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Catia Customization for Design and Modeling of Two Stage Spur Gearbox

Mayuresh V. Patwardhan[1], Uddhavrao Nimbalkar [2]
[1]M Tech (Mechanical) PG student, [2]Assistant Professor, Department of Mechanical Engineering, Rajarambapu Institute of Technology, Sakharale, Maharashtra, 415414, INDIA

Abstract: In this paper, we describe how the customization of design task, in solid modeling with CATIA V5 for two stage spur gearbox can be approached, by means of macros (piece of code) and with GUI form. The user has to supply some basic requirements of the gearbox and rest of the different parameters for design of gearbox is calculated by formulas. And then with the help of these parameters, part model of gearbox is created.
Keywords: CAD, Catia, GUI, Macros, Design, Parametric modeling, two stage spur gearbox

I. INTRODUCTION

Current scenario of the market is competitive. To sustain in the market for company product time to the market have to be minimum. Companies existing product demands from the customer are to be provided quickly as soon as possible. Existing product requirement has same parametric features of components for different specification. Design and modeling time of the product is generally 60-70% of overall time of the product development. Design phase has lot of potential where time can be saved. Parametric modeling can be used for saving the modeling time. Knowledge based approach can be useful for saving the design time. Lot of repetitive calculations can be saving for avoiding tedious work. CATIA software is selected having strong parameterization. Mechanical product selected is gearbox. 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. 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 modeling software. In this with use of Macro which means program written for specific task. For developing advanced macros for special needs Catia V5 is an open system. Macros may be useful for creating, analyzing, measuring, modifying. Translating, optimizing surfaces, solids, wireframes and more. Macros are useful for part operation, assembly operation and all multidisciplinary applications.

II. LITERATURE REVIEW

Many research attempts have been made in the area of parametric modeling.

Ruchik D. Trivedi et al [1] discussed about integrating the commercially available package Pro/E with Microsoft Excel spreadsheet for 3D parametric modeling. Various product variants of the inner ring of spherical roller bearing have been executed by parametric designing concept in Pro/Engineer Wildfire.

Umesh Bedse et al [2] discussed about 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. And creo software is used for modeling. Indrajitsinh J. Jadeja et al [3] discussed about the work reviews the procedural steps involved in the design of couplings and the development of the software package using visual basic as a tool for the design. This system is carried out on the case study of flange coupling and standard design equation being carried out together with the use of programming software and use CREO as modeling software. Dhaval b. shah et al [4] discussed about the 3D models for flange type coupling and related dimension database in Microsoft Excel have been prepared. This Excel sheet has been linked with Autodesk Inventor to transfer data and relate to respective features of the part. User can update the model just by modifying the sheet. This takes comparatively very less time to generate complex part models with respect to generating them individually. This automation can further be proceeded by exporting models to the analysis or CAM package.

L.Karikalan et al [5] discussed about the the main purpose of this assignment is to provide a gear box with Low reduction ratio, low weight and efficient for engine up to 500cc. It should also be used in “All Terrain” vehicles.

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A. CATIA V5

CATIA (Computer Aided Three Dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by French company Dassault Systems and it is marketed world-wide by IBM. Catia is the world's leading CAD/CAM/CAE software. For developing advanced macros for special needs Catia V5 is open system. A macro is a series of functions, written in a scripting language, that you group in a single command to perform the requested task automatically. These macros may be useful for creating, analyzing, measuring, modifying. Translating, optimizing surfaces, solids, wireframes and more. Macros are used to save time, reduce the possibility of human error by automating repetitive processes, standardization, improving efficiency, expanding Catia's capabilities, and for streamlining tasks. For creating basic structure and basic flow of program we require inputs, outputs, and supporting data from the user. Catia provides customization capability. In Catia the part Objects, which are used for developing part model i.e. three dimensional object are structured under a automation tree.

B. CATIA V5 Macros

A macro is a series of functions, written in a scripting language, that you group in a single command to perform the requested task automatically. In simple it is a piece of code written in certain programming language which groups a set of operation that defines a certain task. For each task separate code is written and assembled together by using forms.

C. CATIA Customization/Automation Objects

In CATIA the part objects, which are used for developing part model i.e. three dimensional object are structured under a tree as shown in the following figure. As and when needed the part object can be extracted with the macro programming for customization or automation of CATIA V5 The Part Document object aggregates, or includes, the part tree structure starting with the Part object located at the top of the part specification tree. These Part Document objects are: Origin Element, Geometric Elements, Bodies and Part objects are: Constraints, Relations, Parameters, and Factory3D, Shape Factory (Sketches, Geometric Elements, and Shapes)

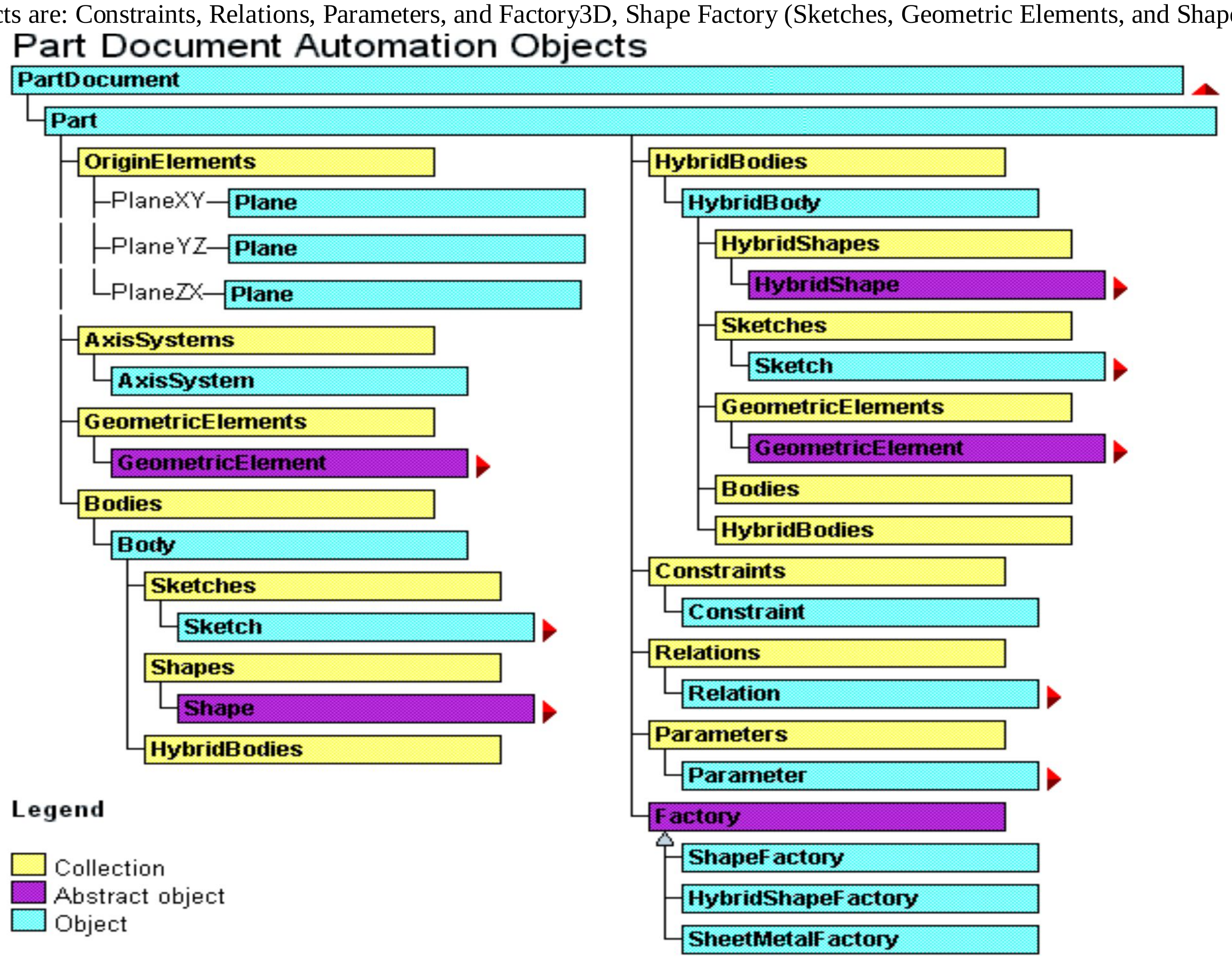

Fig 1: Part Modeling Object Tree

III. METHODOLOGY

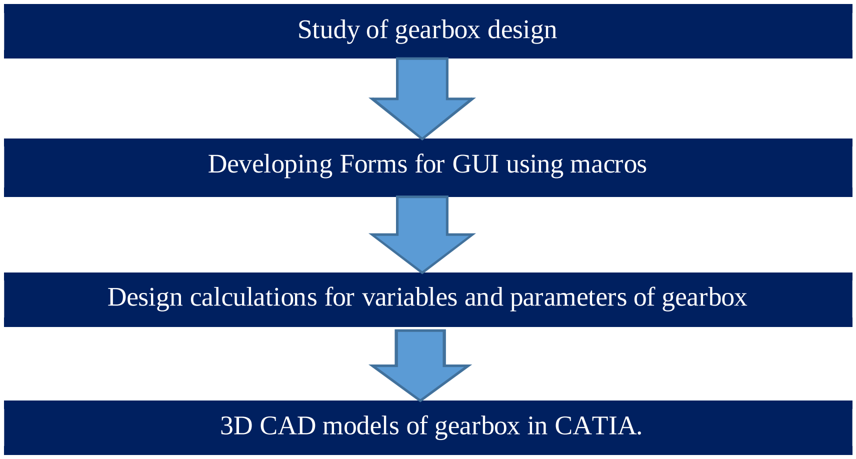

Fig 2: Methodology

1) First user need to give input parameters of gearbox to GUI form

The input parameters are as follows

- Power (P) in KW
- No. of teeth on gear 1 (Z1)
- service factor
- RPM of Gear 1 (N1)
- No. of teeth on gear 3 (Z3)
- factor of safety
- RPM of Gear 4 (N4)
- surface hardness (BHN)
- Ultimate stress for gear material Sut – N/mm^2

2) As the input parameters are given from calculate module we get the value which is best suitable according to design procedure of gearbox

3) As user fill that value into the input module value the design is getting checked

4) And gear dimensions are generated and model is generated.

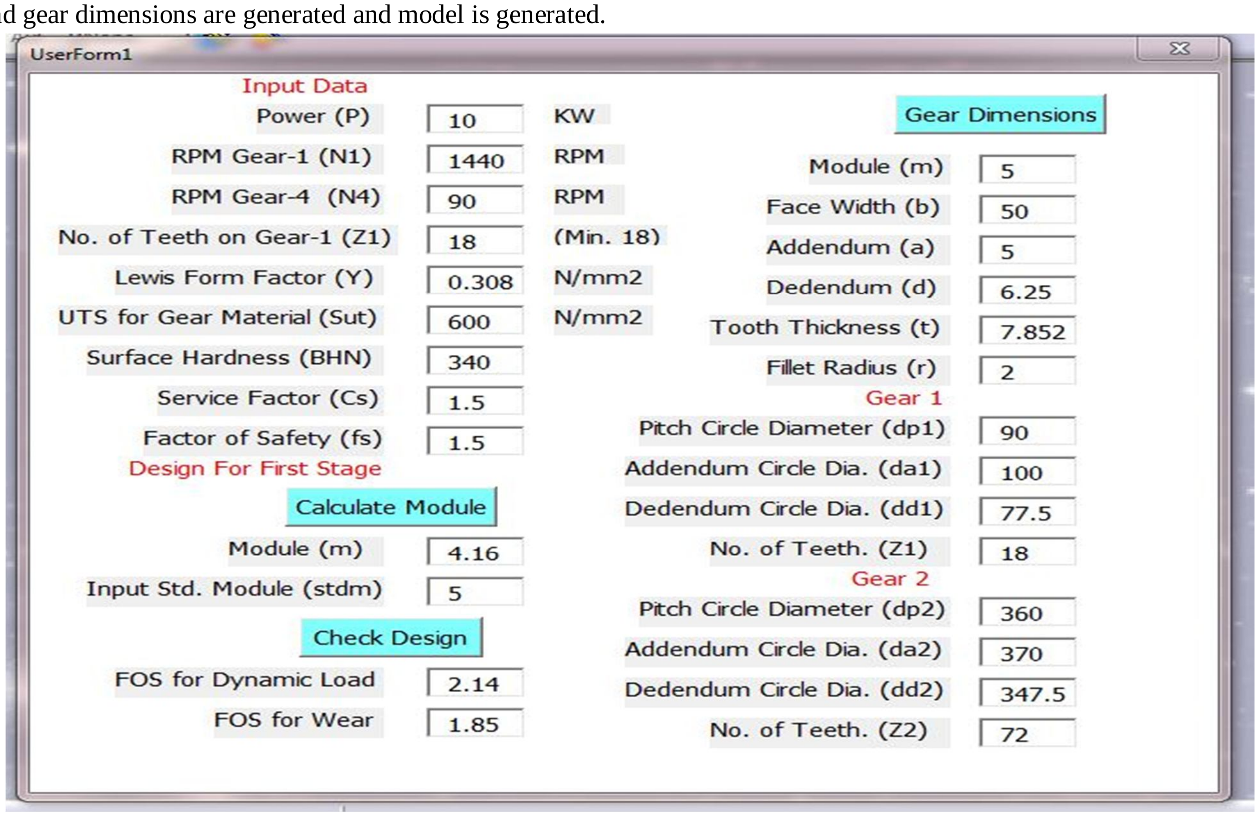

Figure 3: Developed GUI

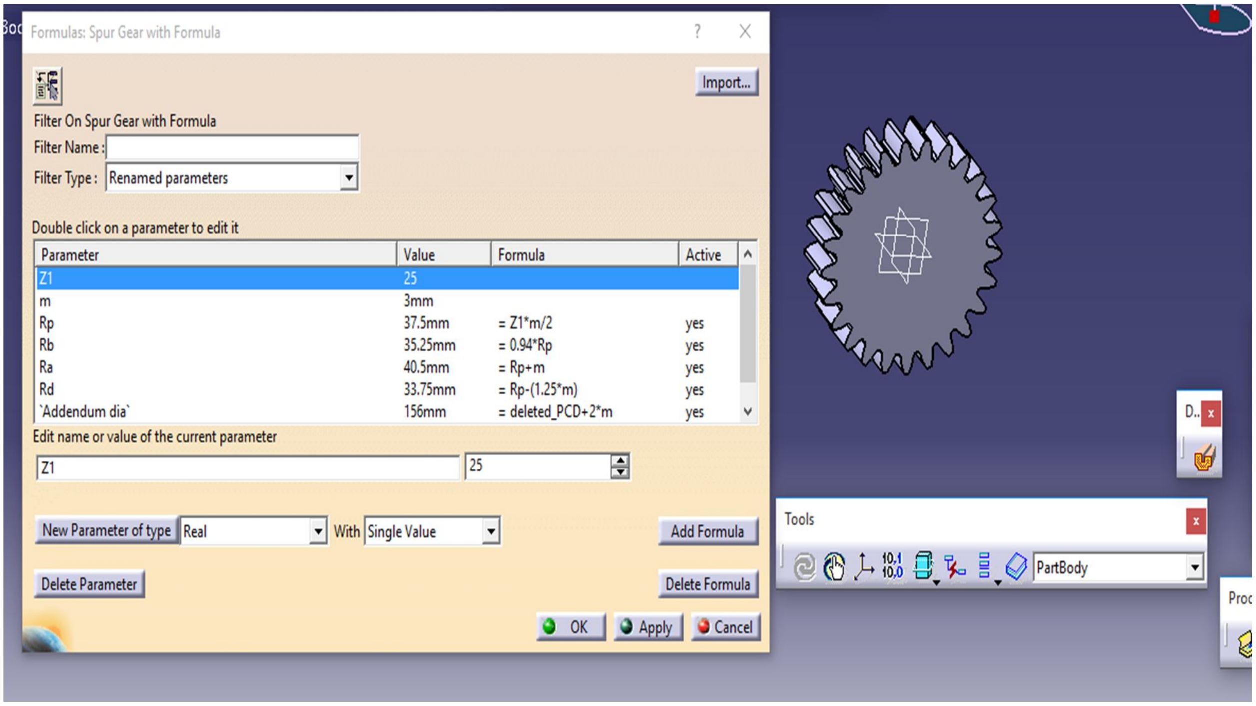

Figure 4: Spur gear with formula

A. Design Calculations

	Notation	Value	Unit	formula
Input Data				
Power to be transmitted	P	10	KW	
RPM of Input Shaft (Gear 1)	N1	1440	RPM	
RPM of Output Shaft (Gear 4)	N4	90	RPM	
Minimum number of teeth for Gear 1	Z1	18	Min 18 for 20 Degree Pressure angle	
Lewis form Factor for Gear 1	Y1	0.308		
UTS of Gear material	Sut	600	N/mm2, Mpa	
Surface Hardness for Gears	BHN	340		
Service factor	Cs	1.5	Maximum torque or starting torque /Rated torque	
Factor of Safety	fs	1.5		
Assumptions				
Gear teeth pressure angle	□	20		
Pitch line velocity	v	5	m/s	
Ratio b/m	b/m	10		b - Width of gear, m- module
Material for all gears is considered same, the pinion is weaker than gear, Hence it is necessary to design for Pinion i.e. Gear 1				

B.	Module Based on Beam Strength				
	Velocity Factor	Cv	0.375		3/(3+v)
	Permissible bending stress for gear teeth	□b	200	N/mm2	Sut/3
	Torque transmitted by Gear 1	Mt	66305.96223	Nmm	(60*10^6)*(P)/(2*3.142*N1)
	Module step-1		19096117		60*10^6/3.142
	Module step-2		22.50		P*Cs*fs
	Module step-3		5987520.000		Z1*N1*Cv*(b/m)*□b*Y
	Module step-4		71.760		Step1*(step2/step3)
	Module Based on Beam Strength	m'	4.16		Cuberoot(step-4)
B	Selection of Module & FOS For Beam Strength & Wear Strength				
	Standardized Module	stdm	5		
	Pitch Circle diameter for Gear 1	dp1	90	mm	m*Z1
B1	FOS For Considering Dynamic load				
	Tangential force due to rated torque	Pt	1473.465827	N	
	Actual Pitch line velocity	Va	6.78672	m/s	Create If Function for Cv
	Velocity Factor	Cv	0.30654		
	Effective load	Peff	7210.1987		Peff=Cs*Pt/Cv
	Beam Strength	Sb	15400.000	N	m*b**sb*Y
	FOS Considering Dynamic load	Fsb	2.1359		
B2	FOS For Wear or Pitting Failure				
	Total transmission ratio	i	16		N1/N4
	Speed reduction at each stage	i1	4.000		sqrt(i)
		Z2'	72.000		i1*Z1
	Number of teeth for Gear 2	Z2	72		
	Pitch Circle diameter for Gear 2	dp2	360	mm	
	Width of gear tooth	b	50	mm	
	Ratio factor for external gears	Q	1.6000		Q= 2Z2/(Z1+Z2)
	Load stress factor	K	1.8496		K=0.16*(BHN/100)^2
	Wear strength for Gear	Sw	13317.12000	N	Sw= b*Q*dp1*K
	FOS for wear load	Fsw	1.84698		Fsw=Sw/Peff

IF Fsw is less than 1, Message Box Increase Module
IF Fsw is more than 1, Message Box Design is safe against wear load

C. Gear Dimensions

						E.g.
Module	m	5	mm	(b/m)*m	tbmg -	tb-template box for mg
Face Width	b	50	mm	m	tbb	tb-template box for b value
Addendum	a	5	mm	m	tba	
Dedendum	d	6.25	mm	1.25*m	tbd	
Tooth Thickness	t	7.854	mm	1.5708*m	tbt	
Fillet radius	r	2	mm	0.4*m	tbr	
Gear 1						
Pitch Circle diameter	dp1	90	mm		tbdp1g	
Addendum Circle diameter	da1	100	mm	dp1+2*a	tbda1	
Dedendum Circle Diameter	dd1	77.5	mm	dp1-2*d	tbdd1	
Number of teeth	Z1	18			tbZ1g	
Gear 2						
Pitch Circle diameter	dp2	360	mm		tbdp2g	
Addendum Circle diameter	da2	370	mm	dp1+2*a	tbda2	
Dedendum Circle Diameter	dd2	347.5	mm	dp1-2*d	tbdd2	
Number of teeth	Z2	72			tbZ2g	

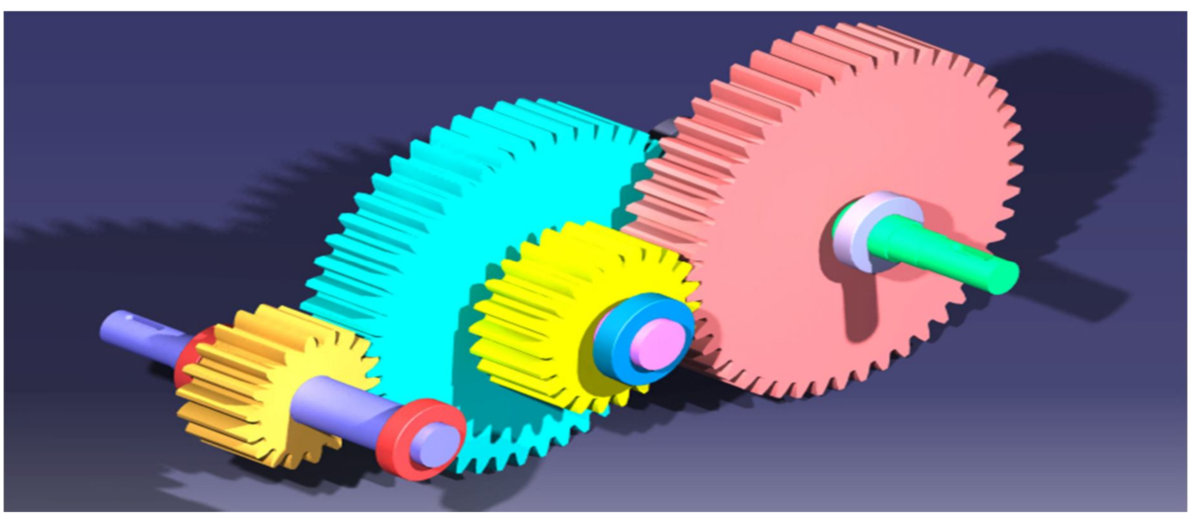
Figure 4: model for assembly of gearbox

D. Shaft Selection

Shaft 1				
Center Distance between Gear1 & Gear2	C1	225	mm	(dp1+dp2)/2
Center Distance between Gear3 & Gear4	C2	225	mm	(dp3+dp4)/2
ASME code for Bending moment	kb	1.5		
ASME code for torsional moment	kt	1		
Assumptions				
Factor of Safety for shaft 1	Fss	2		
Distance Between Bearings on Shaft 1	L1	200	mm	
Permissible Shear Stress	Ssy	108	N/mm2	0.18*Sut
Gears are fixed on shaft by Keyways, Therefore	tmax	40.5	N/mm2	0.75*Ssy/Fss
Tangential Force at Gear 1 (C)	Ftc	1473.466	N	T1x2/dp1
Axial Force at Gear 1	Fac	536.298	N	Ftc* tan20
Resultant force at C	Fct	1568.030	N	Ftc/ Cos20
Weight of Spur Gear 1	Ws1	24.499	N	3.142/4*dp1*dp1*b* (7.85*10^(-6))*9.81
Total Resultant Force at C	Fc	1592.528		
Reactions at A	Ra	796.264	N	Fc*(L1/2)/L1
Reactions at B	Rb	796.264	N	Fc-Ra
Maximum Bending moment at C	Mbc	79626.40518	Nmm	Fc*L1/4
Equivalent twisting moment	Te1	136610.0309		Sqrt((Kb*Mbc)^2+(Kt*Mt)^2)
Shaft 1 Diameter cube	d1^3	17176.76477		(16/(3.142*tmax))*Te
Shaft 1 Diameter	d1	25.802		
		25.00	mm	
Considering next standard value for Shaft Diameter			27.00	mm
Shaft 2				
Distance Between Bearings on Shaft 2	L2	180	mm	
Distance Between Bearing and Spur Gear 2	LEG	45	mm	
Distance Between Gear 2 & 3	LGH	90	mm	
	LEH	135		
	LHF	45		
Tangential Force at Gear 2 (G)	FtG	368.366	N	Mt/(dp2/2)
Weight of Gear 2	Wg2	389.9790136		
Total force at Gear 2	FG	758.345	N	

Tangential Force at Gear 3 (H)	FtH	1473.466	N	Mt/(dp3/2)
Weight of Gear 3	Wg3	24.37369	N	
Total force at Gear 3	FH	1497.840		
Taking moment at E, Force at F	RF	1312.966004	N	(FG*LEG+ (FH*(LEG+LGH)))/L2
Force at E	RE	943.219	N	FG+FH-RF
Bending moment at G	MG	42444.85418	Nmm	RE*LEG
Bending moment at F	MH	59083.4702	Nmm	RE*LEH-FG*LGH
Maximum Bending moment	Mmax2	59083.4702	Nmm	
Equivalent Twisting moment	Te2	110683.8183	Nmm	Sqrt((Kb*Mmax2)^2+(Kt*T)^2)
	d2^3	13916.91298		
	d2	24.05364907	mm	
		24	mm	
Considering next standard value for Shaft Diameter	d2	26	mm	
Shaft 3				
Distance Between Bearings on Shaft 3	L3	240	mm	
Distance Between Bearing and Spur Gear 4	LKJ	150	mm	
	LIK	90		
Tangential Force at Gear 4 (K)	FtK	368.366	N	Mt/(dp4/2)
Axial Force at Gear 14	Fak	134.074	N	Ftk* tan20
Resultant force at k	FrK	392.007	N	Ftk/ Cos20
Weight of Gear 4	Wg4	389.979		
Total Force at Gear 4	Fk	781.986	N	
Reaction at J	RJ	293.245	N	FK*LIK/L3
Reaction at I	RI	488.742	N	FK-RJ
Maximum Bending moment at K	MbK	43986.73551	Nmm	RI * LIK
Equivalent twisting moment	Te3	93540.65777	Nmm	sqrt((Kb*MbK)^2+(Kt*Mt)^2)
Shaft 3 Diameter cube	d3^3	11761.40482		(16/(3.142*tmax))*Te
Shaft 3 Diameter	d3	22.742	mm	
		22.00	mm	
Considering next std value for Shaft Dia	d3	30.00	mm	

E. Bearing Selection

for Shaft-1 Diameter at bearings		25	mm
Selected Bearing Number		6005	

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Load factor / Service Factor (Ks)		1.5		
Bearing ID		25	mm	
Bearing OD		47	mm	
Thickness		12	mm	
Static Load Rating	C01	6.55	KN	
Dynamic Load Rating	C1	11.9	KN	
Radial load at Bearing A	Fra	796.264	N	Ra
Axial Load at Bearing A	Faa	0	N	
RADIAL LOAD RATING FOR BEARING	X	1		
AXIAL LOAD RATING FOR BEARING	Y	1		
EQUIVALENT DYNAMIC BEARING LOAD	Pb	1194.396078		$(XF_r+YF_a)*Ks$
Bearing life in Revolutions	LRev	989.00	Millions of revolutions	

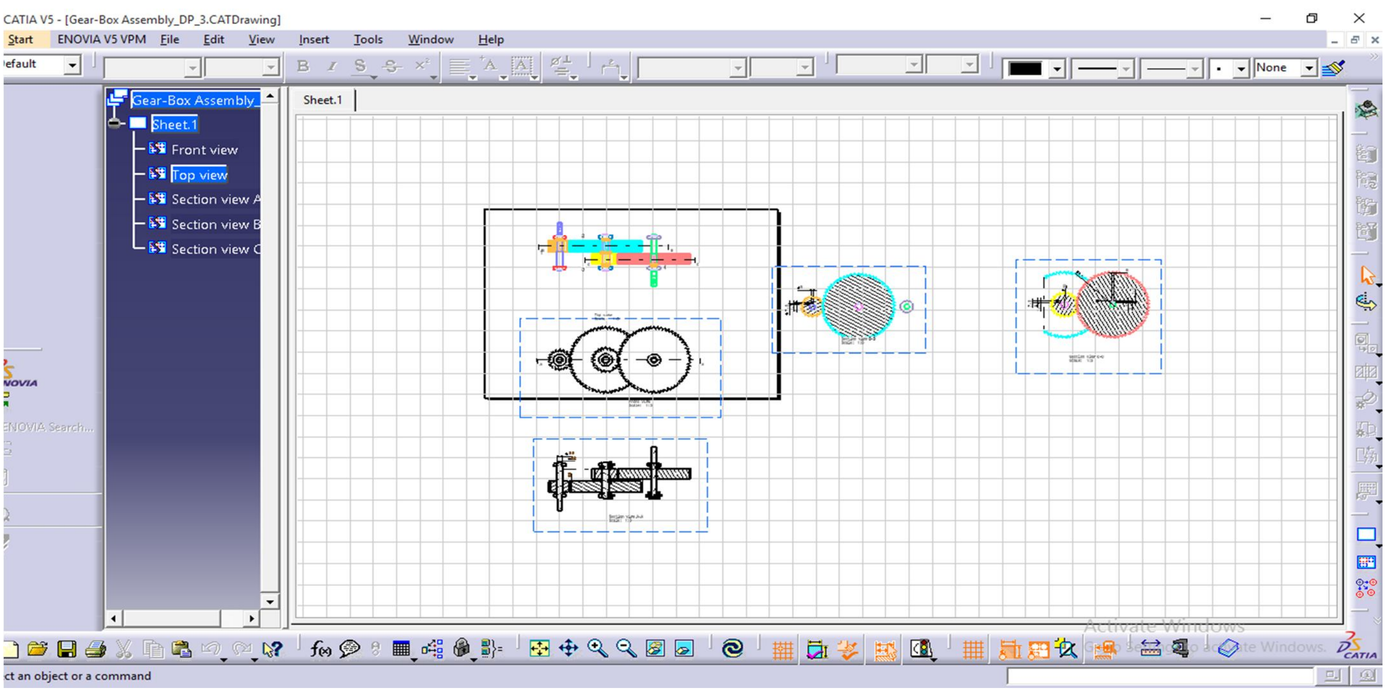

Fig 5: Drafted View of Gearbox

IV. CONCLUSION

The objective was to customize CATIAV5 for design two stage spur gearbox with minimum user requirements (inputs). With the help of this customization gearbox is generated. Also the time required for generating part model (three dimensional model) of gearbox is reduced to few minutes. This part model can be used to draft different views of the gearbox which can directly be used for manufacturing processes. Thus, customization will increase productivity of the designer with increase in quality of design which in turn reduces lead time for design of gearbox.

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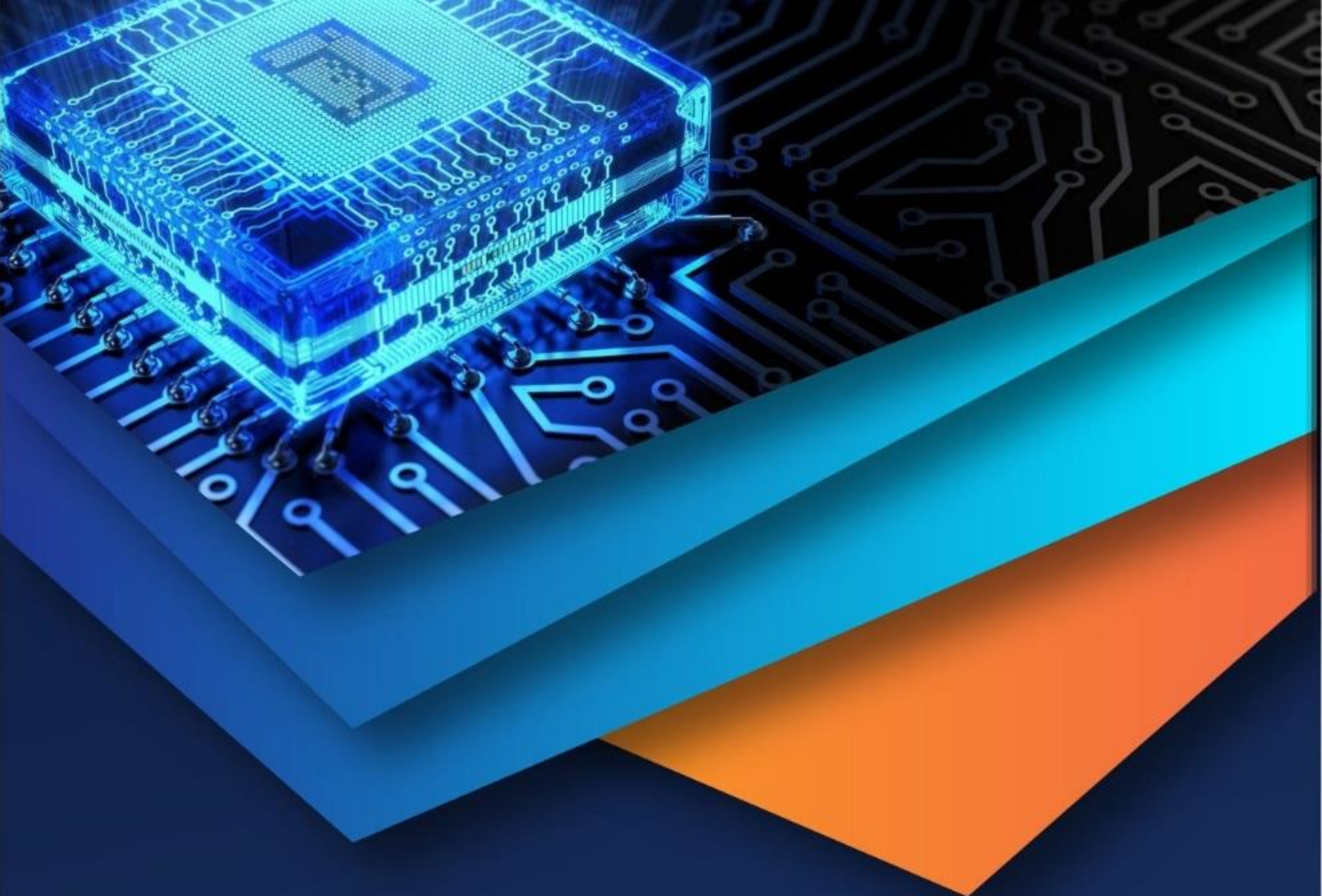

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