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Design and Drawing Automation Using Solid Works Application Programming Interface

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Abstract: *Computer Aided Design (CAD) is revolution in today's competitive industry. In mechanical industry, design process is very time consuming because it is iterative and requires experienced peoples. Computer Aided Design tool can be used for various application in mechanical engineering resulting less time in design and better productivity and quality. There are many CAD packages available in market for design which demands modelling skills.*

This paper aims to developed software application for product design and its CAD model updating by automating repetitive tasks using SolidWorks application programming interface (API). A case study of Winding Machine which is a mechanical product for which a program using Visual basic language i.e. Vb.Net Application is developed. Such developed application is integrated with SolidWorks CAD package through application programming interface (API). Developed application having front end and back end, front end having GUI (Graphical User Interface) through which, input design data/parameter is taken from user. Back end having internal program according to this design of winding machine is obtained in output. Output design result is passed to SolidWorks CAD package, which updating CAD models of machine and its manufacturing drawing. In addition to this it can also generate Bill of Material (BOM), bought out part list in MS-excel format.

Because of this developed application lot of time reduced in design process, CAD modelling hence overall cost of the design is also reduced. User need not require highly CAD modelling skills and design knowledge of product.

Keywords: *Computer Aided Design, Application Programming Interface, Solidworks, Microsoft visual studio, Vb.Net*

1. Introduction

1.1. Design Automation

Design automation is to automate conventional manual design process by use of computer or by extracting knowledge from knowledge base. This knowledge can be standard design procedure, past experience, manuals, charts, etc.

In this design knowledge, past experience, condition is stored in computer database or programmed so that it can be reuse again whenever needed.

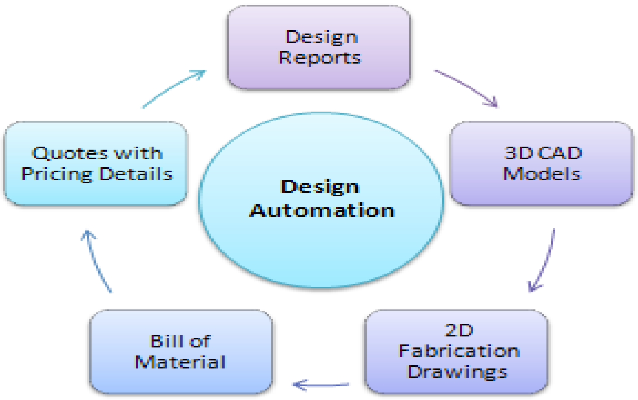


Fig1.1. *Design Automation*

In this Winding Machine design automation is done. Winding Machine is used for coil winding in power transmission industry. It having components viz. Headstock, Base frame, Tailstock, coupling, standard bought out parts like gearbox, bearing, bolts, nut etc. As soon as design process is done, its CAD models and manufacturing sheet is done in SolidWorks CAD package. Also making of BOM for standard parts and manufacturing parts with its mass, material, etc. in excel sheet also costing is done. All this activities done by manually, this thesis aims to develop a system which automates the above manual activities resulting less time in design and high efficiency.

1.2. Application Programming Interface (API)

API (Application Programming Interface) is software development technique for integrating two different software. With the help of API we can develop custom stand-alone windows executable files, for API programming we can use VB.NET, C#, Visual C++ languages.

In this paper for developing software application, Microsoft visual Basic Version 2010 is used. We integrated Microsoft visual studio express 2010 with CAD package; this resulted in exchanging data between these two software. There are many CAD software packages having Application Programming Interface functionality. In this SolidWorks CAD package is used because it is user friendly, most important it supports Application Programming Interface functionality.

Microsoft Visual Studio2010 is integrated with SolidWorks via COM (Component Object Management). It means we connect two different software, we can exchange data between them, so by doing programming in Vb.net it will affect change in SolidWorks software.

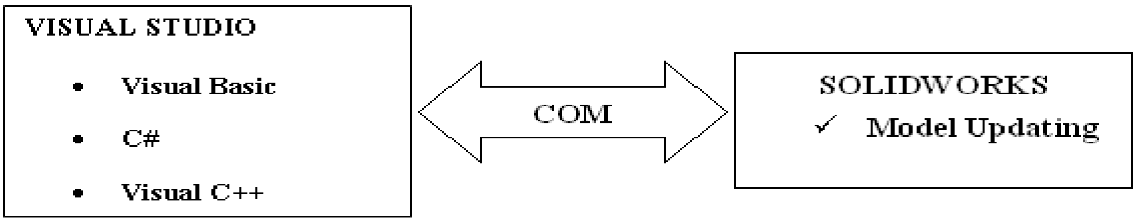


Fig1. 2. *Application of Programming Interface*

2. PROBLEM DEFINITION

- As discussed above winding machine having many mechanical components. Designs of these components depend on customer requirement. These design calculations for all components are repetitive and time consuming task.
- Also this design process is currently done on past experience; experienced personal are needed every time for designing. This involves selection of standard parts like gearbox, motor, bearing, hardware like nut, bolt, screw etc. There is no standard design procedure adopted.
- After design calculation are done, it is time consuming to make CAD models of machine part and its manufacturing drawing which also requires skill.

3. OBJECTIVES OF THE WORK

- To develop standard method or procedure for designing a component.
- To develop application which can automate above design process. It means to store or formulate past design experience, knowledge, procedure in computer database, which can be used repetitively again and again.
- To develop methodology and to integrate above application with SolidWorks CAD package to set automatically updated versions of CAD model and manufacturing drawing.

4. PARAMETRIC MODELING AUTOMATION

There are following two approaches for modelling automation

a) Master Model

b) Generative Model

The first method, which we call the master model method, uses a worst case model and drives that model. You don't create geometry. You don't create assemblies or drawings. You simply open an existing model and you drive it. The other method, known as generative modeling actually generates models and assemblies and drawings on the fly. There are certainly cases where both have their distinct advantages.

With the master model approach, you start off with a "worst case" master model. We use SolidWorks to suppress or delete features that we don't want, for example. That means that all of the features and components that you might need, have to be in the master model. Does this make the models more complex? Certainly, it does. But the programming for master models, and this includes programming in the traditional sense, where you're working with the SolidWorks API and when you're writing rules inside of a DriveWorks or a TactonWorks(Commercially available solution partner product) type of product. It is a lot easier to delete a component than to describe to a computer how it is to be assembled into an assembly.

The generative approach, suffers from the complexity of using the SolidWorks API. Well you can't easily look and make that determination programmatically.

Model testing is certainly also easier with a master model because you can test with SolidWorks clicks. With generative code, you need to run the code to test anything. But the final decision that people have to make is whether their design can effectively be represented in a "worst case" model. In most cases it can, so we're going to focus primarily on the master model approach, however, we will address both in this project.

5. DESIGN PROCEDURE

There is no standard design procedure used, it depends on past experience and knowledge of that design engineer, in this we are going to develop standard procedure for design. So that it can be used by person not having more experience and design knowledge of machine. Design starts with customer order, in that following main parameters are given by customer. Depends on that design done, we are using standard formulae for strength calculation.

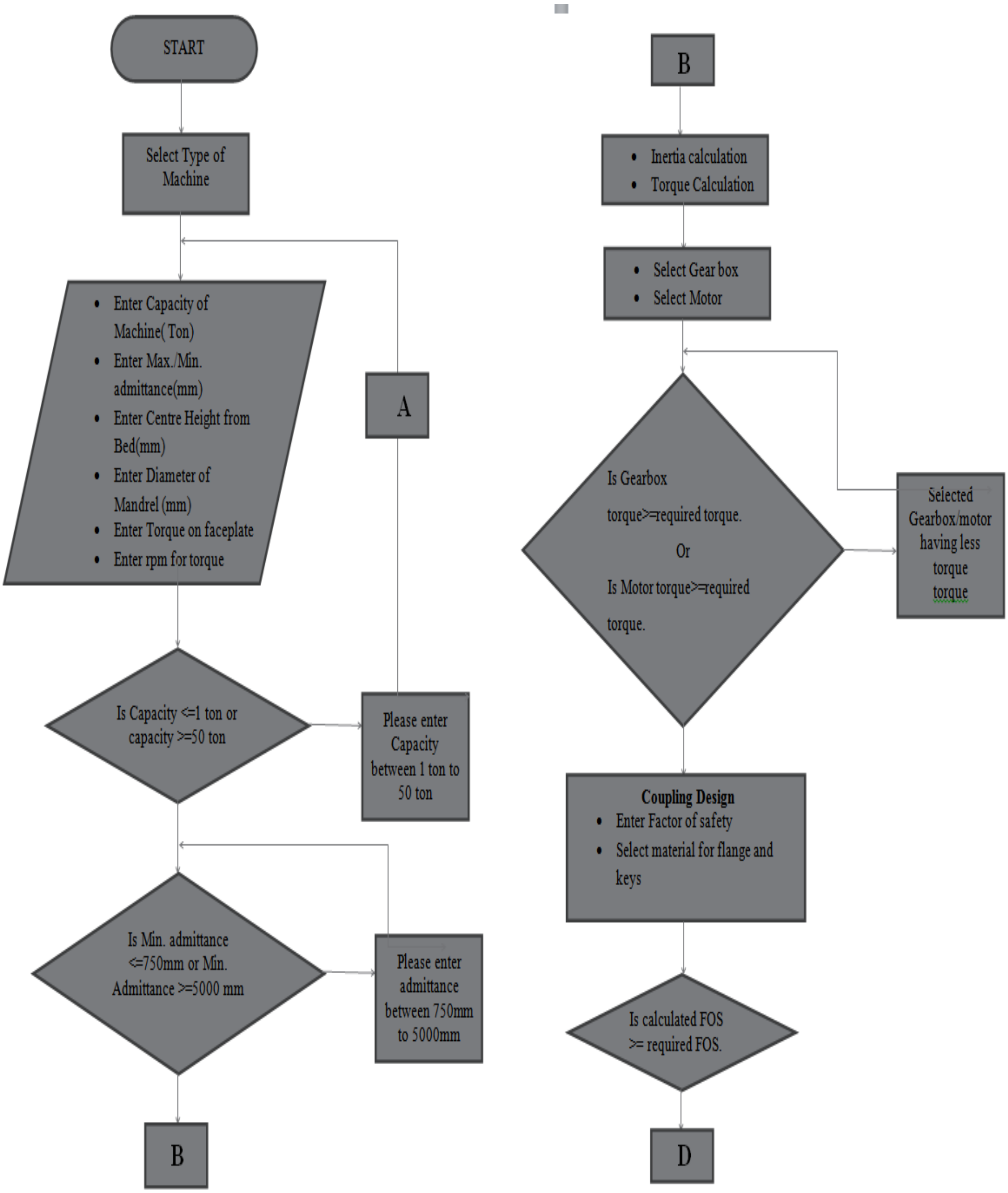
5.1. Design Parameters

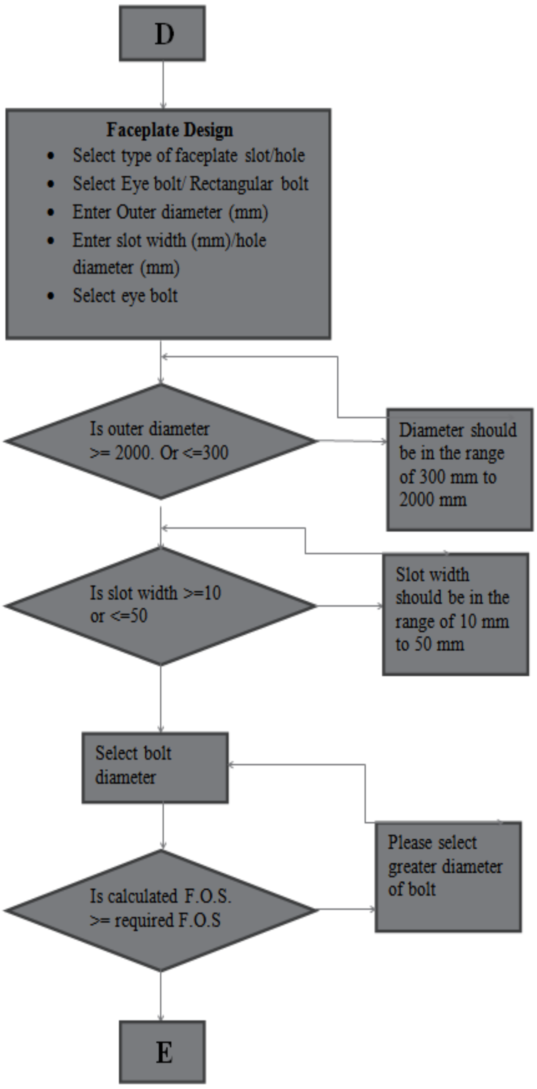
- **Capacity of machine (Ton):** It is weight taken by machine with full coil winding.
- **Output torque (Kgm):** It is required output torque with that coil can easily get wound. Sometimes customer also mentioned motor capacity (HP)
- **Output Speed (RPM):** It is output speed (RPM) of faceplate. It is given in terms of maximum and minimum output speed.
- **Centre height from bed (mm):** It is height of centre from bed, depends on customer.
- **Maximum Admittance (mm):** It is maximum distance between headstock faceplate to tailstock faceplate
- **Minimum Admittance (mm):** It is minimum distance between headstock faceplate to tailstock faceplate.

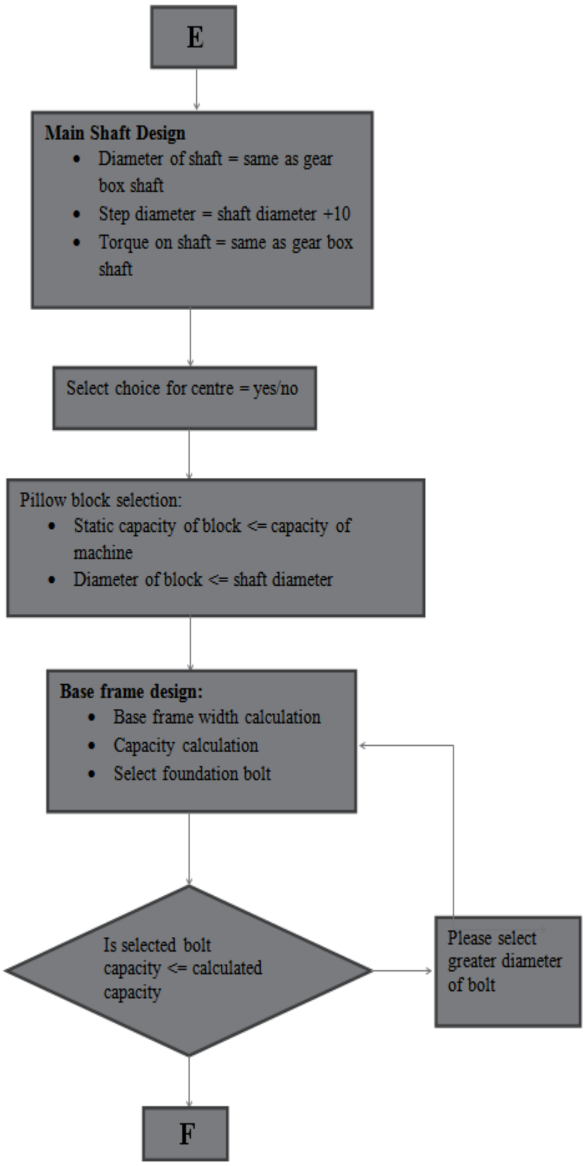
5.2. Following Component is to be Design

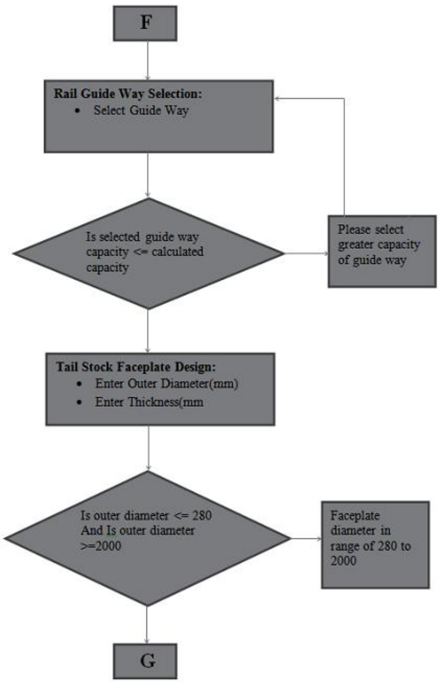
- Motor Selection
- Gear Box Selection
- Coupling Design
- Faceplate Design
- Bearing Selection
- Base frame Design
- Selections of hardware component nuts, screws, guide ways etc.

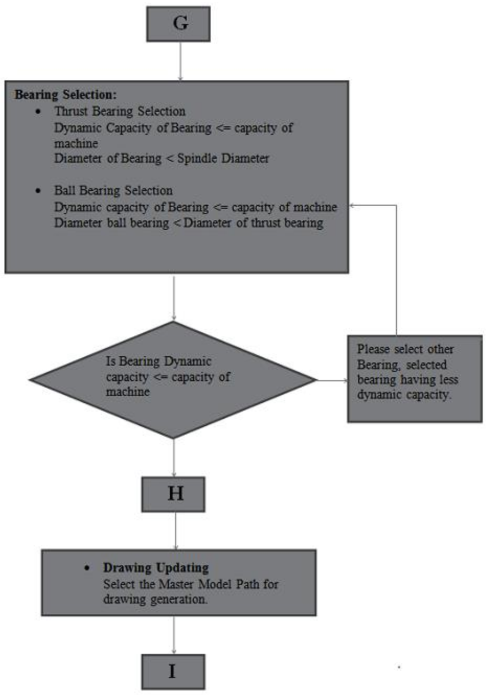
6. ALGORITHM FOR DESIGN PROCESS AUTOMATION

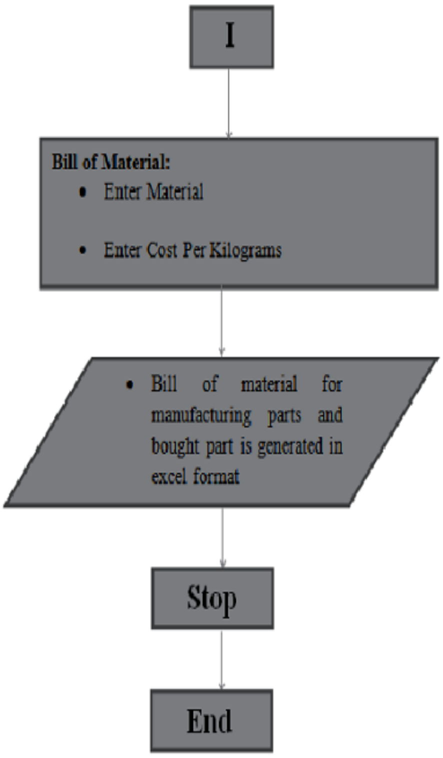



D
Faceplate Design
• Select type of faceplate slot/hole
• Select Eye bolt/ Rectangular bolt
• Enter Outer diameter (mm)
• Enter slot width (mm)/hole diameter (mm)
• Select eye bolt
Is outer diameter >= 2000. Or <=300
Diameter should be in the range of 300 mm to 2000 mm
Is slot width >=10 or <=50
Slot width should be in the range of 10 mm to 50 mm
Select bolt diameter
Is calculated F.O.S. >= required F.O.S
Please select greater diameter of bolt
E


E
Main Shaft Design
• Diameter of shaft = same as gear box shaft
• Step diameter = shaft diameter +10
• Torque on shaft = same as gear box shaft
Select choice for centre = yes/no
Pillow block selection:
• Static capacity of block <= capacity of machine
• Diameter of block <= shaft diameter
Base frame design:
• Base frame width calculation
• Capacity calculation
• Select foundation bolt
Is selected bolt capacity <= calculated capacity
Please select greater diameter of bolt
F


F
Rail Guide Way Selection:
• Select Guide Way
Is selected guide way capacity <= calculated capacity
Please select greater capacity of guide way
Tail Stock Faceplate Design:
• Enter Outer Diameter(mm)
• Enter Thickness(mm
Is outer diameter <= 280 And Is outer diameter >=2000
Faceplate diameter in range of 280 to 2000
G


G
Bearing Selection:
• Thrust Bearing Selection
Dynamic Capacity of Bearing <= capacity of machine
Diameter of Bearing < Spindle Diameter
• Ball Bearing Selection
Dynamic capacity of Bearing <= capacity of machine
Diameter ball bearing < Diameter of thrust bearing
Is Bearing Dynamic capacity <= capacity of machine
Please select other Bearing, selected bearing having less dynamic capacity.
H
• Drawing Updating
Select the Master Model Path for drawing generation.
I



Following is the sample code developed for model updating in SolidWorks vb.Net API

- **To open part document and it's updating:**

```
oDoc = oApp.OpenDocSilent("c\documents\model items \Top plate.SLDPRT",SolidWorks.Interop.swconst.swDocumentTypes_e.swDocPART , lErrs)
oDoc.Parameter("D9@Sketch1").SystemValue = (GB_Width + 200) / 1000
oDoc.Parameter("D2@Sketch1").SystemValue = (GB_Width) / 1000
oDoc.Parameter("D5@Sketch1").SystemValue = (GB_Length + 16 + 6)/1000
Total_Length = ((GB_Length + 16 + 6) + Val(TxtmaxAdd.Text) + ((Bsfrm_width + 200) * (11 / 17)) + 100 + 100).ToString("0")
oDoc.Parameter("Thru Tap Drill Dia.@Sketch8").SystemValue =(small_d)
oDoc.Parameter("Thru Tap Drill Dia.@Sketch6").SystemValue =(small_d)
oDoc.EditRebuild()
oDoc.Save()
```

- **To open drawing document and it's updating:**

```
oDoc = oApp.OpenDocSilent(c\documents\model items\DOOR.SLDDRW", SolidWorks.Interop.swconst.swDocumentTypes_e.swDocDRAWING, lErrs)
oDoc = oApp.ActiveDoc
swdr = oDoc
oDoc.DeleteCustomInfo2("", "DATE")
oDoc.AddCustomInfo3("", "DATE", swCustomInfoType_e.swCustomInfoText, sheet_date)
oDoc.DeleteCustomInfo2("", "NAME")
oDoc.AddCustomInfo3("", "NAME", swCustomInfoType_e.swCustomInfoText, "H -" + Txtton.Text + " -" + Txtminadd.Text + " -" + TxtmaxAdd.Text + " -" + Txtcentreht.Text + " - SA - 02 - 019")
oDoc.EditRebuild()
oDoc.Save()
Clsdoc = oApp.CloseAllDocuments(True)
```

7. Screenshots of Developed Application

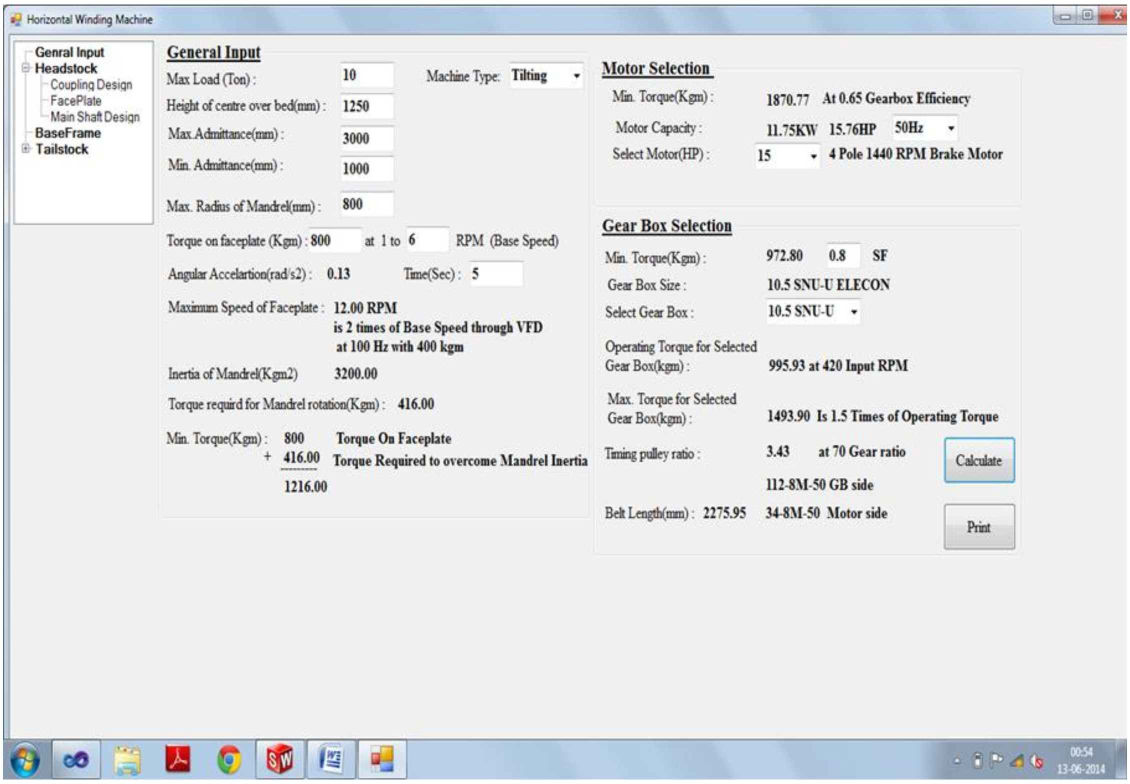


Fig7.1. *Graphical User Interface for General Input*

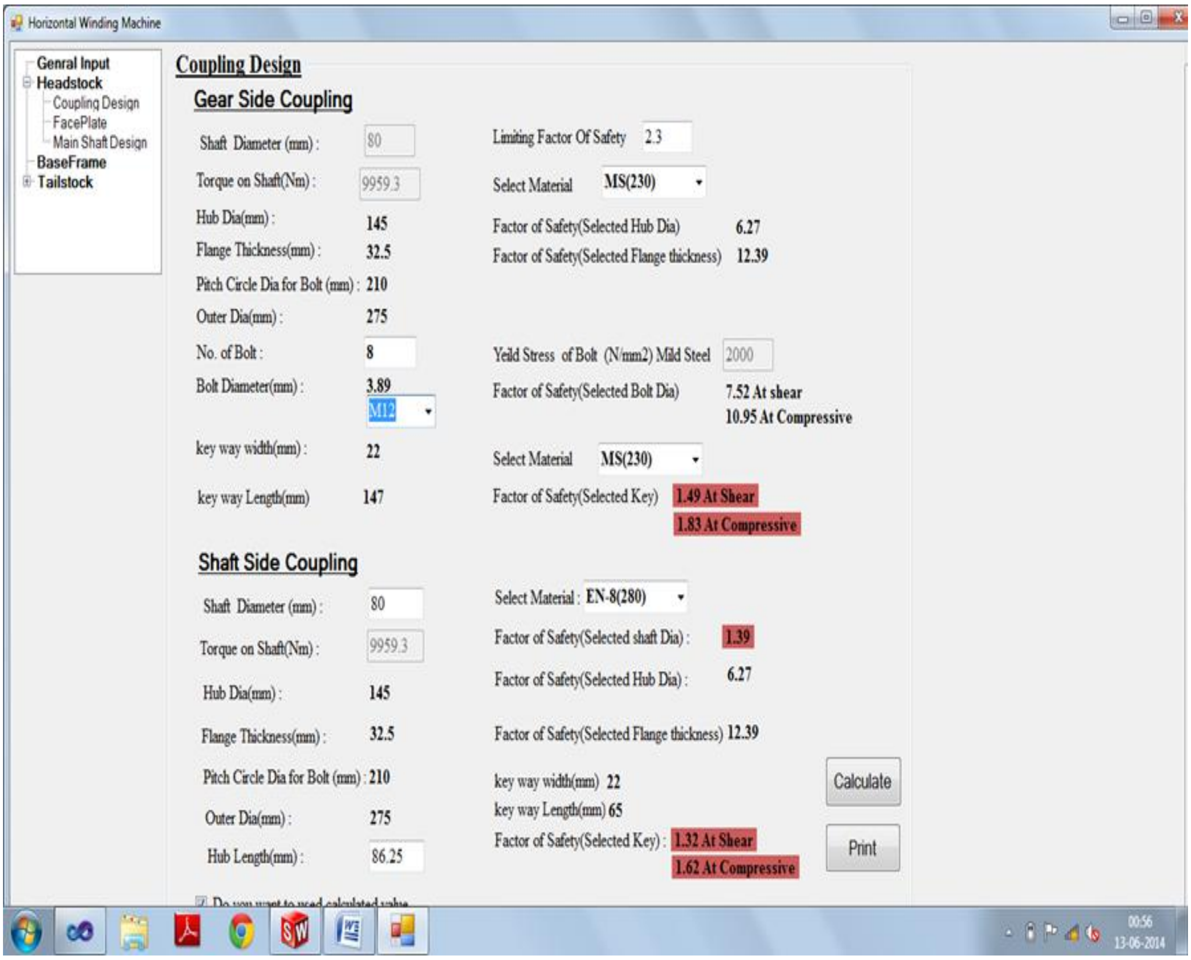


Fig7.2. *Graphical User Interface for Coupling Design*

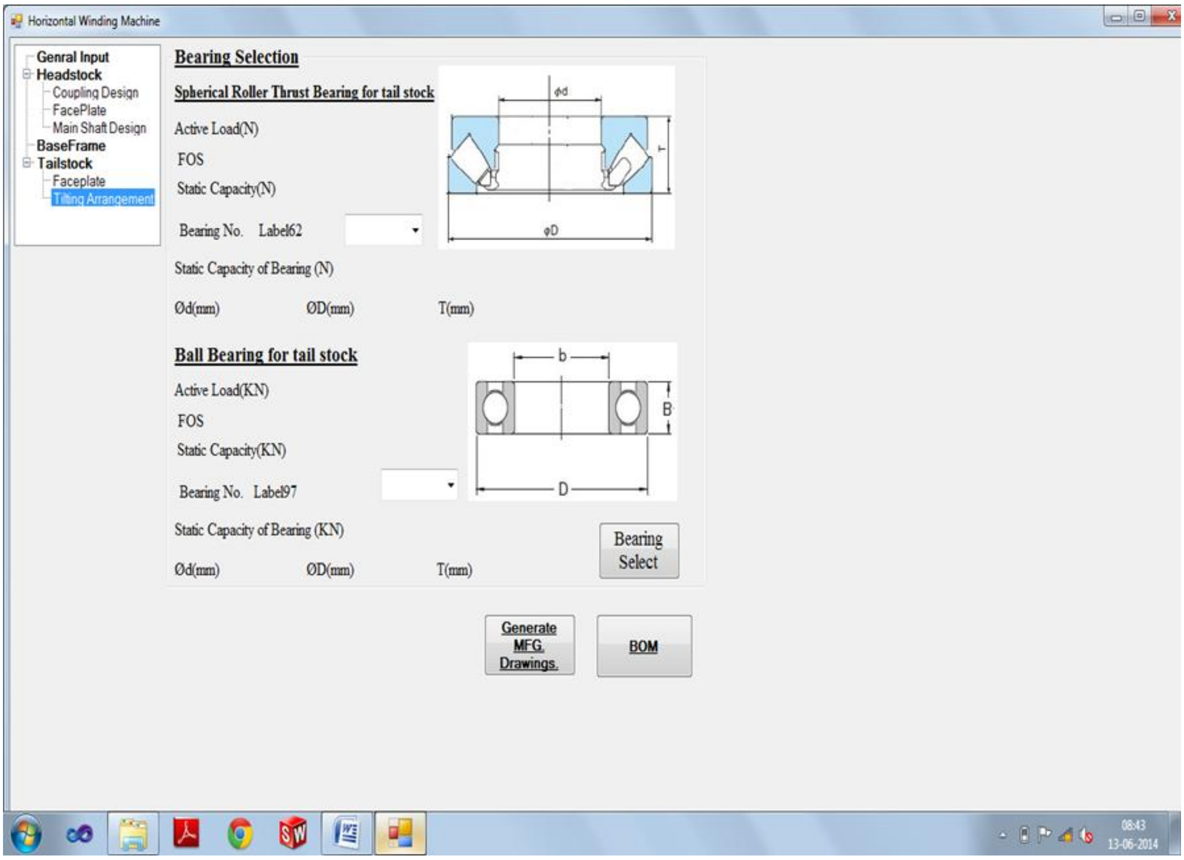


Fig7.3. *Graphical User Interface for Bearing Selection*

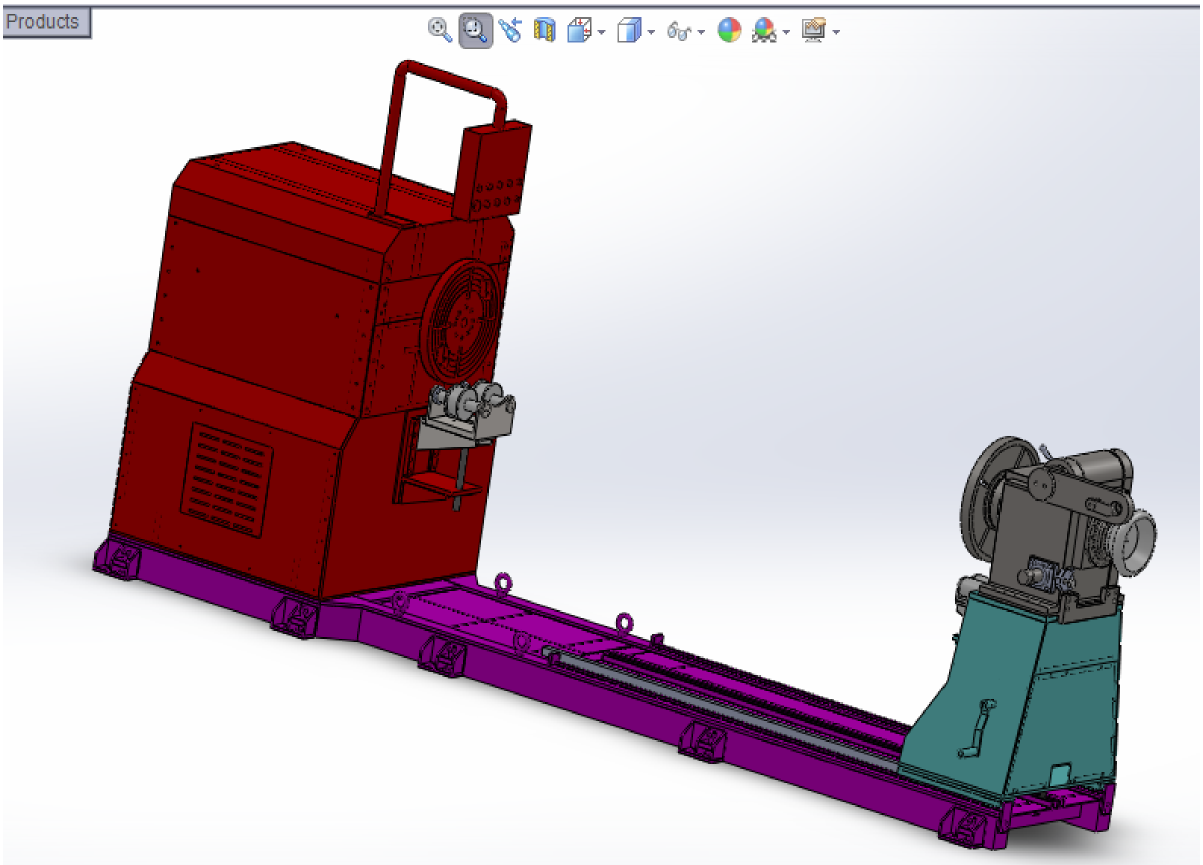


Fig7.4. *CAD Model of Winding Machine*

	A	B	C	D	E	F	G
1	30 TON HWM						
2	Engineering Pvt Ltd.						
3	List of Hardware						
4	Project No.				DATE		
5	Sr.No	Description	Size	Qty	Remark	Cost per pice	Total cost
6	A	BASE FRAME ASSEMBLY					
7	1	HEX BOLT	X 110 LG	10	Foundation	0	0
8		NUT	M20	10			0
9	2	S.H.C.S.	M8X25 LG	33	Rail		0
10	3	HEX BOLT	M24X80 LG	6	Base Top Plate		0
11		TAPER WASHER	M24	6			0
12		NUT	M24	6			0
13	4	S.H.C.S.	M10X25 LG	6	Rack		0
14	5	EYE BOLT	M30	4			0
15	6	CSK(SS)	M8X20	6	Rail Stoper		0
16	7	S.H.C.S.	M8X55	4	Rail Stoper-1		0
17	8	STUD	M20X300	10	Foundation		0
18		NUT	M20	20	Foundation		0
19		PLAIN WASHER	M20	10			0
20	B	HEAD STOCK ASSEMBLY					
21	1	CSK(SS)	M12X15 LG	39	Head stock Bottam Assembly		0
22	2	S.H.C.S.	M12X60 LG	12	MOTOR GUIDE		0
23		PLAIN WASHER	M12	12			0
24		SPRING WASHER	M12	12			0
25	3	HEX BOLT	M12X50 LG	4	Motor Mtg.		0

Fig7.5. *Manufacturing Part List in MS-Excel*

	A	B	C	D	E	F	G	H	I
1	5 TON HWM								
2	Engineering Pvt Ltd.								
3	List of Hardware								
4	Project No :-			DATE- 19/10/2011					
5	Sr.no	Description	Finished Size	QTY	Weight(per Kg)	Material	Cost Per (Kg)	Total Cost	Total Weight(Kg)
6	A	Head Stock Assemly							
7		Lower Side Channel	150 x 75 x 5.4 THK x 1196.00 Lg	3	24.08	M.S.	1	72.24	72.24
8		Lower Side Channel-1	150 x 75 x 5.4 THK x 1196.00 Lg	1	24.08	M.S.	1	24.08	24.08
9		Front And Back Lower Channel	150 x 75 x 5.4 THK x 1075.00 Lg	2	21.75	M.S.	1	43.5	43.5
10		Motor Fitting Base	1225.00 x 1196.00 x 16 THK	1	182.71	M.S.	1	182.71	182.71
11		Verticle Chaneel640	150 x 75 x 5.4 THK x 461.00 Lg	1	9.33	M.S.	1	9.33	9.33
12		Upper Side Chaneel	150 x 75 x 5.4 THK x 770.00 Lg	2	14.19	M.S.	1	28.38	28.38
13		Bottam Plate(Head Stock)	1237.00 x 1218.00 x 12 THK	1	51.3	M.S.	1	51.3	51.3
14		Gear MTG.Plate	1196.00 x 1037.00 x 36 THK	1	334.82	M.S.	1	334.82	334.82
15		Vert Plate-1(Head Stock)	512 x 1196 x 6 THK	1	28.81	M.S.	1	28.81	28.81
16		Vert Plate(Head Stock)	1237.00 x 948.00 x 16 THK	1	133.65	M.S.	1	133.65	133.65
17		Angle Plate	1196.00 x 135 x 16 THK	2	9.05	M.S.	1	18.1	18.1
18		cover Lower Angle	50 x 1196.00 x 16 THK	1	4.66	M.S.	1	4.66	4.66
19		Angle Plate	50 x 462 x 10 THK	2	1.8	M.S.	1	3.6	3.6
20		Ibeam	50 x611x 10 THK	1	2.38	M.S.	1	2.38	2.38
21		Welded Back Fixed Cover	106 x 813 x 6 THK	2	3.72	M.S.	1	7.44	7.44
22		Lower Motor Angle	75 x 75 x 8 THK x 1176 Lg	2	9.8	M.S.	1	19.6	19.6
23		Top Fitting Cover	1218.00 x 241 x 6 THK	1	100.34	M.S.	1	100.34	100.34

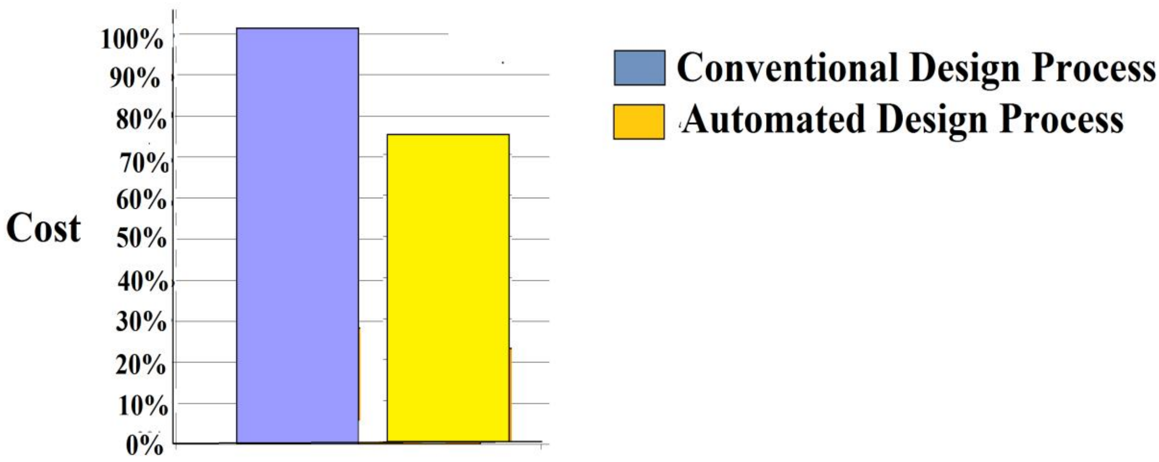
Fig7.5. *Bill of Material (BOM) in MS-Excel*

8. Result and Discussion

By using above developed application, it reduces 80 present time required for overall design process hence significant amount of saving in cost.

Following table shows comparison of time line between conventional and automated method.

Conventional Design Method	Automated Design Method
5-6 days	**2 hours**



Using this application 30 minutes are required for design calculation process and generating updated versions of CAD models hence overall cost reduction is 20 to 25%.

As there is no 100 percent design and drawing automation is achieve. In this 1.30 hrs required for drawing sheets checking because design is based on customer requirement sometimes drawing views are scale down or scale up this have to do manually.

9. FUTURE SCOPE

The work presented here is developing a design and drawing automation system for Winding Machine. Yet, the approach presented in this thesis could be further enhanced and extended by considering the following aspects:

- Presented work shows design and drawing automation of winding machine, this application can be developed with other design standards and other types of winding machine.
- Further, it can be developed for the CAE automated application to solve and simulate the components.

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