Developing a GUI based Design Software in VB Environment to Integrate with CREO for Design and Modeling of CI Engine

Umesh A. Bedse
Student of M. Tech CAD-CAM
G. H. Raisoni College of Engineering,
Nagpur, India

Laukik P. Raut
Assistant Professor, Department of Mechanical
Engineering,
G. H. Raisoni College of Engineering, Nagpur, India

Abstract- In mechanical industry, design process requires more time because it is iterative process and requires experienced people. We know that there are many CAD packages available in the market for design which demands modeling skills. It has been observed that many research efforts have been made in the area of design automation like integration of different CAD software like Creo Parametric, CATIA, SolidWorks with different computer programming languages like Visual Basic, Java, C++.But it is observed that Visual Basic is having some advantages over others like it will give us best frame work for product design input base as well as it can be easily interface with intermediate software like MS-excel which provides an input to other modeling or analysis software and among all available parametric modeling software Creo is widely used in industries. During the literature review, it is observed that integration of GUI or tailor made software development using a computer programming language with modeling software is done till now but further integration with analysis software is not done yet. This integration plays very important role for design automation of complicated assemblies which will definitely save much time of product design and development phase.

Keywords –Design Automation, CAD, GUI, KBE, Parametric Modeling.

I. INTRODUCTION

In recent trends of research and development field, every industry strives to do the maximum automation in every department. Design phase is the most time consuming phase of the product design and development stages, the main reason behind this is that it is an iterative process which requires complete knowledge of design of machine elements and every time highly skilled draftsman or persons having complete modeling knowledge are required. Nowadays best of the best innovations are coming into picture, in these, researchers have made one way to reduce maximum design time by doing design automation concept which means integration of GUI developed with the help of computer programming language and market available CAD packages. Graphical User Interface (GUI) is the only way for users to communicate with the system. Design automation is the process to automate conventional manual design process by use of computer. Most of the time information or knowledge of any product design is available in database of system. This knowledge can be stand past experience, standard design procedure, design manuals, etc. There are a number of software available for drafting, modeling as well as for analysis like ProE, CATIA, CREO Parametric, SolidWorks, Hypermesh, ANSYS etc. But no specific software is available for the design of a specific product. So by this dissertation approach it is very important to make one tailor-made software which will be useful for complete design of a specific component and output of the software should easily be integrated with other software of modeling and analysis which are highlighted above. To develop this software use of computer programming language is necessary. This work can be done in any computer programming language like Java, C++. But output from Visual Basic can be easily interface with further software like MS-excel which provides an input to other modeling or analysis software. For the design and modeling of the product time is generally 55-65 % of overall time of the product development. It has been observed that design phase has a lot of potential where time can be saved and parametric modeling is the best option for saving the modeling time also

knowledge based approach can be useful for saving the design time. With the help of design automation lot of same calculation can be saved avoiding complex work. During review it has been observed that Creo 2.0 software is the best option as modeling software because it is having strong parameterization. The main purpose of this design automation is to create a solution which will satisfy the designer requirements in an innovative direction. We know that designer spends more time in understanding the existing designs and dealing with the tasks associated with the already existed design modifications. Lots of engineering man hours gets wasted for doing repetitive tasks of modeling and analysis of the existing designs.

II. LITERATURE REVIEW

A. Design Automation

Many research efforts have been made in the area of design automation. Kirankumar M. et al [1] discussed about the development of one tailor made software which is used for complete design of flange coupling. This software is developed using Visual Basic as a computer programming language and CREO parametric as modelling software and explained that with the help of methodology used having three phases, are design phase, integration phase and modelling phase. Abhishek Lad [2] discussed about design and drawing automation of different components of a horizontal winding machine. It is observed that with this integration they have saved 80% of time of designing and hence significant amount of cost has been saved and bill of material of complicated assembly having many numbers of mechanical components can be easily obtained with this integration. For this, they have used VB.Net as a computer programming language and Solid Works API and taken the case study of horizontal winding machine. Chu et al [3]developed computer aided parametric design automation for 3D tire mold production. Shah Dhaval et al[4] described parametric modelling and drawing automation for the case study of flange coupling using Microsoft Excel and it has been observed that this automation has taken very less time as compared to general conventional design processes. They have shown how to generate excel spreadsheet, how to generate models and how to transfer data from excel sheet to Pro/E. Also, a suggestion has been given that this automation can further be extended to analysis or CAM packages. Yogesh H. Sawant et al [5] has done automated modelling of screw conveyor components in CATIA, they developed system which is used for the generation of 18 components having 29 subcomponents. User can simply enter the parameters of the component via developed GUI, the system automatically updates 3D model.

B. Knowledge Base Engineering

Knowledge Base Engineering (KBE) is nothing but an automation of repetitive design tasks depends on previous knowledge of the designer. KBE is a process or system which collects and organizes this knowledge and makes it available for the designer in the reusable form. Knowledge-based engineering (KBE) provides a way of automating and formalizing product development. Zhongtu L. et al [6], in this paper, it has been observed that they have developed CAD system for mechanical design processes which uses a knowledge base approach and the system was developed for the Intesolid 2.0. GoranDevedzic et al [7] said that the basis for the implementation and development of knowledge-based engineering is a parametric explanation of the computer representations of real geometric objects with dimensional, physical, functional, and other sets of parameters. Fonseca D. J. et al [8] developed a knowledge base system for selection of conveyor equipment. They created an expert system for identifying the suitable conveyor from three categories of conveyors (unit, bulk and sortation conveyors) with 76 types of conveyor by simply entering the conveyor attributes. Zhangtu L.et al [6] described the knowledge base system approach for mechanical product design. They developed a knowledge base system for Intesolid 2.0 system (CAD system) and with this module they explain examples of 3D model generation of two-stage gear box. Hussein H. M. A [9]constructed a knowledge base system for sheet metal blanking dies. This system was built under CATIA V5 and the program was scripted in Visual Basic. Sanshan Z. et al [10] developed GUI for composite component design by using VB.NET computer programming language. They have integrated that developed tailor-made software with CATIA software.

C. Parametric Modelling

Parametric modeling can be used for saving the modeling time. Parametric modeling is very useful and strong tool for mechanical design in industries. Gulati V [11] discussed about the parametric modeling for jewelry in Visual Basics Application with AutoCAD under programming language environment with the help of that active automation is done. They have used this parametric modelling concept for modelling of jewelry which is really unique. Ault H.K [12] has discussed the basic concepts of parametric modeling. Mandarin J. [13] describes the evolution of parametric technique. Macros are one type of tool which be used for remodeling. Script of commands

and data values are generally recorded in the Macros to generate new model. Pipe and Lufeng [14], created the gear shaft using Pro/E concept and Visual Basic C++ programming environment. In this, the GUI is developed with the help of Visual Basic C++ and successful integration of GUI, database and Pro/E CAD model is done for the creation of driving gear shaft. Trivedi et al [15] explained the methods of 3D parametric modelling for different products using case studies on the inner ring of spherical roller bearing. They have described the integration method of Pro/E and MS-Excel sheet.

D. Visual Basic

Visual Basic is a computer programming language which gives us dot net framework. VB. Net is mainly used for designing the forms and projects. Ruchika D. Trivedi et al [15] has discussed about how to make excel datasheet and how to transfer data from excel sheet to Pro/E to do design automation. Thus, at the end excel sheet is connected with the Pro/E model. User can modify the model just by updating the site. This takes comparatively very less time to generate complicated part models with respect to generating them separately. R. K. Abdel et al [16]has done work on a CAD system for building a die set. They have discussed and gave information about how to make GUI using visual basic (VB) interfacing with AutoCAD. It shows how integration between a selection of die set of the blanking die and the automatic design of the die set to be useful. J Shankar et al [17] they describe how to do automation of design phase in solid modelling with Pro/E can be integrated with MS-Excel using visual basic programming language.

III. EXPERIMENTATION

A. Development of GUI using Visual Basic

In this paper, developed GUI is made for the case study of design of CI engine parts like cylinder head, cylinder block, piston and crankshaft. CI engine is having many numbers of mechanical components, but parts named above are the most important parts of any CI engine. So design of these parts is useful to take into account to develop a GUI.

Input Variables for design of cylinder block

Brake Power (watt)
Speed (RPM)
Mean Effective Pressure (MPa)
Number of Strokes
Explosion Pressure (MPa)
Bore (mm)
Bending Stress (MPa)
Cylinder Wall Pressure (MPa)
No. of Piston Rings

Output Variables
Thickness of Piston Head (mm)
Thickness of Ribs (mm)
Radial Thickness of Piston Ring (mm)
Clearance

Allowable circumferential stress (MPa)
Output Variables
Bore (mm)
Length/Stroke (mm)
Input Variables for design of piston head

Axial Thickness of Piston Rings (mm)

Input variablesfor design of crank shaft
Bore (mm)
Length (mm)
Explosion pressure (MPa)

Output variables
Dia. Of crank pin (mm)
Length of crank pin (mm)
Bending moment at the crank pin (N-mm)
Bending stress (MPa)

In above input variables, some variables like allowable circumferential stress for cylinder, bending stress and cylinder wall pressure for piston design depend on the selected material. With this developed GUI, it has been observed that the design of these parts is done within few seconds while these calculations takes much time when done manually.
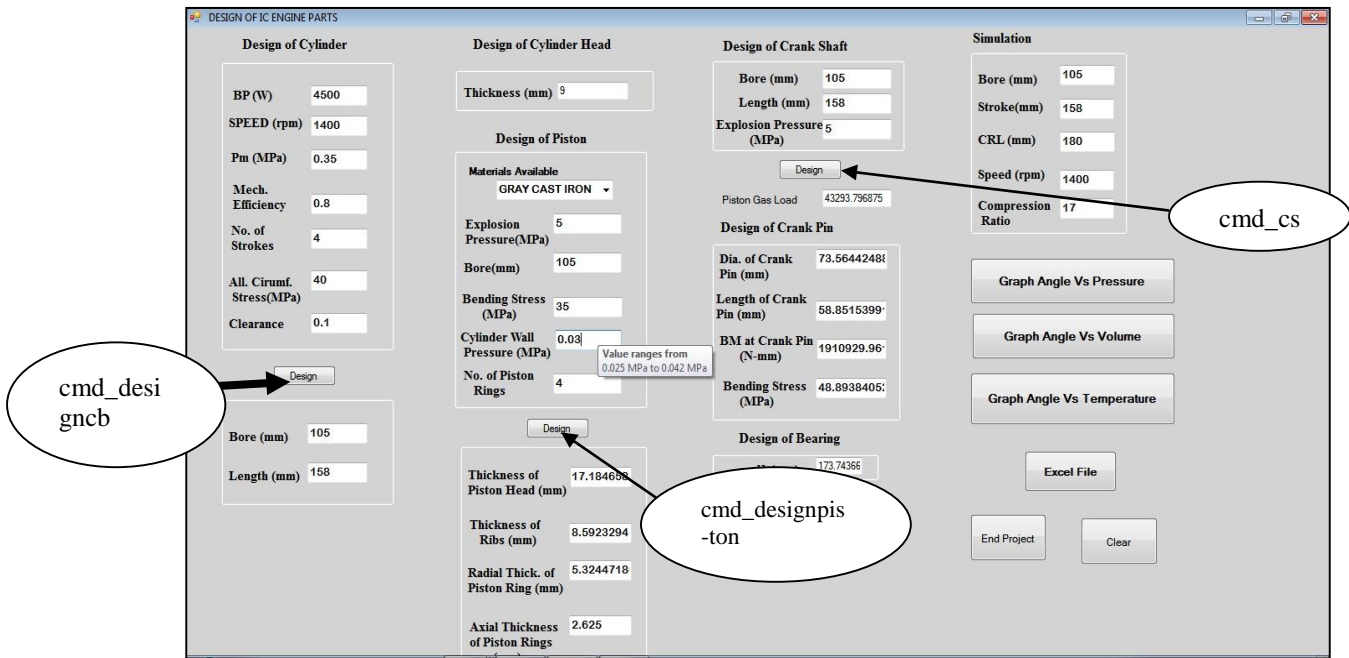
Figure 1: Developed GUI using Visual Basic

a)   Coding for Design of Cylinder Block

```
PrivateSubcmd_designcb_Click(ByVal sender
AsSystem.Object, ByVal e AsSystem.EventArgs)
Handlescmd_designcb.Click

Dim bp, N, s, d, l, ip, t, sigmat As Integer
Dim pm, p, c, mecheffAsDouble
bp = Integer.Parse(txt_bp.Text)
N = Integer.Parse(txt_speed.Text)
pm = Double.Parse(txt_pm.Text)
mecheff = Double.Parse(txt_mecheff.Text)
s = Integer.Parse(txt_strokes.Text)
c = Double.Parse(txt_clearance.Text)
sigmat = Integer.Parse(txt_tensile.Text)
ip = bp / mecheff

 d = Math.Pow(((60 * 1000 * 4 * ip) / (pm * 1.5 *
3.1415 * (N / 2))), (1 / 3))
l = 1.5 * d
p = 9 * pm
t = d * Math.Sqrt((c * p) / sigmat)
txt_bore.Text = d.ToString()
txt_thickness.Text = t.ToString()
txt_length.Text = l.ToString()
txt_borepiston.Text = d.ToString()
txt_bor.Text = d.ToString()
txt_len.Text = l.ToString()
txt_boresimulate.Text = d.ToString()
txt_stroke.Text = l.ToString()
txt_boresimulate.Text = d.ToString()
txt_stroke.Text = l.ToString()
txt_speedsimulate.Text = N.ToString()
EndSub
```

Where, bp= Brake power (W)
        N= Speed (rpm)
        s= stroke (mm)
        d= bore of piston (mm)
        l = length of stroke (mm)
        ip= indicated power (W)
        pm= mean effective pressure (MPa)
        p= maximum pressure in the engine cylinder
        t= thickness of cylinder (mm)
        c= clearance (mm)
        mecheff = mechanical efficiency

b)   Coding for Design of Piston

```
PrivateSubcmd_designpiston_Click(ByVal sender
AsSystem.Object, ByVal e AsSystem.EventArgs)
Handlescmd_designpiston.Click

Dim pe, dp, sigmat, th, tr, t1, pw, ta, nr As Double
pe = Double.Parse(txt_explosionpressurepiston.Text)
sigmat = Double.Parse(txt_bendstresspiston.Text)
pw = Double.Parse(txt_cylinderwallpress.Text)
nr = Double.Parse(txt_noofrings.Text)
dp = Double.Parse(txt_borepiston.Text)
th = Math.Sqrt((3 * pe * dp * dp) / (16 * sigmat))
tr = th / 2
t1 = dp * Math.Sqrt((3 * pw) / sigmat)
ta = dp / (10 * nr)
txt_thickofpistonhead.Text = th.ToString()
txt_thickofribs.Text = tr.ToString()
txt_radialthick.Text = t1.ToString()
txt_axialthick.Text = ta.ToString()
txt_pressure.Text = pe.ToString()

EndSub
```

Where,
pe= maximum gas pressure or explosion pressure (MPa)
dp= bore of piston (mm)
sigmat = permissible bending (tensile) stress for material of the piston (MPa)
th = thickness of piston the head (mm)
tr = thickness of ribs
t1= radial thickness
pw= cylinder wall pressure (MPa)
nr = no of rings
na= axial thickness

c) Coding for Design of Crank Shaft

PrivateSub**cmd_cs**_Click(ByVal sender AsSystem.Object, ByVal e AsSystem.EventArgs) Handlescmd_cs.Click

Dim d1, len, p, fp, dc, pb, lc, m, z, sigmab, bendstress, d2, t, l1, m1 AsDouble
d1 = Double.Parse(txt_bor.Text)
len = Double.Parse(txt_len.Text)
p = Double.Parse(txt_pressure.Text)
pb = 10
sigmab = 60
fp = (3.1415 / 4) * d1 * d1 * p
dc = Math.Sqrt(fp / (0.8 * pb))
lc = 0.8 * dc
m = (3 / 4) * fp * lc
z = (3.1415 / 32) * dc * dc * dc

bendstress = (m / z)
t = 0.6 * dc
l1 = 1.7 * dc
m1 = fp * ((0.75 * lc) + (t) + (5 * l1))
d2 = Math.Pow((m1 * 32) / (3.1415 * sigmab), (1 / 3))
txt_pistongasload.Text = fp.ToString
txt_bmcrankpin.Text = m.ToString
txt_bendingstress.Text = bendstress.ToString
txt_diacrankpin.Text = dc.ToString
txt_lencrankpin.Text = lc.ToString
txt_bearing.Text = d2.ToString

EndSub
Where,
 d1= piston diameter or cylinder bore (mm)
len= length of stroke (mm)
p= maximum intensity of pressure on the piston (MPa)
fp= gas load on the piston
dc= diameter of crank pin (mm)
pb= permissible bearing pressure (MPa)
lc= length of the crank pin
m= maximum bending moment on the crank web (N- mm)
z= section modulus (mm^3)
sigmab= allowable bending stress (MPa)
bendstress= bending stress (MPa)
d2= diameter of shaft

B. Transfer of ouput data from GUI to Excel sheet

CAD software like Creo Parametric, CATIA, Pro/E are having the facility to import data from different database in the form of excel sheet to update the model. This type of integration of different software is very useful to do automation in mechanical design which saves a huge amount of design time. In this paper, output from the developed GUI is exported to the excel sheet as shown by clicking on the button Excel File in the GUI and this output will be helpful to integrate with the Creo Parametric 2.0 to do design automation. After integration, user can simply modify the CAD model just by modifying excel data sheet.

	Cylinder Block	Piston	Crank Shaft
	105	17.18465886	73.56442489
	158	8.592329428	58.85153991
	9	5.324471805	173.7436626
		2.625	

Figure 2: Output in MS-Excel sheet

C. Integration of Visual Basic and CREO using Excel Sheet
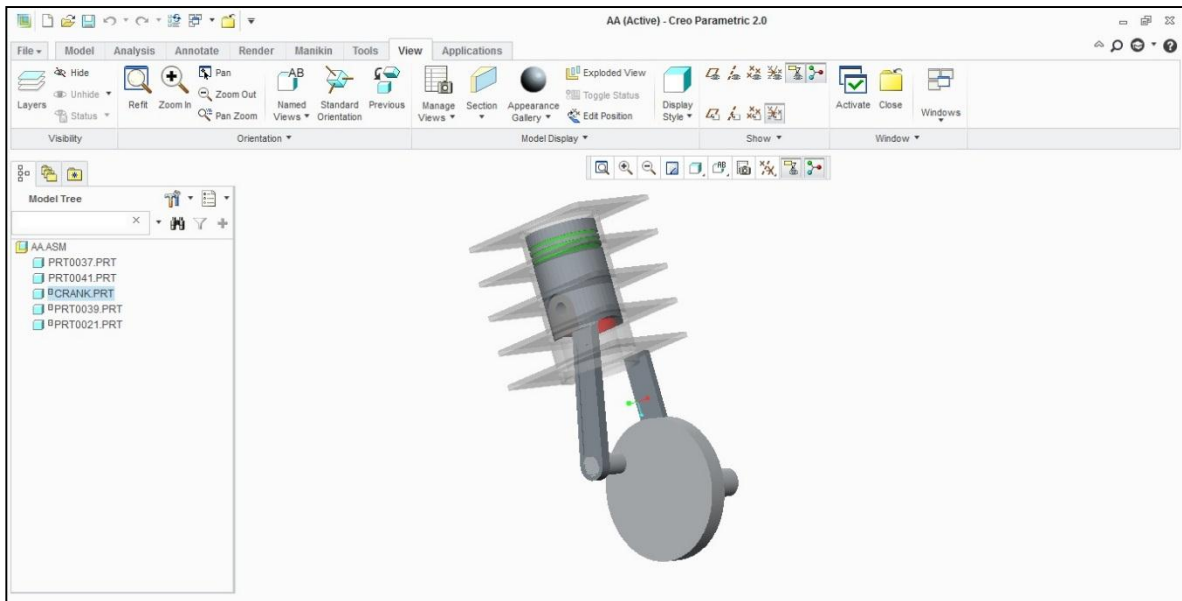

Figure 3: CAD model of Assembly of CI Engine

CAD model of assembly of CI Engine shown in figure 3 having basic important parts as piston, cylinder block with fins attached, connecting rod, crank shaft , crank pin etc.

D. Procedure of integration :-

To understand the concept of integration, here example of piston has taken. After creating excel sheet, open individual parts of assembly. With the help of analysis menu available in Creo Parametric 2.0 in that go to excel analysis. New window will appear on screen as shown in picture. Go to load file as marked 1 in circle and load that excel file generated using visual basic then select output values of design of that particular part then click on output cells button marked as 2 then click on compute button marked as 3. Then go to add feature and enter the name of that excel file there and close this window. Then go to tools of menu bar, in that click on relations. Here assign all required dimensions to be updated from excel sheet to the dimensions of model. So the software will understand that which cell value of excel sheet is for which dimension of model. User should know that which output value is going to be use for which dimension
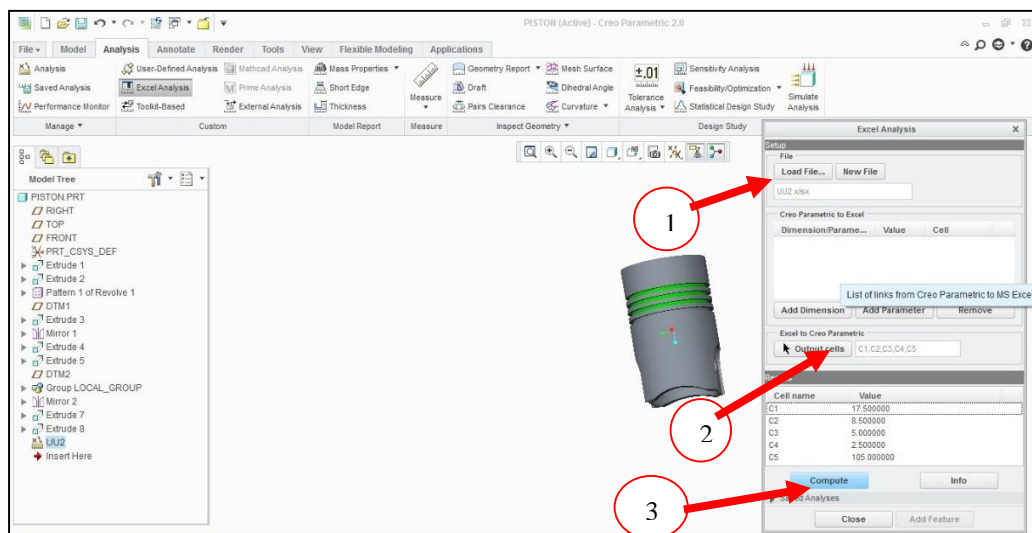

Figure 4: Excel Analysis in CREO

After all these actions, just go to model menu on menu bar and click on regenerate marked as 4 in picture shown. This completes the complete procedure of model updating of that particular part. Further user wants to update the dimensions of that model then just go to excel sheet as marked as 5 and right click on that and click on edit definition then click on next button. As user clicks on next button excel file gets open on screen, just update that sheet and regenerate the model. Within seconds, models gets updated. Repeat the same procedure for all parts. After update of all individual parts of any assembly just open assembly file and click on regenerate button , automatically complete assembly gets updated. Firstly user has to do these first 4 steps, after these 4 steps user has to only open excel sheet and update that excel sheet to get required updated model.
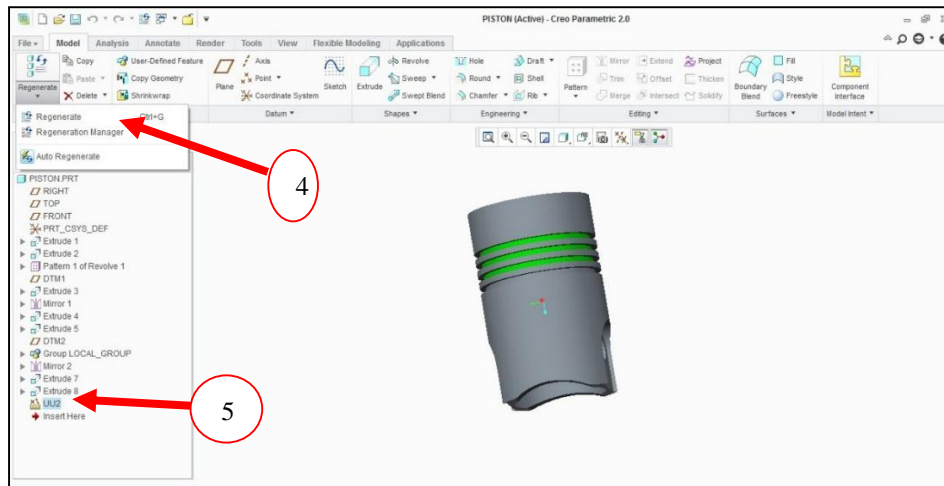

**Figure 5:** Regeneration of new updated model

E. Simulation of CI engine processes

In engineering, simulation process has come to mean developing and using the appropriate combination of assumptions and equations that permit the process to be analyzed. The modelling of engine processes continues to develop as our basic understanding of the chemistry and physics of the phenomena of interest steadily expands. Computer simulation activities can make major contributions to engine design at different levels of generality or detail, corresponding to at different stages of model development.

In the above shown GUI, one column of simulation having input variables bore, stroke, connecting rod length, speed and compression ratio is there. With the help of these inputs, simulation of CI engine process will be done in the form of real time graphs of Pressure (bar) Vs. Crank angle (degree), Volume (cc) Vs. Crank angle (degree) and Temperature (Kelvin) Vs. Crank angle (degree). Here simulation is done for compression stroke, combustion stroke and expansion stroke of CI engine and gives each value of pressure, temperature and volume at each crank angle in the form of real time graph as shown. With this, user can easily analyze how the process is happening in the engine.
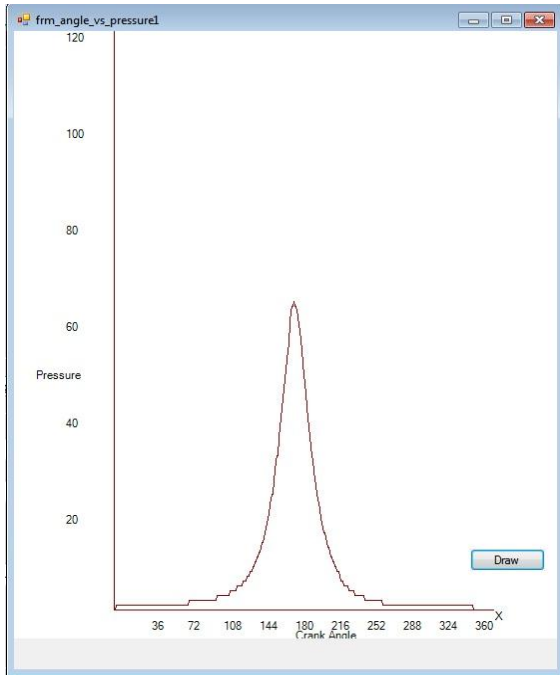
Figure 6: Graph of Pressure vs Crank Angle
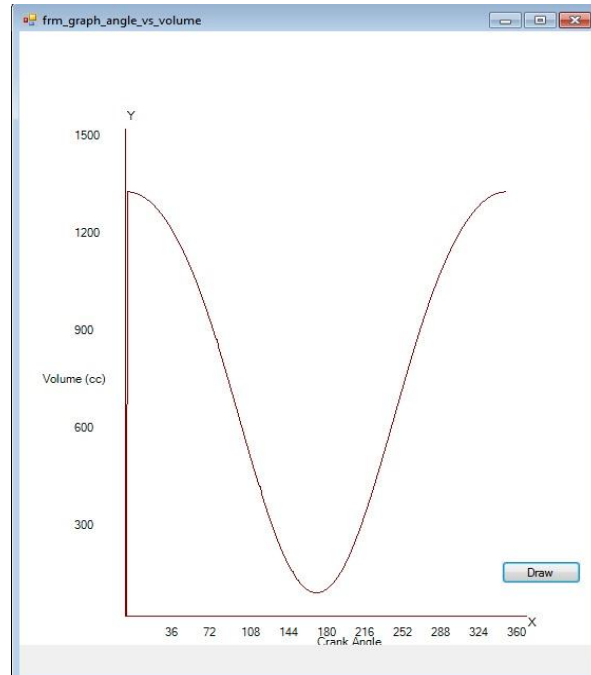
Figure 7: Graph of Volume vs Crank Angle

IV.CONCLUSION

Nowadays it is very important to make maximum automation in all the sectors or department of an industry. With the help of this integration of developed GUI and parametric modeling software or CAD packages available in the market has lots of potential to reduce design time by huge amounts. It has been observed that among all computer programming languages available Visual Basic is more suitable and similarly in the case of CAD software CreoParametric 2.0 is more suitable for design automation. The software developer has the freedom to develop more and more advance software. In future, integration of design and modelling phase can be extended to integrate with an analysis phase to do the complete automation which will play very crucial role in automation.

V. REFERENCES

[1] K. M. B. Indrajitsinh J. Jadeja, "Developing a GUI based Design Software in VB Environment to Integrate with CREO for Design and Modeling using Case Study of Coupling," *International Journal of Engineering Sciences & Research Technology,* pp. 4089-4095, April, 2014.

[2] A. R. Abhishek C. Lad, "Design and Drawing Automation Using Solid Works Application Programming Interface," *International Journal of Emerging Engineering Research and Technology,* vol. Volume 2, no. Issue 7, pp. 157-167, October 2014.

[3] M.-C. S. V. C. L. Chih-Hsing Chu, "Computer aided parametric design for 3D tire mold production," *Computers in Industry An International, Application Oriented Research Journal,* vol. Volume 57, no. Issue 1, p. 11–25, January 2006.

[4] D. Shah, "Parametric Modeling and Drawing Automation for Flange Coupling," *International Journal of Research in Engineering & Technology (IJRET),* vol. Vol. 1, no. Issue 2, pp. 187-192, July 2013.

[5] U. M. N. Yogesh H. Sawant, "Automated Modeling of Screw Conveyor Components in CATIA," *International Journal of Engineering and Technical Research (IJETR),* Vols. Volume-3, no. Issue-4, pp. 112-116, April 2015.

[6] Q. W. L. C. Zhongtu L., "A Knowledge-based Approach for Task Implementation in Mechanical Product Design," *International Journal of Advance Manufacturing,* pp. 837-845, 2006.

[7] G. D. I. G. G. Saša Ćuković, "Automatic determination of grinding tool profile for helical surfaces machining using catia/vb interface," *U.P.B. Sci. Bull., Series D,* vol. Vol. 72, no. Iss. 2, pp. 85-96, 2010.

[8] G. U. T. J. G. Daniel J Fonseca, "A Knowledge-based System for Conveyor Equipment Selection," *Expert Systems with Applications,* vol. Volume 26, no. Issue 4, p. Pages 615–623, May 2004.

[9] H. Hussein, "Computer Aided Blanking Die Design Using CATIA," *Procedia CIRP,* vol. Volume 18, p. 96–101, 2014.

[10] Z. S. M. Y. A. S. Mei Zhongyi, "Research on Knowledge-based System for Typical Aircraft Composite Component Design," *Advanced in Control Engineering and Information Science,* p. 1431 – 1435, 2011.

[11] V. Gulati, "Parametric Jewelry Modeling in AutoCAD using VBA," *International Journal of Computer Application,* vol. VOLUME 1, no. ISSUE2, pp. 158-164, FEBRUARY 2012.

[12] A. H.K., "3-D Geometric Modeling for the 21st Century," *Engineering Design Graphics Journal,* vol. 63, pp. 33-42, 1999.

[13] J. Monedero, "Parametric design: a review and some experiences," *Automation in Construction,* vol. Volume 9, no. Issue 4, p. 369–377, July 2000.

[14] L. L. Guo Peipei, "Parametric design of gear shaft based on Pro/E," in *2011 International Conference on Electronics, Communications and Control (ICECC)*, Nigbo, China, 2011.

[15] D. B. S. K. M. P. Ruchik D. Trivedi, "3D Parametric Modeling for Product Variants Using Case Study on Inner Ring of Spherical Roller Bearing," in *Chemical, Civil and Mechanical Engineering Tracks of the 3rd Nirma University International Conference on Engineering*, Ahmedabad, 2013.

[16] H. H. J. A. Q. U. U. R.K. Abdel-Magied, "Computer Aided Design of the Die-Set for Sheet Metal Punching and Blanking Dies," *Applied Mechanics and Materials,* vol. Volume 619, pp. 78-82, 2014.

[17] S. J.Shankar, "Automation of Design by Integrating Pro/Engineer with Ms-Excel," *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),* pp. 69-72, 2014.