A Feature Recognition System in Automated Modular Process Planning System

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Abstract:*The paper focuses on feature recognition system for rotational part, which is very important for the Automated Modular Process Planning System. Feature recognition is nothing but reading part drawing so as to understand manufacturing entities and corresponding geometrical information. As an entire process plan depends on accuracy of feature recognition. It is necessary to reduce ambiguity and provide consistency in product data interpretation, whilst offering flexibility to CAD modelling. Features are basically different shapes of line segments with a start point, end point and direction. The horizontal and vertical lines are the lines parallel and perpendicular respectively to the centre line of the part drawing. While inclined lines make certain acute angle with the centre line measured in anticlockwise direction. In this work nine form features for rotational parts are classified in two groups viz. primary features and secondary features. The Primary features are those which are drawn on zero layer and retained on '0' layer. While those which are extracted from zero layer and put on other than zero layer automatically are called secondary features. All primary features are external features which include cylinder, facing, taper, and chamfer. The secondary features can be external as well as internal, which include recess, arc, hole and thread. From the results it is clearly observed that the developed feature recognition system is successfully providing accurate results and have the capability to be incorporated automated modular process planning system.*

KEYWORDS:*Automated ModularProcess Planning, Computer Aided Design, Feature recognition*

1. INTRODUCTION

Feature recognition has been the subject of research since last two decades due to its large variety of applications in different areas [1, 2]. In order to use CAD drawing directly in process planning without intervention of human element, one has to use feature recognition technique[3, 4,10]. This is because, the CAD models contain low level entities such as faces, edges, points, and topological relationship for bounding model using primitives. The internal CAD data have no explicit knowledge of the manufacturing entities such as hole, slot, recesses, etc. It exists in the database as a set of faces, edges, curves and vertices, and hence not directly usable for manufacturing applications [5, 6,11]. The manufacturing entities which convey some meaning to a process planner are called as 'features'[7]. Hence the purpose of feature recognition in AMPPS is to read and interpret the part drawing in terms of size, shape, dimensions, and manufacturing entities [8,9,10].

2. THE FEATURE RECOGNITION SYSTEM

A modular program is developed for each of the functions in Visual Basic having connectivity between them. Visual Basic has been selected as a programming language as it has compatibility with Auto-CAD and

it is more users friendly. An output of each step is taken as an input toa subsequent step. A structure as shown in fig.1 facilitates the accurate transfer of data corresponding to each feature from one step to another step. Each of the steps is described in subsequent sections.

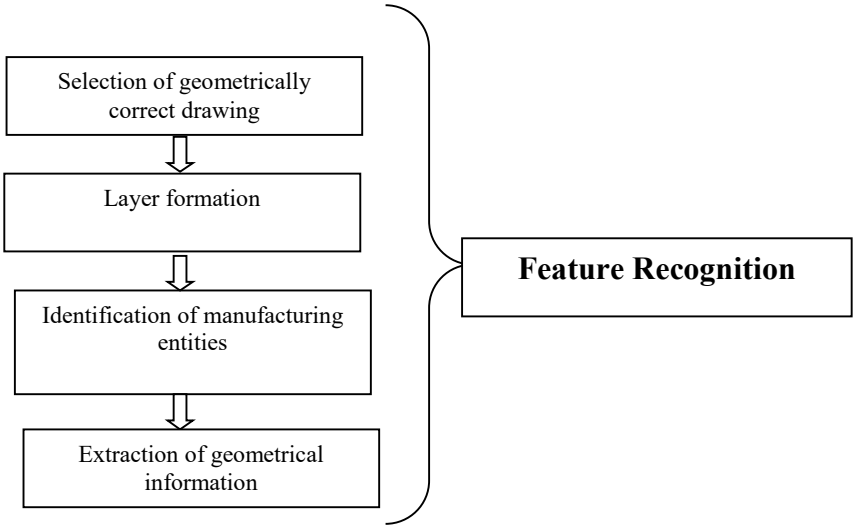

Fig.1 A structure of Feature recognition

2.1.Selection of Geometrically Correct Drawing

In order to recognize features and extract geometrical information precisely, it is necessary to process correct part drawing in subsequent steps. Hence inbuilt checks are incorporated to check correctness of part drawing. The algorithm developed for checking correctness of part drawing is shown in Fig. 2.

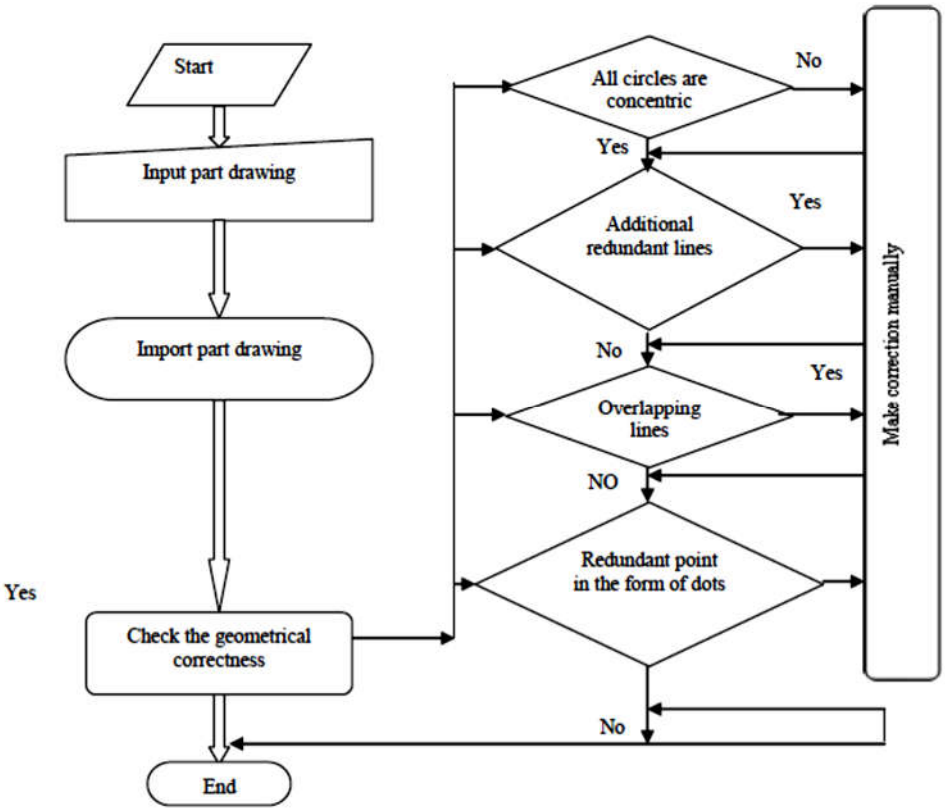

Fig.2 Algorithm for checking correctness of drawing

After giving input as a file name of a particular part drawing, a part drawing is extracted from Auto-CAD. Part drawing is checked for concentricity of circle in side view. If the circles are not concentric, then the alert/ message is given like circles are not concentric, but the corrections are to be done manually by the user. Other checks include the presence of redundant lines, overlapping lines and the point. The algorithm provides a facility for revising the drawing manually.

2.2 Layer Formation

A sample window demonstrating how layers are indicated is shown in Fig.3. Every drawing by default is drawn on a layer named '0' (zero), as highlighted, which can be neither deleted nor renamed. AutoCAD also has another layer, 'DEFPOINTS', which is generated automatically when the dimensional object is modified. Once this layer is generated it can neither be deleted nor renamed.

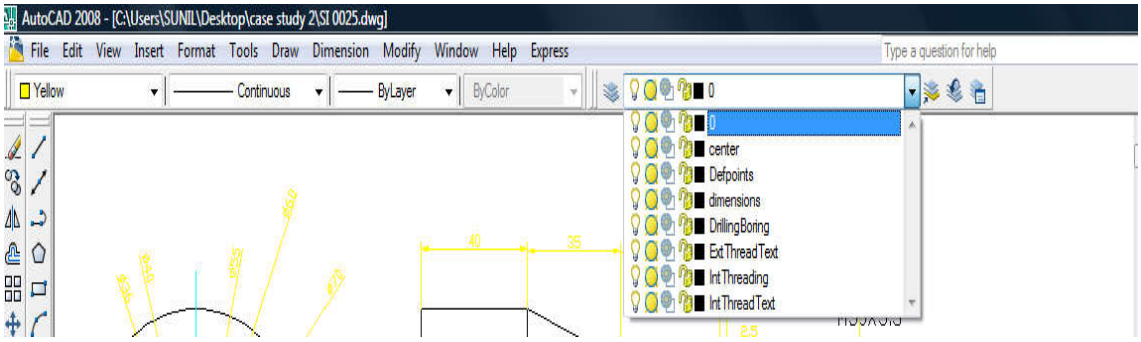

Fig. 3 Window of Layer Formation

The layer facility in Auto-CAD ensures that every drawing includes at least one layer and simultaneously enables the user to create additional special layers. Apart from '0' and 'DEFPOINT' layer, additional layers are created and named appropriately so that the titles selected are self explanatory to notify the contents. For example centre layer, which is used to draw centre lines, the dimensions layer is used to store the dimensions drawn on '0' layer, ExtThreadText and IntThreadText layers are used to store pitch value of external and internal thread respectively etc. For transferring a particular information from '0' layer to special layers, first new layer is created and named, and the corresponding dimensions, centre line, pitch etc, are transferred to this layer by clicking on respective line, diameter, text etc.

2.3 Identification of Manufacturing Entities

The features are identified in feature recognition module in the form of manufacturing entities, based on following rules. As rotational parts are symmetrical bout centre, only upper half portion of the centre line of part is considered while implementing these rules.

Summary of feature recognition for identifying different manufacturing entities is presented in Table 1.

Table 1. Rule based key for Feature recognition

Sr.No.	Entities Identified	Name of the Feature
1	A ByLayer line parallel to the centre line and corresponding circle in other view	Cylinder
2	Rightmost vertical ByLayer line perpendicular to center line and corresponding circle in another view	Facing
3	Inclined ByLayer line having inclined length more than 5mm and corresponding two circles in another view	Taper

4	Inclined ByLayer line having inclined length 5mm or less and corresponding two circles in another view	Chamfer
5	ByBlock line having two lines at the start point and end point	Arc
6	A continuous line (red colour) parallel to the centre line and circles (one corresponding to red continuous line and another corresponding to the cylinder) in another view with same line type	Recess
7	A ByLayer two continuous line (yellow colour) parallel to the centre line and corresponding two circles in another view with same line type	Extrnal thread
8	A ByLayer 'ISO dash' (ACAD_ISO002W) line parallel to the centre line and corresponding circle in another view	Hole
9	A ByLayer 'ISO dash space' (ACAD_ISO003W) line parallel to the centre line and corresponding two circles in another view	Internal thread

2.4. Extraction of Geometrical Information

The machining features help in identifying the manufacturing process (operations) required to acquire finished shapes. In order to execute the process selection, additional information related to geometry (dimensions) and non geometric parameters (part no., part name etc.) for each of the features is essential. The geometrical information includes dimensions like length, diameter, radius, angle, etc. This information is further used for calculation of tool travel, machining time, and generation of CNC code. Additionally, the information is also used for determining the stock size of the part. Though tool travel required for machining a specific feature depends on the features to be machined subsequently, extraction of geometrical information for each individual feature is presented in this section.

Cylinder: Example of geometrical information is taken for cylinder only in this paper. The geometrical information of a cylinder required for turning (plain and step) operations include diameter, start point, and length of cylinder. The cylinder is further classified as a large cylinder (maximum diameter) and step cylinders. The part has largest cylinder only when left most features is a cylinder. If it is not so, then all cylinders are called as step cylinders.

A cylinder is represented by two horizontal lines drawn one each on both sides of the centre line as shown in fig. 4. The diameter D is extracted directly from the diameter of the corresponding circle in side view. The length L of a cylinder is estimated using (1).

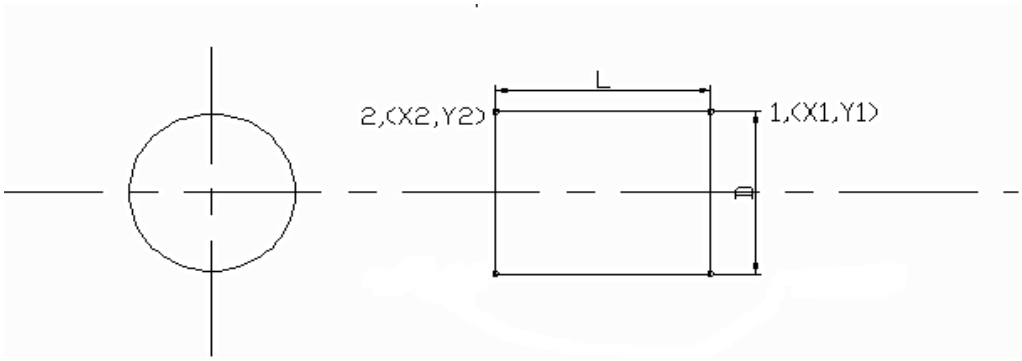

Fig.4 Geometrical information for cylinder

$$L = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2}$$

$$Y_2 = Y_1$$

$$L = \sqrt{(X_2 - X_1)^2}$$

$$L = |X_2 - X_1| \quad \text{--- (1)}$$

As the length is always positive, eq. (1) is modified by taking mod value.

Start point shall be 1 with coordinates (X_1, Y_1)

3. CASE STUDY

Part drawing is checked for concentricity of the circle, redundant line, overlapping lines and point in case of any corrections, the algorithm provides a facility for revising the drawing accordingly. As shown in fig. 5 the part name is extracted from the file name of drawing which is given to the drawing in Auto CAD. The part name is displayed on the task bar of the window as “Head pin” in the selected case study. The layers used in this case study for dimensions only. The remaining part drawing is displayed on “0” layer which occurs by default in Auto CAD. The part material is extracted from “material layer” and displayed on process sheet.

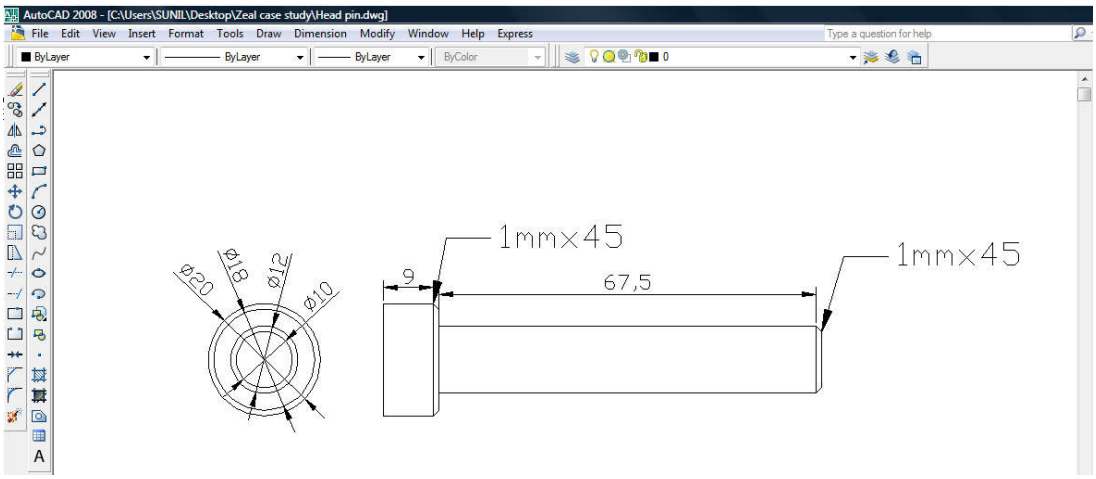

Fig.5 Part drawing selected for case study

4. RESULTS AND DISCUSSION

It can be seen from component drawing, as shown in Fig.6, that it has 3 features. They are,

- Face,
- Two cylinders, and
- Two chamfers

All these features come under the category of primary features. The feature recognition module recognizes these features along with geometric information (length and diameter) and displays the same as shown in Fig.7. From the results it is clearly observed that the developed feature recognition system is successfully working with hundred percent accuracy. The system is capable to display the results up to three digits. This feature recognition system can be incorporated automated modular process planning system.

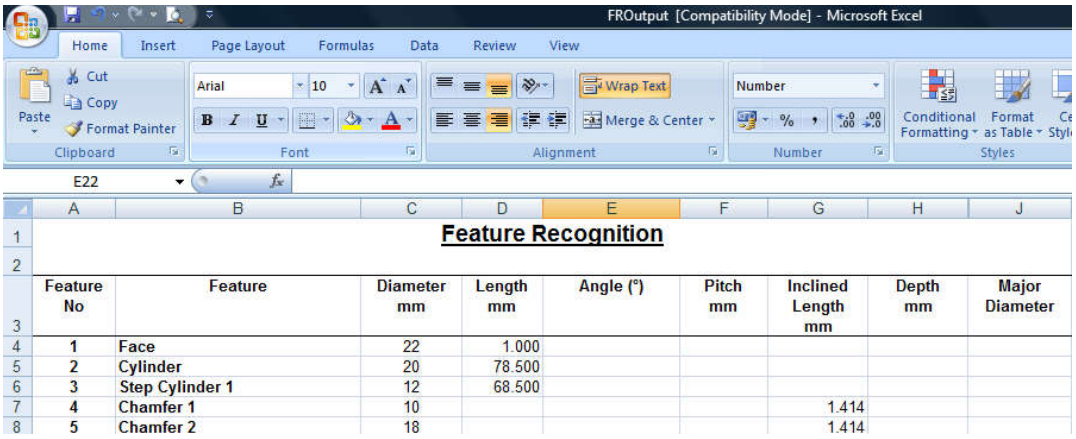

Fig.6. Results of developed Feature recognition system

5. CONCLUSION

A technique used for process planning of prismatic components may not be equally useful for cylindrical components. As feature recognition is the most important step in the integration of CAD and CAM, a critical examination is necessary before selecting the technique. A compatibility of feature recognition technique with other steps in process planning, user friendly, and also the extent of programming methodology involved in a technique need to be given due consideration. The developed feature recognition system is successfully working with hundred percent accuracy.

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