Study the Design Automation of Two-Plate Plastic Injection Molds

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Abstract In this paper, the authors present the design automation of three-dimensional (3-D) models of moldbase for two-plate plastic injection molds. Design automation of moldbase is an important stage in the mold design process, because it helps to reduce errors and time spent on tedious, repetitive modeling tasks. VBA programming language was used to build an automation tool for quickly designing of a moldbase with various input geometrical parameters. The input geometrical parameters of the moldbase can be customized by the user or defined according to the moldbase supplier's catalogues. The VBA design automation tool was implemented in Catia software and Microsoft Excel in order to rapidly create moldbase for two-plate injection mold design. The results show that the various moldbase can be rapidly created using the tool developed in this study. This demonstrates that the tool can be further developed for design automation of subsequent stages in the mold design process as well as enormous potential application in designing products in plenty of other areas.

Keywords Design automation · Parametric design · Injection molding · VBA

1 Introduction

The development of computer aided design (CAD) from 2-D design to 3-D design and Virtual Reality (VR) has led to the appearance of various rapid, effective, and high-productivity design tools, which inevitably require programming technique and other

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automatic design tools. Recently, automatic designing tool for a wide variety of gears has been created [1–5]. These tools are based on parameterization design principle, in which the tools can be incorporated with engineers' knowledge, experience in order to quickly generate the design products and components. The parametric design and design automation is play an important role in the engineering design process. This is because it does not only help to reduce errors and time spent on tedious, repetitive designing and modeling tasks, but it can also be scaled to streamline downstream development processes.

Injection molds play a key role in manufacturing components by molding and non-cutting shaping technology, as well as has a wide application in many industries in both military and civil sectors such as automotive, telecommunication, smart devices, electric equipment [6–10]. Injection mold design process is normally time consuming process. This is because every product has its own shape and structure which requires a specific mold design to form that product. Since, the product is normally different from other products. Therefore, the molds to form every product are different from each other. This requires people to design each mold for each product correspondingly. However, the mold design process is normally conducted manually by engineers. Particularly, mold design process nowadays is often implemented manually in 3D CAD design software like Catia, NX, Creo, etc. [11, 12]. The process starts with parting surface definition, then a moldbase will be called out (from available libraries in the softwares) and inserted with the part already separated by the parting surface to make boolean operations for core and cavity creation. After that, engineers will create other systems of the mold manually like ejector system, runner system, cooling system, sliders, etc. The disadvantages using the integrated moldbase provided from the 3D CAD design software is due to the fact that the designer difficult to customize the dimension or input parameters of the moldbase components. Instead, the designers have to select the predefined moldbase provided by the software. This sometimes cause the moldbase is not suitable or to big for the mold to form a product. In addition, the predefined moldbase library provided by the 3D CAD design software is normally limited in types, size, or standard, etc. Therefore, creating a design automation tool which enables us to automatically and rapidly create customizable moldbase according to any standard is highlightly demand. In order to address this problem, this research focuses on method to create design automation of moldbase incorporated with cooling system, runner systems, and other mold components to make the mold design process more effective and productive. In this paper, the authors present method to create design automation of moldbase for two-plate injection molds.

2 Design Automation Process

2.1 Methodology

Figure 1 shows the general process of designing a plastic injection mold proposed in this study. The process consists of the following main steps: (1) study product requirement; (2) Product design; (3) Determine number of cavities; (4) Define mold type; (5) Design mold layout; (6) Create moldbase and split core and cavity; (7) Design runner system; (8) Design cooling system; (9) Design ejection system; (10) Calculate mold strength; (11) Molding CAE simulation; (12) Design air venting system; (13) Design guiding and positioning system; (14) Mold material selection; (15) Technical drawing creation. The highlighted stages in the process are supposed to be utilized design automation in this study.

The design automation of the moldbase studied in this paper is utilized for two-plate injection mold. Figure 2 shows the flow chart to design a mold using the moldbase which is created by using the design automation tool developed in this paper.

In order to create design automation tool of moldbase by the method proposed in this paper. First of all, all necessary input parameters are defined in an Excel file. This file can consist of user defined parameters for a moldbase or consist the predefined parameters of moldbases standard of some moldbase suppliers in the market such as FUTABA, DME, Hasco, etc. The design automation tool is developed to create any moldbase for two-plate injection mold with arbitrary valid input parameters. However, for demonstration, in this paper, FUTABA moldbase type was chosen to be created using the developed tool in this paper (Fig. 3).

There is a total of 6 types of two-plate-type moldbase provided by FUTABA supplier with the standardized parameters are described in the Table 1. These input parameters are assigned value according to the moldbase part number as described in the Excel file as in the Fig. 4.

2.2 VBA Programming

To make it more convenient for designers to choose parameters available in the catalog, which is displayed in Excel, a VBA program will be written in the same software, functioning as a button for opening Catia and creating components and products automatically. VBA (Visual Basic for Applications) is a programming language hosted in applications such as CATIA, Microsoft Word, Excel, etc. VBA provides a complete programming environment with an editor, debugger, and help object reviewer. Declaring the object library used is allowed. In CATIA, VBA has the full Visual Basic syntax and IDE, which is like VBA in Excel. It is event-driven, GUI-oriented, and has full IDE yet cannot run a program without the host application running. Its advantages are using the GUI, building forms, and the debugging ability

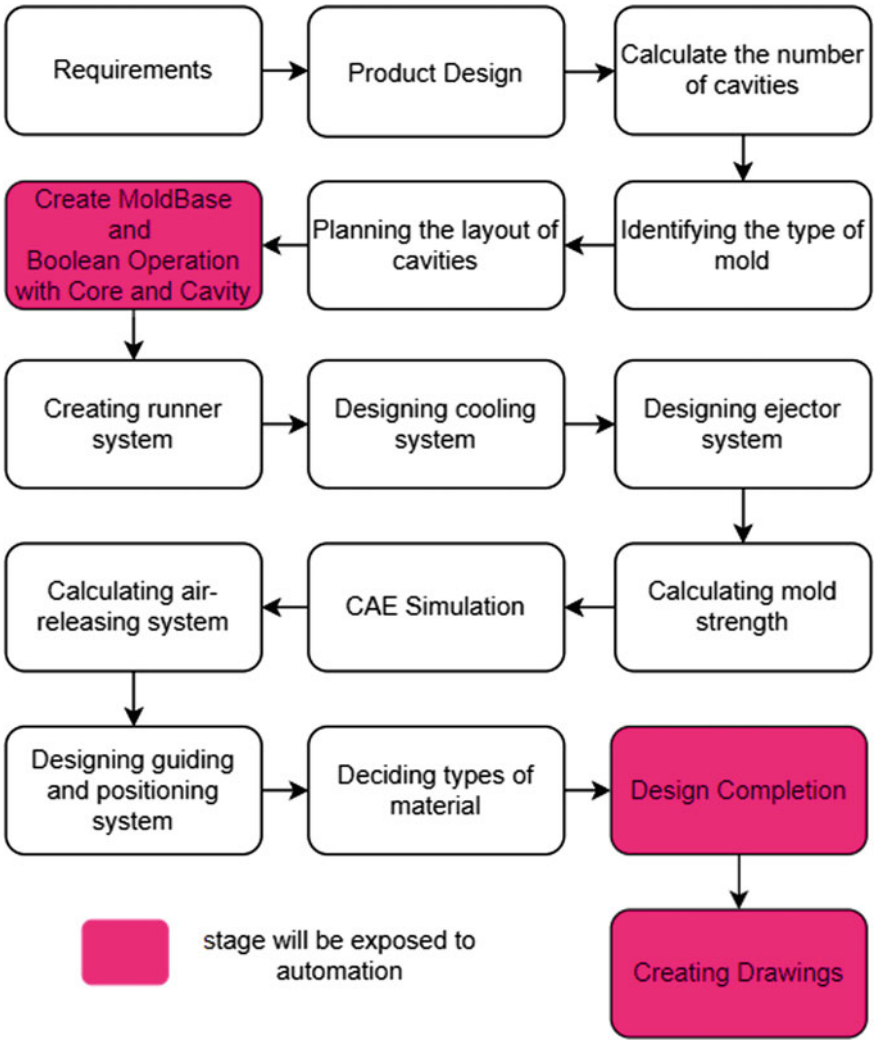


Fig. 1 General process of injection mold designing process

of the macro editor, while the disadvantage of it is that VBA programs cannot be compiled into executables or DLLs and they do not run in their own memory space. The extension is **.catvba**. [13].

Figure 5a shows the flow chart to create VBA for the design automation tool to generate a MoldBase automatically. First of all, a parametric mold of moldbase is created in Catia. Then an excel form is created to assign the value for the parameters in the parametric model of the moldbase. Then a VBA program is created to create the moldbase with the parameters matched with parameters in the Excel form. This process is repeated until the creating moldbase meets the requirements.

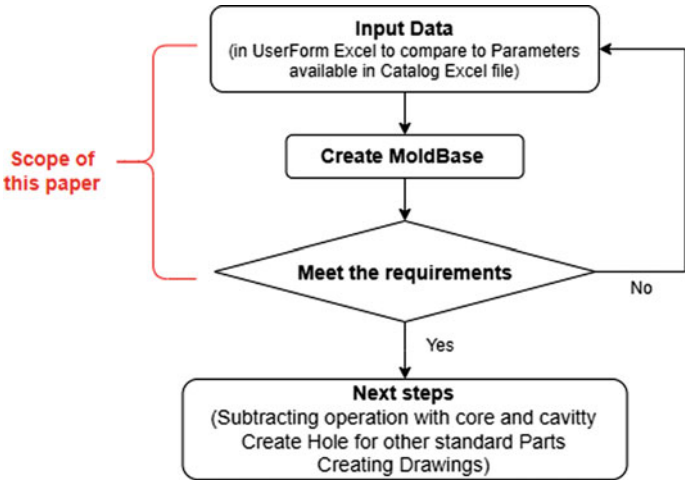


Fig. 2 Flow chart to design a mold using moldbase

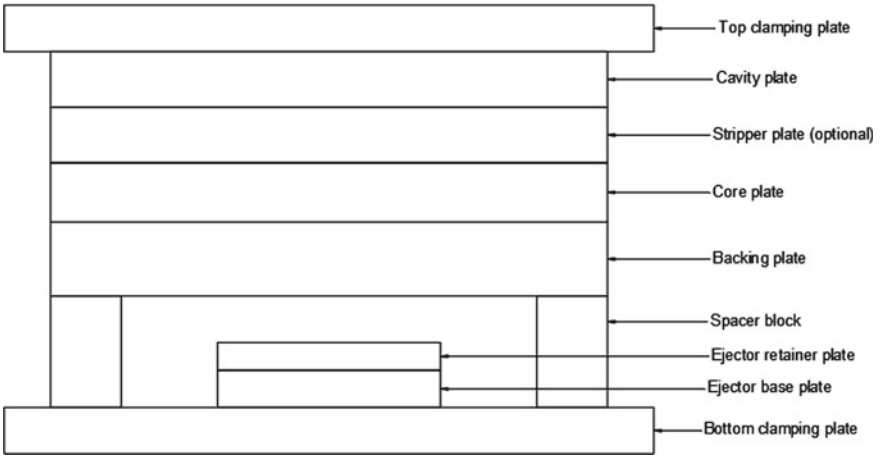


Fig. 3 Structure of a moldbase for two-plate injection mold

To be able to work with Catia from Excel without unexpected problems, the environment setting for the VBA program is shown as in the Fig. 5b.

Each reference is a type library (.tlb) found in CATIA "bin" directory, which are necessary for exposing functions to Windows by acting as maps pointing to the function inside of the dll files that make CATIA V5 work.

Firstly, a piece of code is written to call Catia environment from Excel no matter whether Catia is open already or not.

Table 1 List of input parameters

Denotes	Description
Mold W	The width of moldbase
Mold L	The length of moldbase
TCP_h	The height of top clamping plate
BCP_h	The height of bottom clamping plate
C_w	The width of spacer block
EF_w	The width of ejector plates
EJA_h	The height of ejector retainer plate
EJB_h	The height of ejector base plate
AP_h	The height of cavity plate
BP_h	The height of core plate
CP_h	The height of spacer block
T_w	The width of top clamping plate
U_h	The height of supporting plate
S_h	The height of stripper plate

PartNumber	mold_w (mm)	mold_l (mm)	TCP_h (mm)	BCP_h (mm)	C_w (mm)	EF_w (mm)	EJA_h (mm)	EJB_h (mm)	S_h (mm)
1515	150	150	20	20	28	90	13	15	15
1518	150	180	20	20	28	90	13	15	15
1520	150	200	20	20	28	90	13	15	15
1523	150	230	20	20	28	90	13	15	15
1525	150	250	20	20	28	90	13	15	15

Fig. 4 Some input parameters for FUTABA moldbase catalogue

```
'Get CATIA or Launch it if necessary
Dim CATIA As Object

On Error Resume Next
Set CATIA = GetObject(, "CATIA.Application")

If CATIA Is Nothing Then
    Set CATIA = CreateObject("CATIA.Application")
    CATIA.Visible = True
End If
On Error GoTo 0
```

To cover all the available parameters in the catalog, a UserForm is designed along with the corresponding codes as shown in Fig. 6.

After choosing the proper type of mold base as well as other parameters in the UserForm, the click "CREATE MOLDBASE" button to assign all the values to the parameter of the 3-D model needing to be called as shown in the Fig. 7. It will be opened if it is not called in the Catia environment yet and it will be updated its parameter if it is called already. As a result, the 3D model of moldbase will be automatically created rapidly.

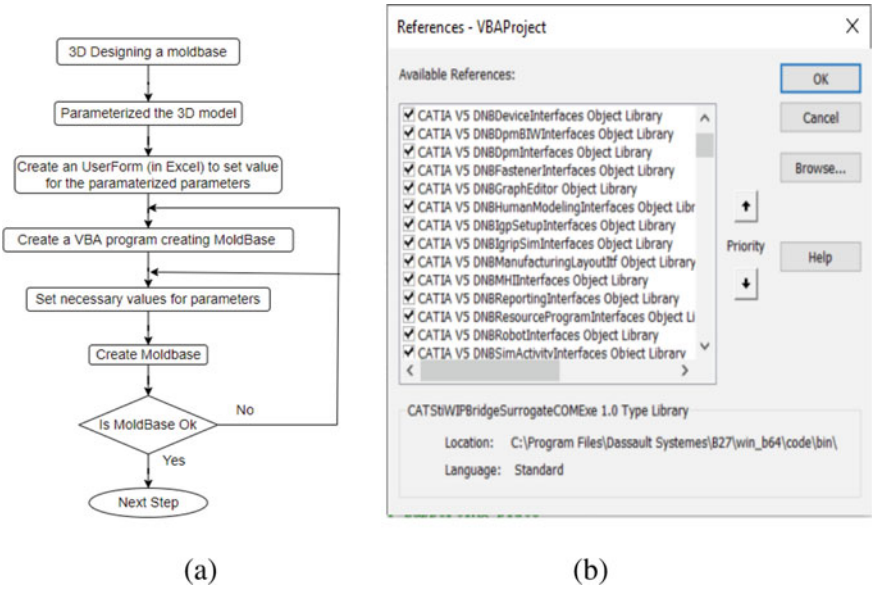


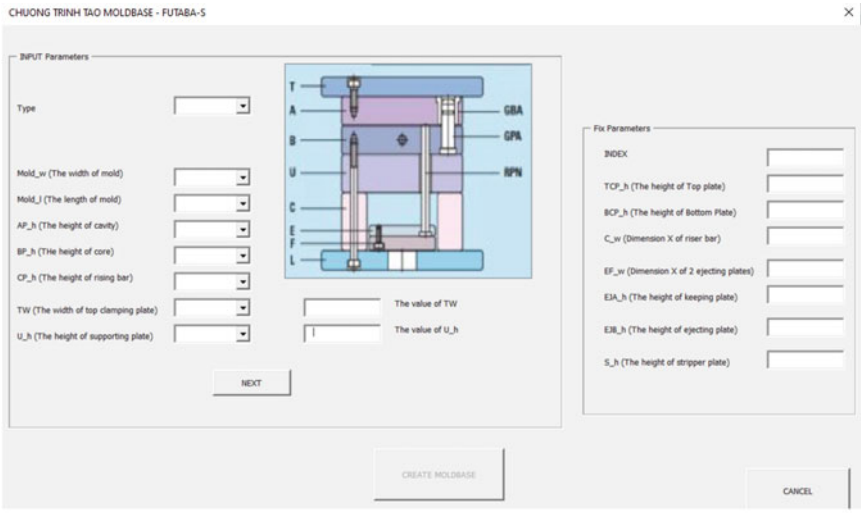
Fig. 5 **a** Flow chart to create moldbase automatically, **b** setting environment in CATIA for VBA program running

3 Results and Discussions

Application of design automation tool developed in this study, any type of moldbase for two plate injection mold can be created rapidly. As demonstration 4 set of FUTABA moldbases with various geometrical parameters are tested to create using the tool developed in this paper. Set 1 is SA-type Moldbase; Set 2 is SB-and-SE-type Moldbase; Set 3 is SC-type Moldbase; and Set 4 is SD-and-SF-type Moldbase. The four set of moldbase with the input parameters and information are as in the Table 2.

The result of the moldbases created by the design automation tool developed in this paper are shown as in Fig. 8.

The design automation is effective to automatically create moldbase for two-plate injection mold rapidly. This tool helps the mold designer save a lot of time during the mold design process. In addition, it also enhanve the accuracy of the designing process. The design automation tool for subsequence systems in the injection mold are under research process and will be represented in near future.




```
Private Sub MoldLengthComboBox_Change()
    f = f + 1

    If e >= 1 Then
        Select Case MoldWidthComboBox.Value
            Case Is = 150
                If MoldLengthComboBox.Value < 150 Or MoldLengthComboBox.Value > 300 Then
                    MsgBox "There is no value in standard"
                    MoldLengthComboBox.Value = ""
                End If
            Case Is = 180
                If MoldLengthComboBox.Value < 180 Or MoldLengthComboBox.Value > 350 Then
                    MsgBox "There is no value in standard"
                    MoldLengthComboBox.Value = ""
                End If
            Case Is = 200
                If MoldLengthComboBox.Value < 200 Or MoldLengthComboBox.Value > 450 Then
                    MsgBox "There is no value in standard"
                    MoldLengthComboBox.Value = ""
                End If
            Case Is = 230
                If MoldLengthComboBox.Value < 230 Or MoldLengthComboBox.Value > 400 Then
                    MsgBox "There is no value in standard"
                    MoldLengthComboBox.Value = ""
                End If
            Case Is = 250
                If MoldLengthComboBox.Value < 250 Or MoldLengthComboBox.Value > 500 Then
                    MsgBox "There is no value in standard"
                    MoldLengthComboBox.Value = ""
                End If
            Case Is = 270
                If MoldLengthComboBox.Value < 300 Or MoldLengthComboBox.Value > 500 Then
                    MsgBox "There is no value in standard"
                    MoldLengthComboBox.Value = ""
                End If
            Case Is = 290
                If MoldLengthComboBox.Value < 300 Or MoldLengthComboBox.Value > 400 Then
                    MsgBox "There is no value in standard"
                    MoldLengthComboBox.Value = ""
                End If
            Case Is = 300
                If MoldLengthComboBox.Value < 300 Or MoldLengthComboBox.Value > 600 Then
                    MsgBox "There is no value in standard"
```

Fig. 6 User form and code to define input parameters for the moldbase

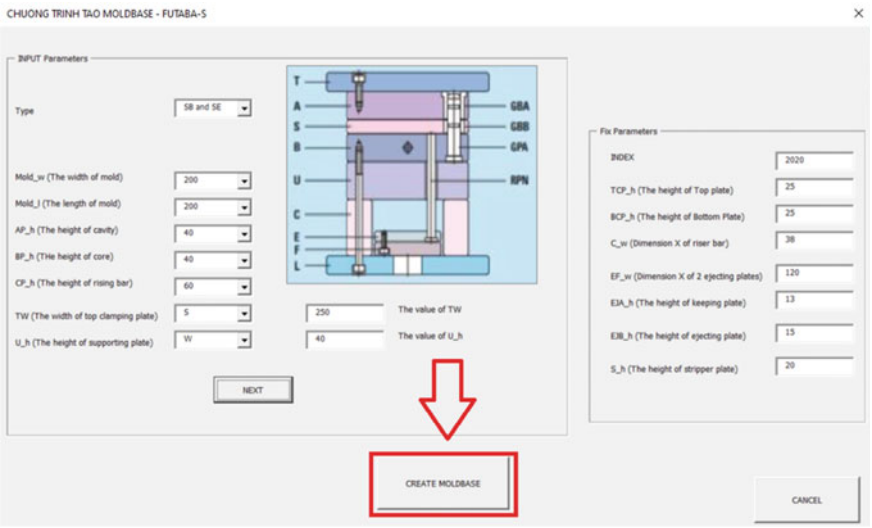
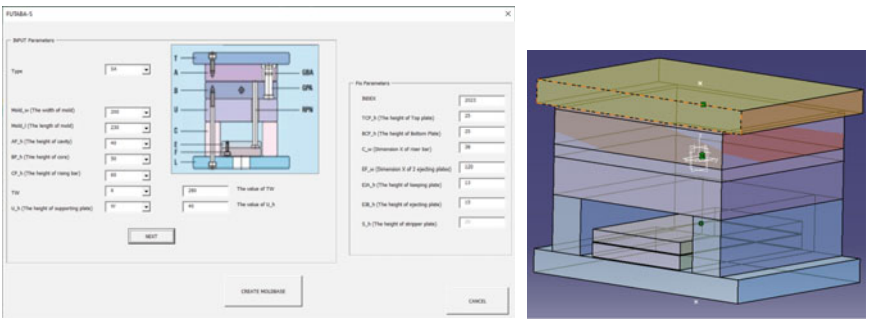


Fig. 7 Input parameters for creating of the moldbase

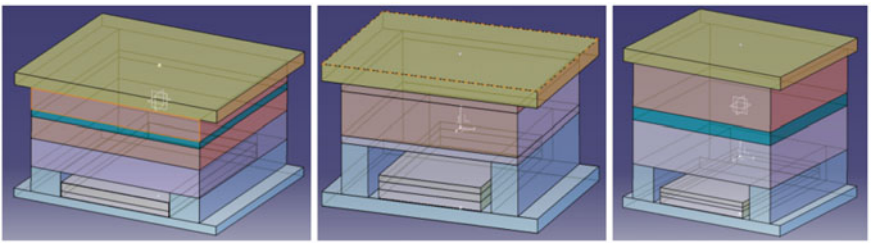
Table 2 Input parameters for the various moldbase types (unit is mm)

Input parameters	Mold_W	Mold_L	AP_h	BP_h	CP_h	TW	U_h
Set 1	200	230	40	50	60	280	40
Set 2	500	500	60	80	70	600	80
Set 3	400	450	90	90	90	550	50
Set 4	330	350	100	108	80	400	60



(a) Moldbase Set 1, (SA-type, Mold_w=200, Mold_l=200, AP_h=40, BP_h=50, CP_h=60, TW=280, U_h=40)

Fig. 8 Moldbases created automatically by developed VBA program



(b) Moldbase of set 2 (c) Moldbase of set 3 (d) Moldbase of set 4

Fig. 8 (continued)

4 Conclusion

In this paper, the authors have successfully developed a design automation tool to automatically creation of 3D models of moldbase for two-plate plastic injection molds by using VBA programming in Catia software and Microsoft Excel software. This tool enables the designers to create any type of moldbases for two-plate injection mold in which input geometrical parameters of the moldbase can be customized by the user or defined according to the moldbase supplier's catalogues. The results show that various moldbase types can be quickly generated using the tool developed in this study. This demonstrates that the tool can be further developed for design automation of subsequent stages in the mold design process as well as other product design process.

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