the drawing into fourth partitions, according to the original and basic surrounding lines which are gathered from CAD system as DXF data file, see figure (5). These lines can be arranged in different ways /

vectors as it seen in figure (6). So in this way the fourth partitions are isolated correctly. The steps to allocate the center of drawing are:

- Step 1: the first step is to allocate the fourth sides of the drawing, the right line as the right side, and so on for the others sides.
- Step 2: point 1, point 2, point 3, and point 4 must be found. This done by using the equation (1) and equation (2), which is true for point 1 (x, y).

\*For right line, x-axis:

$$(X_{R1}=X_{R2}):$$

$$X_1 = X_{R1} \text{ or } X_{R2} \quad \dots\dots(1)$$

$$Y_1 = (Y_{R1} \text{ or } Y_{R2}) / 2 \quad \dots\dots(2)$$

The other points can be found in the same way.

- Step 3: to allocate the center:

$$X_c = (X_1 + X_2) / 2 \quad \dots\dots(3)$$

$$Y_c = (Y_3 + Y_4) / 2 \quad \dots\dots(4)$$

The flow chart of allocation the center algorithm is shown in figure (7).

#### 4.3. Reference Point Algorithm:

The algorithm is suitable to run simply for dies and part drawings, mold part drawing was selected, (appendix B). These parts are symmetrical holes almost around the center. Taking the zero point at the middle as a reference point is preferred. The supported previous algorithms are used divided the drawing and to

identify the central point. The steps of the reference point allocation algorithm are:

- 1- Identify whether shapes have a central feature or not.
- 2- Identify if it has symmetrical holes around that feature, then select the central point as reference point.
- 3- Select the central point as reference point if all the holes lay on the same line.
- 4- If there is no central feature, but there are holes around the central point, select the left bottom hole center as reference point.

#### 5. The Software:

The software designed to assist the designer and planner engineer in their work. It works simply under Windows using Visual Basic, also linked to AutoCAD system for inputs and outputs using DXF data. See figure (13) for the start menu and figure (14) shows the input/output screen.

#### 6. Conclusion:

Datums and reference points are essential features mostly for drawing and manufacturing. They have influences on the dimensioning and tolerancing operation, also affects the manufacturing planning.

The proposed program was tested and the output was illustrated in figure(14), and the source of the program can be seen in appendix (C).

The benefits of this program are listed below:

- The program saves time and effort due to automation process.
- The process of allocation of reference Points are quickly and accurately. The program aids the engineers even the non-experts in their works to allocate the reference points due to simple and sequential steps.
- The program can be used for documentation by printing the datums lines on the drawing as the output.

For future work, the program can be developed to include other shapes. In addition, the integration with other software can be done in the future.

**References:**

- 1- H. C. Zhang, S. H. Huang, and J. Mei, Operational dimensioning and Tolerancing in Process Planning: Setup planning, Int. J. Res., 1996, Vol. 34, No. 7, 1841-1858.
- 2- Giesecke, Mitchell, Spencer and Hill, "Technical drawing", Collir-Macmillan International Edition, 1969.
- 3- Tien- chien Chang, Richard A. Wysk, and Hsu – Pin Wang, computer – aided manufacturing , Prentice – Hall, 1998 {ch.2}.
- 4- Frank W. Wilson, Philip D. Harvey, and Charles B. Gump, JR., Die Design H.B., McGraw-Hill, 1965, 2<sup>nd</sup> edition, section 2.
- 5- Gemai Chen and Jiahua Chen, Geometric Quality Inspection, Statistica Sinica 8 (1998), p.135-149.
- 6- David D. Bedworth, Mark R. Henderson and Philip M. Wolfe, Computer - Integrated Design and Manufacturing, McGraw-Hill, 1991, pp268.
- 7- "Geometric Dimensioning and Tolerancing definition", <http://www.engineersedge.com/gdt.htm>,2002.

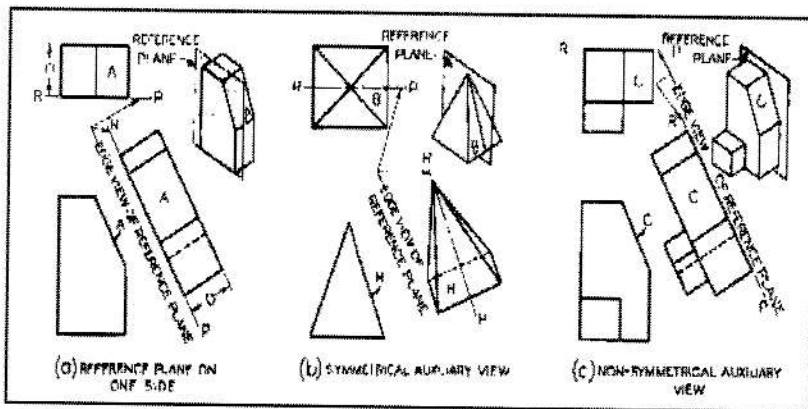


Figure (1) The reference plane [2]

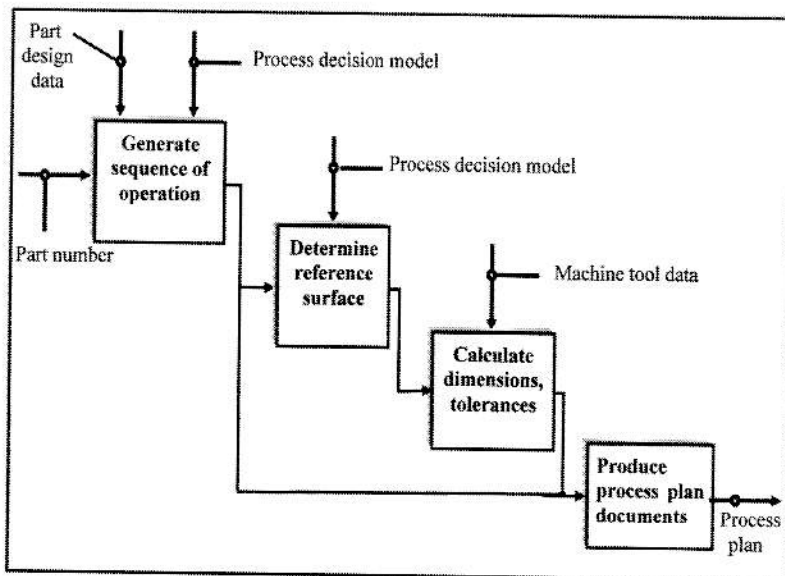
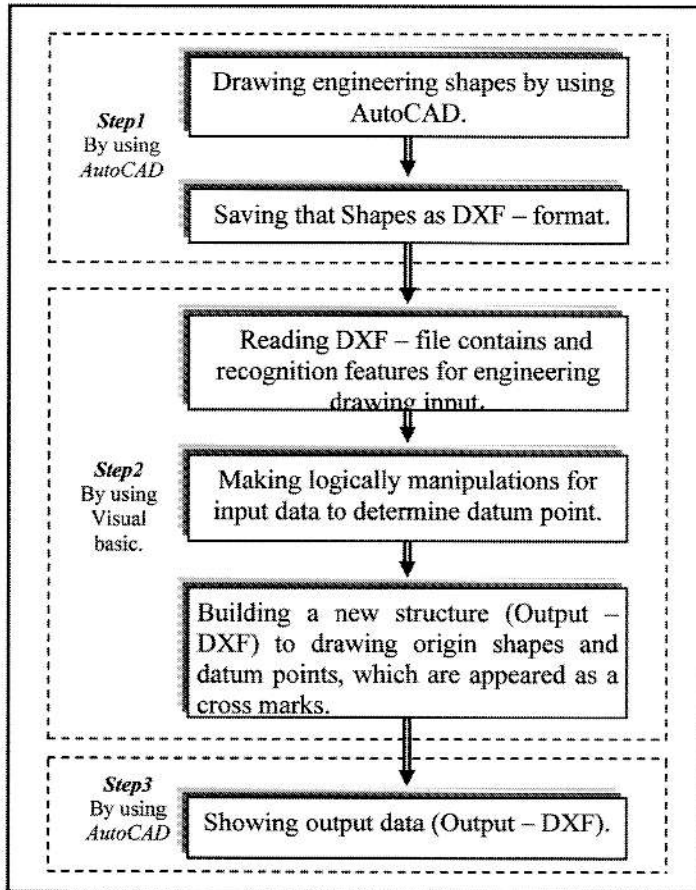


Figure (2) The CMPP process planning functions [3]



**Figure (3) The suggested framework.**



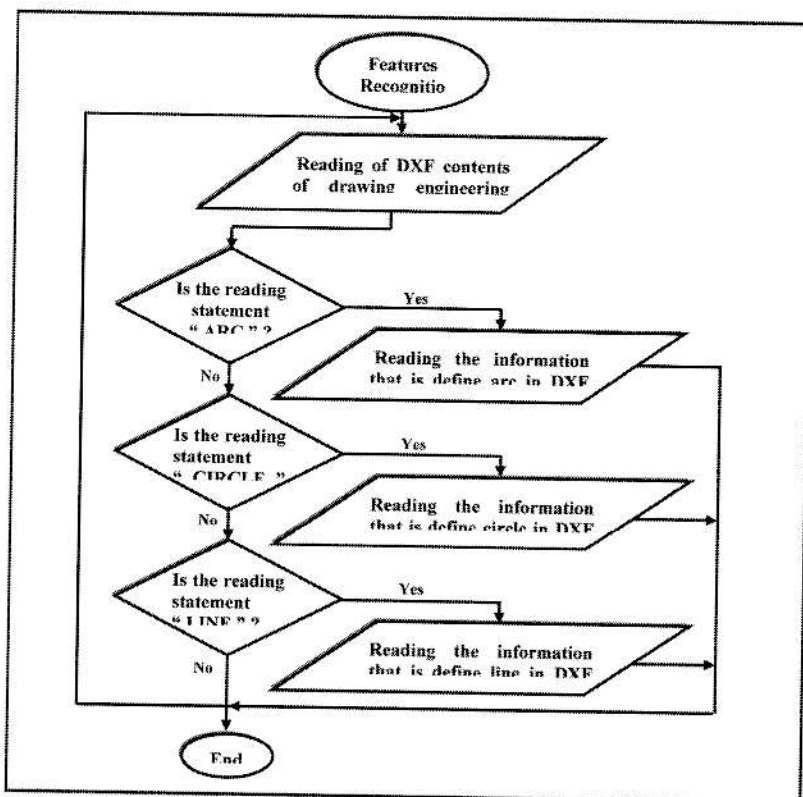


Figure (4) The proposal flow chart algorithm.

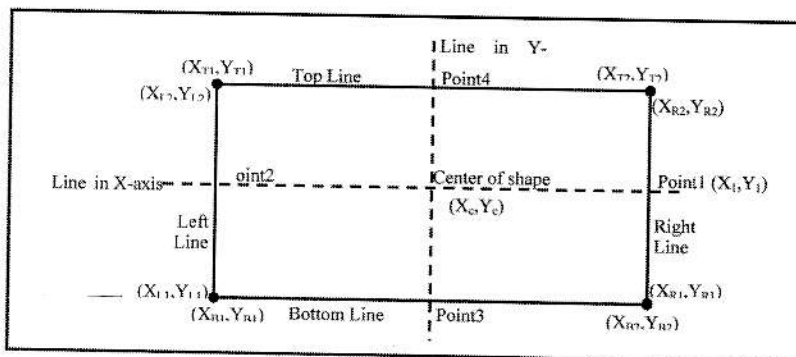


Figure (5) The dashed lines divided the drawing into two partitions.

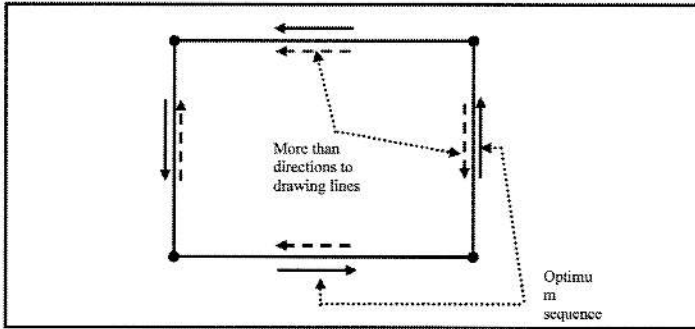


Figure (6) The direction of lines drawing and arrangement.

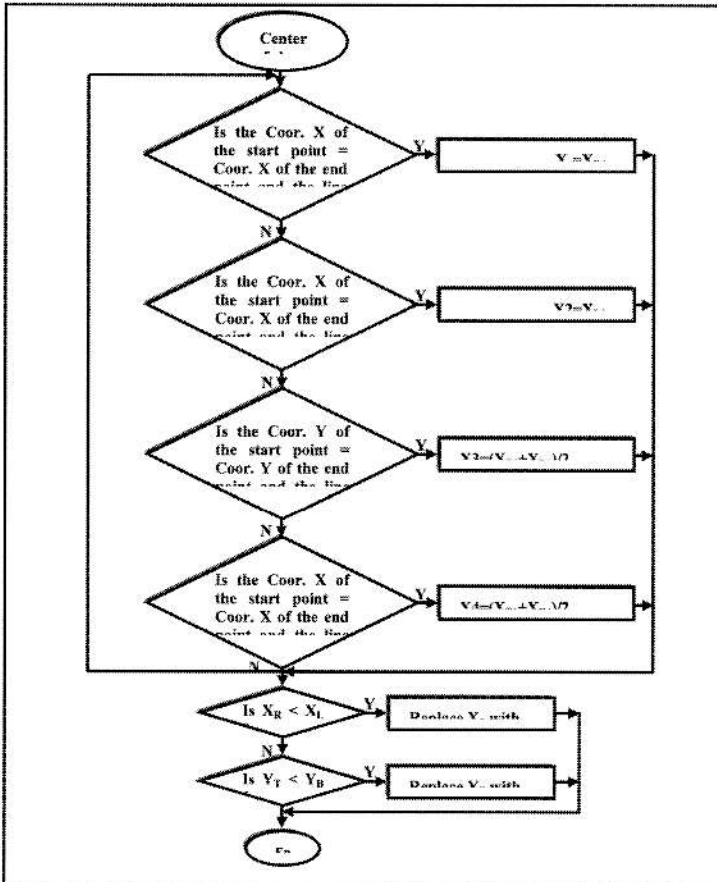


Figure (7) The flow chart of allocation the center algorithm.

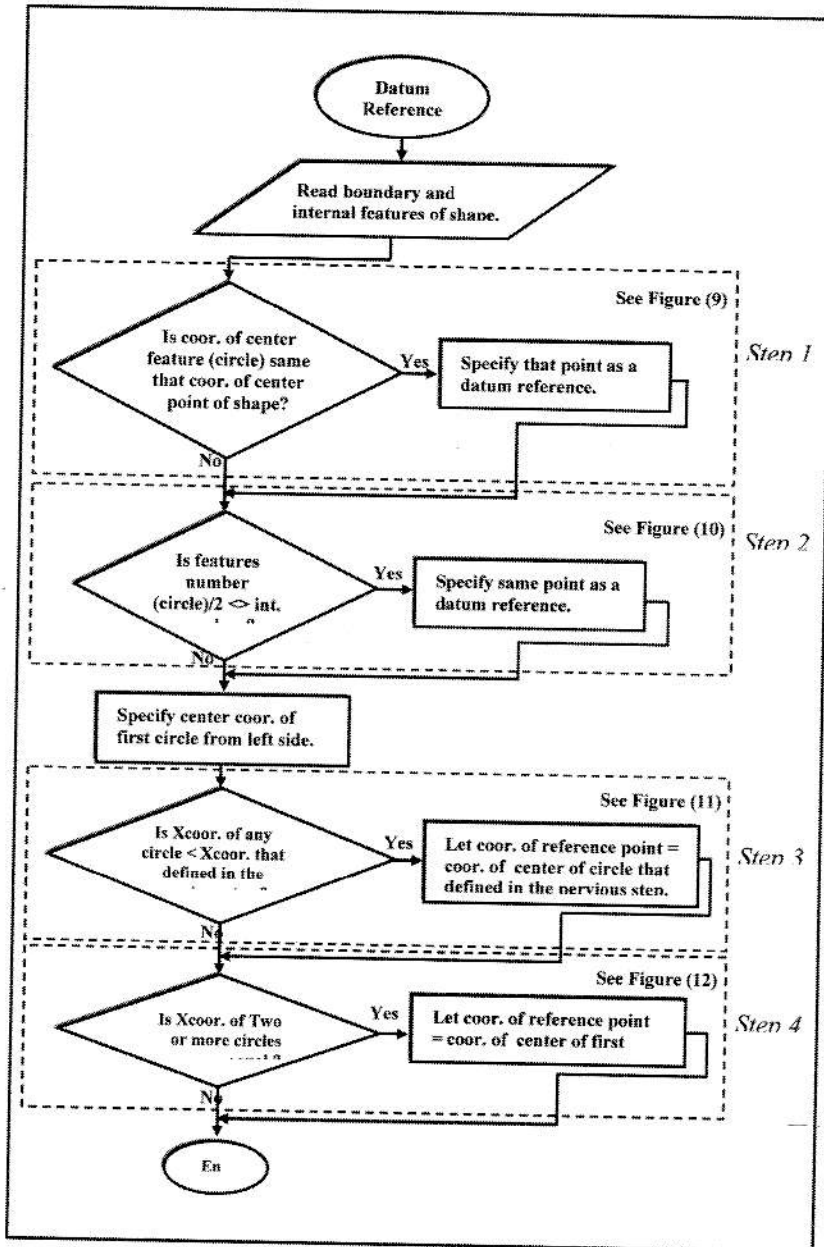
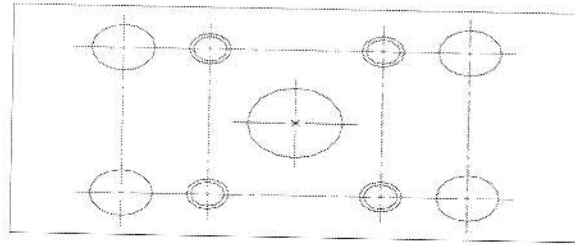
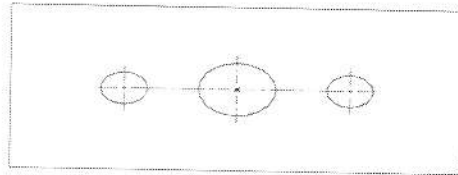


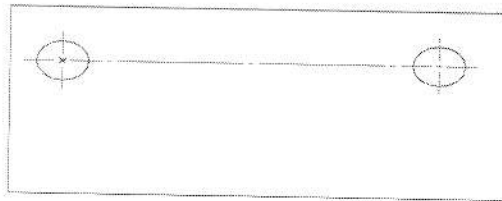
Figure (8) Algorithm to allocate datum point.



*Figure (9) Allocating the datum points in the center for a symmetrical central shape (step1 in Figure 8).*



*Figure (10) Allocating the datum points for central line circles (step2 in Figure 8).*



*Figure (11) Allocating the datum points for a line circles above the center of shape (step3 in Figure 8).*



*Figure (12) Allocating the datum points for two lines apart from the center of shape (step4 in Figure 8).*

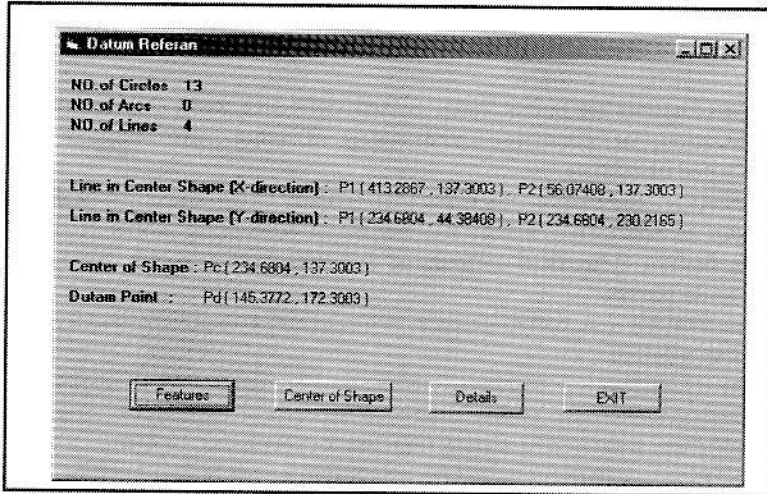


Figure (13) The start menu.

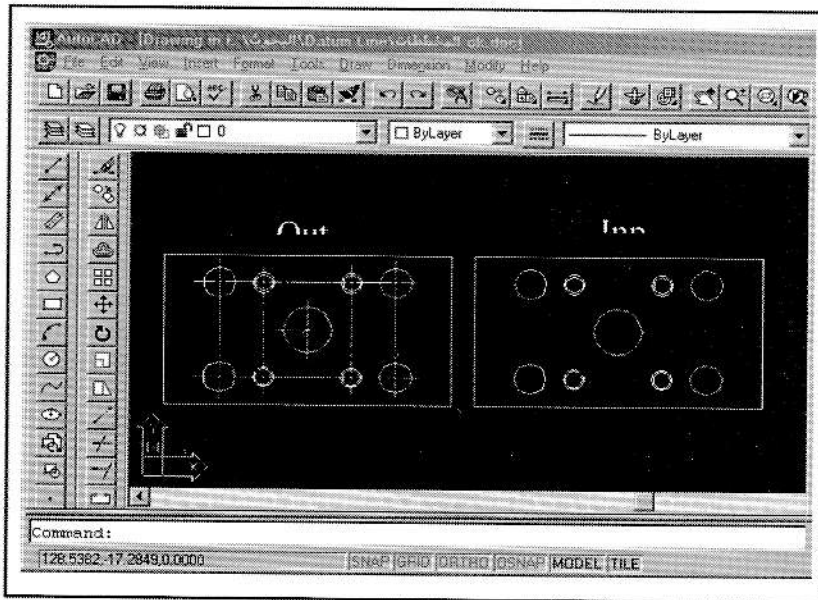


Figure (14) The input / output screen.

## *Appendix -A-*

(from Geometric Dimensioning and Tolerancing definition <sup>[7]</sup> )

**Datum** - Datums are points, lines, planes, cylinders, axes, etc., a, from which the location, or geometric relationship of other part features may be established or related.

**Datum Axis** - the datum axis is the theoretically exact centerline of the datum cylinder as established by the extremities or contacting points of the actual datum feature cylindrical surface, or the axis formed at the intersection of two datum planes.

**Datum Feature** - A datum feature is the actual component feature used to establish a datum.

**Datum Identification frame (Symbol)** - The datum identification frame (symbol) contains the datum reference letter in a rectangular box, usually preceded and followed by a dash (any letter except I, O, or Q).

**Datum Line** - A datum line is that which has length but no breadth or depth, such as, an intersection line of two planes, centerline or axis of holes or cylinders and/or reference line for functional tooling or gauging purposes.

**Datum Point** - A datum point is that which has position, but no extent; such as, the apex of a pyramid or cone, center point of a sphere or reference point on a surface for functional tooling or gauging purposes.

**Datum Reference** - A datum reference is a datum feature.

**Datum Reference Plane** - is a set of three mutually perpendicular datum planes or axis established from the simulated datum in contact with datum surfaces or features and used as a basis for dimensions for designs, manufacture, and inspection measurement.

**Datum Simulator** - A datum simulator a surface of adequate precision oriented to the high points of a designated datum from which the simulated datum is established. Examples: gage pin, block, surface of granite block.

**Datum Target** - is a specified point, line, or area on a part that is used to establish the Datum Reference Plane for manufacturing and inspection operations.

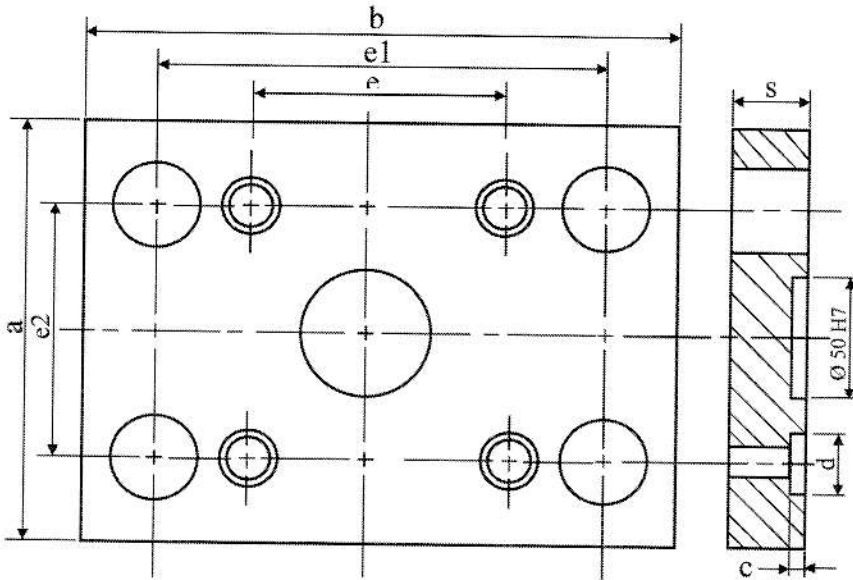
**Implied Datum** - An implied datum is an unspecified datum whose influence on the application is implied by the dimensional arrangement on the drawing; example, Coordinate dimensioning is applied to part, the zero dimension is attached to a feature this feature is implied as a datum element; axis, surface or plan

**Reference Dimension** - A dimension, usually without tolerance, used for information purposes only. It does not govern production or inspection operations. A reference dimension is a repeat of a dimension or is derived from other values on the drawing or related drawings.

**Appendix -B- DXF Output**

0	31	AcDbEntity	31	0,0	8
SECTION	0,0	8	0,0	0	0
2	0	0	0	LINE	62
ENTITIES	LINE	100	LINE	5	251
0	5	AcDbLine	5	28	100
LINE	1F	10	25	100	AcDbLine
5	100	100,1026	100	AcDbEntity	10
1D	AcDbEntity	20	AcDbEntity	8	130,1026
100	8	65,95391	8	0	20
AcDbEntity	0	30	0	62	165,8003
8	100	0,0	62	251	30
0	AcDbLine	11	251	100	0,0
100	10	384,2113	100	AcDbLine	11
AcDbLine	384,2113	21	AcDbLine	10	130,1026
10	20	65,9539122	10	130,1026	21
132,1026	208,6467	100	128,6026	20	168,8003
20	30	AcDbEntity	20	106,8003	31
169,3003	0,0	8	102,3003	30	0,0
30	11	0	30	0,0	0
0,0	384,2113	100	0,0	11	LINE
11	21	AcDbLine	11	130,1026	5
128,1026	65,95391	10	131,6026	21	2C
21	31	100,1026	21	124,3003	100
165,3003	0,0	20	102,3003	31	AcDbEntity
31	0	65,95391	31	0	8
0,0	LINE	30	0,0	0	0
0	5	0,0	0	LINE	62
LINE	20	11	LINE	5	251
5	100	384,2113	5	29	100
1E	AcDbEntity	21	26	100	AcDbLine
100	8	65,95391	100	AcDbEntity	10
AcDbEntity	0	31	AcDbEntity	8	128,6026
8	100	0,0	8	0	20
0	AcDbLine	0	0	62	167,3003
100	10	CIRCLE	62	251	30
AcDbLine	100,1026	5	251	100	0,0
10	20	23	100	AcDbLine	11
132,1026	208,6467	100	AcDbLine	10	131,6026
20	30	AcDbEntity	10	130,1026	21
165,3003	0,0	8	134,6026	20	167,3003
30	11	0	20	97,8003	31
0,0	384,2113	100	102,3003	30	0,0
11	21	AcDbCircle	30	0,0	0
128,1026	208,6467	10	0,0	11	LINE
21	31	130,1026	11	130,1026	5
169,3003	0,0	20	152,1026	21	2D
31	0	102,3003	21	80,3003	100
0,0	LINE	30	102,3003	31	AcDbEntity
0	5	0,0	31	0,0	8
LINE	21	40	0,0	0	0
5	100	15	0	CIRCLE	62
1F	AcDbEntity	0	LINE	5	251
100	8	LINE	5	2A	100
AcDbEntity	0	5	27	100	AcDbLine
8	100	24	100	AcDbEntity	*
0	AcDbLine	100	AcDbEntity	8	10
100	10	AcDbEntity	8	0	344,2113
AcDbLine	100,1026	8	0	100	20
10	20	0	62	AcDbCircle	130,3003
384,2113 8	208,6467	62	251	10	30
0	30	251	100	130,1026	0,0
100	0,0	100	AcDbLine	20	11
AcDbLine	11	AcDbLine	10	167,3003	344,2113
10	100,1026	10	125,6026	30	21
132,1026	21	130,1026	20	0,0	124,3003
20	65,95391	20	102,3003	40	31
165,3003	31	100,8003	30	15	0,0
30	0,0	30	0,0	0	0
0,0	0	0,0	11	LINE	0
11	LINE	11	108,1026	5	0
128,1026	5	130,1026	21	2B	ENDSEC
21	22	21	102,3003	100	0
169,3003	100	103,8003	31	AcDbEntity	EOF

*Appendix -C-*



\* The dimensions  $a$ ,  $b$ ,  $c$ ,  $d$ ,  $e$ ,  $e_1$ ,  $e_2$  and  $s$  were taken arbitrary.