

Identifying Features of a CAD Model from a Part Feature Database

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Abstract

The plastic injection molding process is one of the most popular manufacturing processes for manufacturing thermoplastic products. The main objective of this paper is to describe the development of a part feature database and a CAD file-parsing program, which helps in identifying the features of a model, which is used in the plastic injection molding process. Part geometry is a key factor, which affects both the mold design and the manufacturing processes. For example, the mold base design needs cavity image dimensions and the part weight, which are provided by the parsing program. The manufacturing process involves optimizing the process parameters such as clamp tonnage, injection pressure, back pressure, melt temperature, mold temperature, nozzle temperature. Optimizing these parameters requires information about part surface area and part thickness, which is provided by this parsing program. The part feature database provides the basis for all these three important aspects in the plastic injection molding process.

Introduction

This paper describes the parsing program portion of the IKEM (Intelligent Knowledge-Based Engineering for Manufacturing) project whose primary objective is to develop a knowledge-based engineering (KBE) system for injection molding in which parts production is achieved with less time and greater quality. The rest of the project is divided into Cost Estimation, Mold Design and Manufacturing modules as shown in Figure 1. Often it is the molding parameters that control the efficiency of the process. Effectively controlling and optimizing these parameters during the manufacturing process can promote consistency, which takes the form of part quality and part cost. The experience level of the manufacturer(s) determines how effectively the process parameters are controlled. More often than not, this leads to inconsistency introduced by human error. There is also the case where there is a lack of experience, shortage of time or resources, and little room for innovation. Knowledge based engineering provides a feasible solution to all these problems by creating what is called “an intelligent model” of the problem. There are numerous variables that control the plastic injection molding process. A recent estimate shows that there can be more than 200 different process parameters that determine the final outcome of the product. However, it is important that

we target those that have the greatest influence on the quality and cost effectiveness of the finished product. There are three important parameters that most strongly affect the plastic injection molding process namely temperature, pressure and time.

- **Temperature:** The temperatures that significantly affect the injection molding process are temperature of the material, temperature of the mold, and the temperature of system's hydraulic fluid. While the material properties can change depending on its temperature, there is an optimum point at which the plastic retains its properties and flows properly. This value is obtained by an "educated guess" or by the trial-and-error method. The temperature of the mold affects the strength of the material. Each plastic has a specific mold temperature value at which it behaves best. Mold temperature is controlled by circulating water around the cavity, thus maintaining the mold at the required temperature.
- **Pressure:** Three kinds of pressures are involved in the plastic injection molding process: injection pressure, holding pressure, and clamp pressure. Injection pressure is the pressure required to produce the initial filling of the cavity. Holding pressure, which is applied towards the end of each injection cycle, is the pressure that holds the plastic against the cooling cavity. It is important to control this pressure as it affects the density of the part. The clamping pressure is responsible for holding the mold against the injection pressure. A very high clamping pressure may result in the collapse of the mold, while a very low value of the same can result in flash.

These parameters are to be optimized in order to obtain the best results. The main dominant factor in calculating processing cost is Cycle Time, which needs to be estimated first.

Dependency of Manufacturing, Mold-Design, Cost Estimating Modules on Parsing Program

It can be noticed from Figure 1 that the three modules need information about the part geometry. The main dominant factor in calculating processing cost is Cycle time or "The time taken for the completion of one complete injection molding process". There are many methods for calculating cycle time depending on the factors on which the cycle time depends. But the algorithmic approach, which is developed based on the part geometry, is used in IKEM. This calculation needs information about the features, some of which are shown in Figure 2:

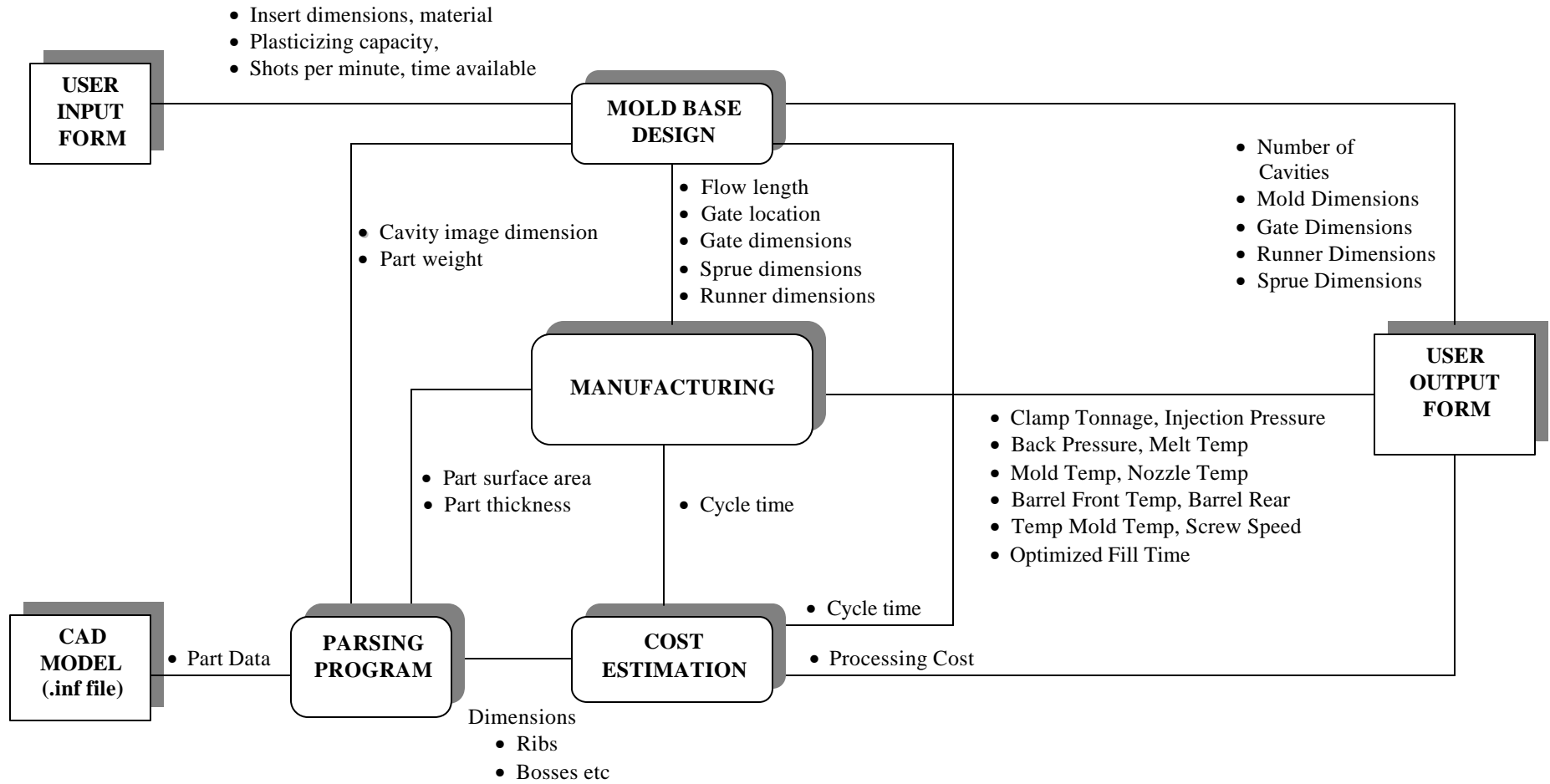


Figure 1. Dataflow Diagram

- 1) Ribs:
 - (a) Whether they are significant or not
 - (b) Which type of rib it is: Unidirectional Rib or Multi Dimensional Rib
- 2) Bosses:
 - (a) Whether they have significant role in calculating cycle time or not
 - (b) Whether it is a solid boss or a hollow boss
- 3) Gusset Plates: Information about their very existence itself
- 4) Surface finish

The parsing program provides all the information needed about these features. The current research project (IKEM) aims at designing a mold base with available specifications like the insert size, number of cavities, viscosity of the material etc. The dimensions of the mold base are determined based on these parameters, and the user is provided with the catalog number that most suits his application. The above parameters depend on part geometry in their calculation or estimation. For example, it needs cavity image dimension and part weight, which are provided by this parsing program. The manufacturing module involves optimizing the processing parameters such as clamp tonnage, injection pressure, back pressure, melt temperature, mold temperature, nozzle temperature, barrel front temperature, barrel rear temperature, mold temperature, screw speed, and optimized fill time. Optimizing these parameters requires information about part surface area and part thickness, which is done by the parsing program.

Brief View of the Part Information Stored in a CAD Application

In most of the plastic industry, *PRO/ENGINEER* has become a standard for design purposes. In this program, the part geometry information is stored in the form of *.inf* files. The parsing program takes this file as an input from the user. The following example illustrates the type of information stored in an *.inf* file.

In Figure 3, a model designed in *PRO/ENGINEER* application is depicted. Next to the model follows the information file for the model. For each feature in the model, a feature number and feature ID is allotted. A parent/child relationship is maintained between all the features. The information about the model in Figure 3 is just a portion of the *.inf* file that is generated for a protrusion on the part. This is the preliminary model developed for parsing the *.inf* file. All the command options used for drawing the feature are displayed under the category "Element Name." At the end of the information file for a particular feature, we can find the dimensions of that particular feature and its location [coordinates] in the space. Based on this information, the initial logic is developed, which is needs to be generalized later.

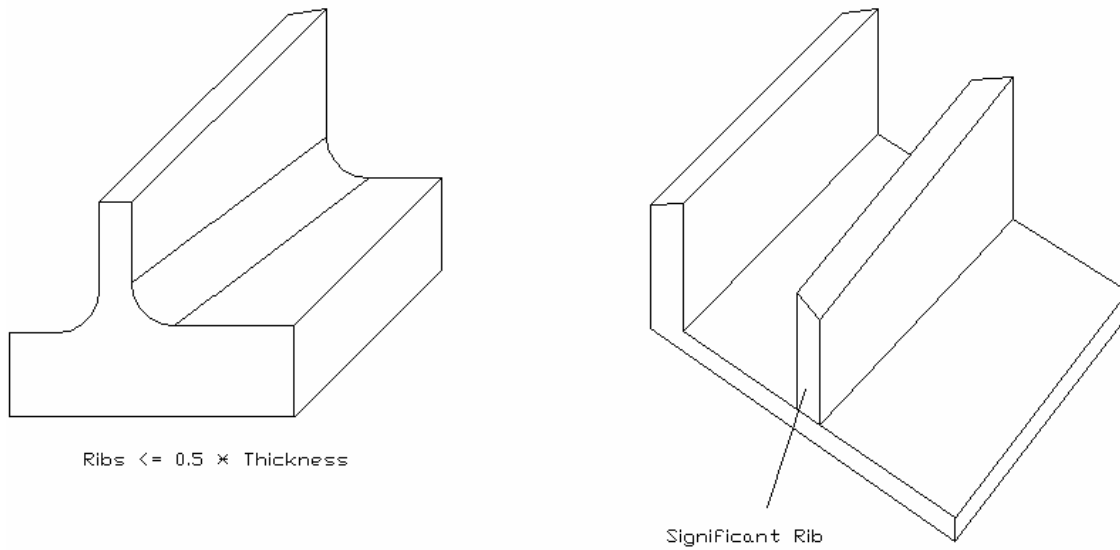


Figure 2. Feature Descriptions

Methodology

1) Converting the .inf File to Text Format

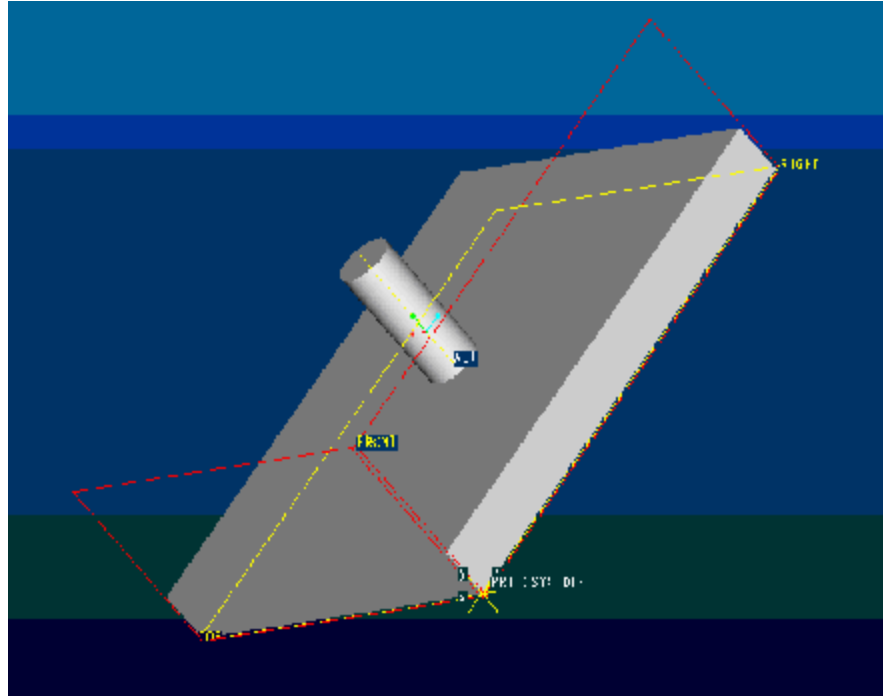
The part information is stored in the form of the *.inf* file, which needs to be saved in text format. This may be done asking the user to prompt the user to enter the file in text format or writing a Perl script to save it in text format.

2) Reading the Part Information from the File

The information in the file is tokenized using the String parsing commands in Visual Basic 6.0. Visual Basic was chosen because the other portions of the IKEM project package require the user interface building capability of Visual Basic.

3) Storing the Required Information into a Database

A structure (user-defined data type) is created with attributes like feature number, feature ID, process and direction. All the information in the file is transferred into these attributes for future use. This means that the file is only opened once during the entire program. During that period, all part information is stored into the database and the file is finally closed.



FEATURE NUMBER 6
INTERNAL FEATURE ID 66

PARENTS = 1(#1) 39(#5)

CHILDREN = 66(#6) 92(#7)

PROTRUSION: Extrude

NO. ELEMENT NAME INFO
STATUS

1 Attributes	One Side	Defined
2 Section	Ski. plane - Surface of feat #5 (PROTRUSION)	Defined
3. Direction		Defined
4 Depth	Blind, depth = 10	Defined

FEATURE'S DIMENSIONS:

d3 = 4.00 Dia

d4 = 15.00

d5 = 20.00

d6 = 10.00

Figure 3. A Model with its .inf File in PRO/ENGINEER

4) Identifying the Feature

Once the information is transferred into the database, the information is used to identify the feature as a boss, rib or something else. The program also gives information about which category the feature falls:

Example:

If it is a rib: A significant rib or not? Type of rib? Dimensions?

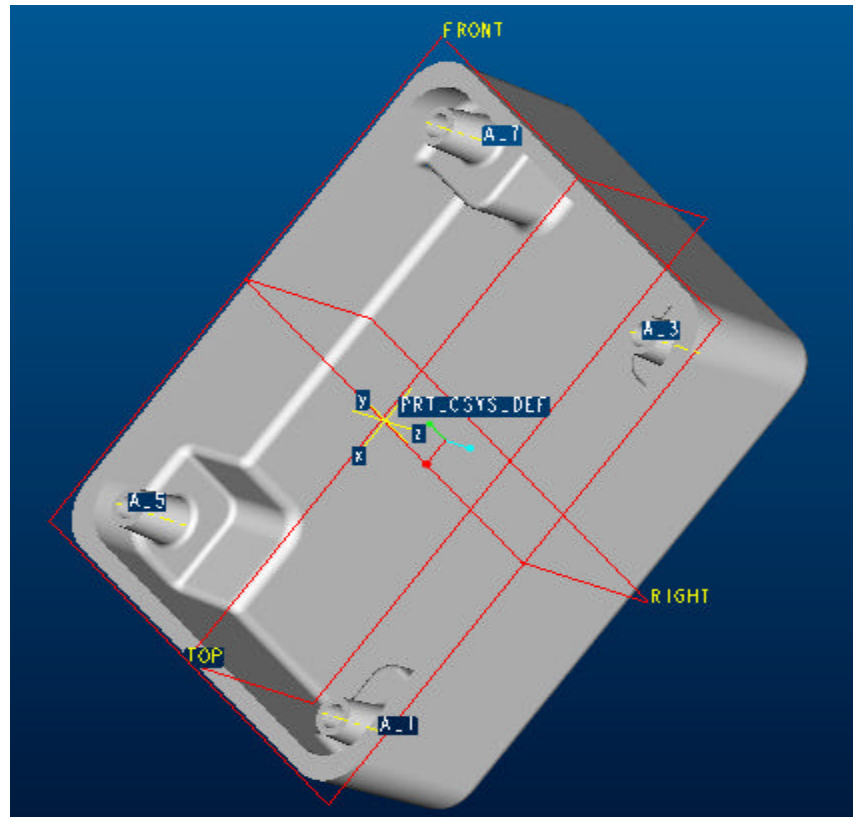
Results and Discussion of Results

Currently information is read from the *.inf* file from the model as shown in Figure 3. The features are then identified and categorized. The parameters such as part thickness, part weight, cavity image are given to other modules in the project. The results have proved promising thus far. Another model shown in Figure 4 is drawn in PRO/ENGINEER to make the logic more general. The information files for the two figures were compared and the differences were noted. The following issues were noticed:

An extrusion process may be drawn using one of the extrusion command options provided in PRO/ENGINEER, but also in several other ways. Consider the case of a boss:

- It may be extruded from one end to one end
- It may be extruded to both ends
- It may be extruded to a surface starting from one end without specifying depth
- It may be extruded started from one end and touching two surfaces on either side
- It may be drawn starting from the end and stopping in the middle and then extruding from there so on

Changes are made in the logic to accommodate for all the options in the extrusion command. Measures are taken to make sure that the program will work for any method of drawing. Care is taken to distinguish between the feature dimensions and the coordinates. In order to keep track of these features, a basic envelope is generated with unbent lengths and unbent breadth, which forces the program to keep track of the state of the system throughout the parsing program. For this reason, global variables are declared and updated after each step, so that at any instant we can get the coordinates of the model or feature. The volume of the part is provided for the Mold-design module in order to calculate the plasticizing capacity. Also the mold-design module is provided with part weight, which aid in calculating gate and runner dimensions. Part thickness is obtained from the basic envelope, which is passed to manufacturing module, which assists in estimating the processing parameters.



FEATURE NUMBER 6
INTERNAL FEATURE ID 66
PARENTS = 39(#5)
CHILDREN = 378(#7) 88(#8) 136(#9) 163(#10) 174(#11) 204(#12) 225(#13)
307(#14) 379(#15) 381(#16) 383(#17) 384(#18) 386(#19) 387(#20)
388(#21) 389(#22) 670(#23) 672(#24) 674(#25) 675(#26) 677(#27)
SHELL

NO.	ELEMENT NAME	INFO	STATUS
1	Remove Surfs		Defined
2	Thickness	0.1875	Defined
3	Spec Thick		Optional

FEATURE'S DIMENSIONS:
d5 = .19 O_THICK
(or)
d5 = .19 (weak)
(or)
d5 = .19 Dia (weak)

Figure 4. Second Model Drawn in PRO/ENGINEER and its .inf File

Summary And Conclusions

The parsing program is applied to some of the models and the results are stored in a separate and file. The dimensions of the features of the model are compared with the actual dimensions, and they are approximately equal.

Future Work

The logic implemented in the above program needs to be generalized to include a wide range of models. The program needs to be tested for the models obtained from industry, and the logic should be further generalized. This method will be adopted for ten models and the performance of the program will be tested with another ten models. Finally an evaluation report will be documented.

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