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Catia Customization for Design and Modeling of Two Stage Spur Gearbox

Mayuresh V. Patwardhan¹, Uddhavrao Nimbalkar²

¹M Tech (Mechanical) PG student, ²Assistant 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 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)

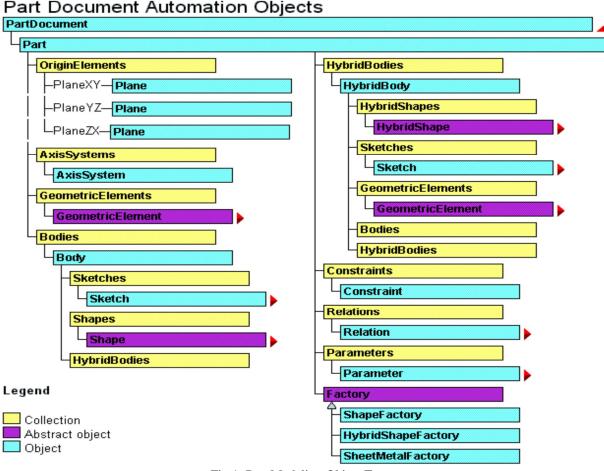
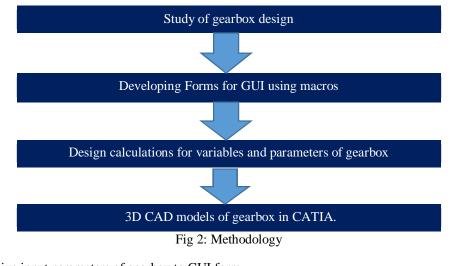


Fig 1: Part Modeling Object Tree



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III. 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
 With the surface hardness (BHN)
 Ultimate stress for gear material Sut N/mm²
- 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.

Input Data				
Power (P)	10	KW	Gea	r Dimensions
RPM Gear-1 (N1)	1440	RPM	Module (m)	5
RPM Gear-4 (N4)	90	RPM	Face Width (b)	50
No. of Teeth on Gear-1 (Z1)	18	(Min. 18)	Addendum (a)	5
Lewis Form Factor (Y)	0.308	N/mm2	Dedendum (d)	6.25
JTS for Gear Material (Sut)	600	N/mm2	Tooth Thickness (t)	7.852
Surface Hardness (BHN)	340		Fillet Radius (r)	2
Service Factor (Cs)	1.5		Gear 1	
Factor of Safety (fs)	1.5	Pitch	Circle Diameter (dp1)	90
Design For First Stage		Adde	ndum Circle Dia. (da1)	100
Calculate	Module	Dede	ndum Circle Dia. (dd1)	77.5
Module (m)	4.16		No. of Teeth. (Z1)	18
Input Std. Module (stdm)	5		Gear 2	
	1	Pitch	Circle Diameter (dp2)	360
Check D	esign	Adde	ndum Circle Dia. (da2)	370
FOS for Dynamic Load	2.14	Dede	ndum Circle Dia. (dd2)	347.5
FOS for Wear	1.85		No. of Teeth. (Z2)	72

Figure 3: Developed GUI



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loc	Formulas: Spur Gear with Formula			? ×		
				Import		
	Filter On Spur Gear with Formula					
	Filter Name :					
	Filter Type : Renamed parameters	-				
	Double click on a parameter to edit it					
	Parameter	Value	Formula	Active ^		
	Z1	25				
	m	3mm	20.00		K 2	
	Rp	37.5mm	= Z1*m/2	yes	Reconst	
	Rb Ra	35.25mm 40.5mm	= 0.94*Rp	yes	YODAN	
	Rd	40.5mm 33.75mm	= Rp+m = Rp-(1.25*m)	yes		
	`Addendum dia`	156mm	= deleted_PCD+2*m	yes v		D., x
	Edit name or value of the current parameter		_			
	Z1	[25			- 🖌 🥵
	New Parameter of type Real	✓ With Single Value		Add Formula	Tools	x
	New Parameter of type Real		•	Add Formula		
	Delete Parameter			Delete Formula	🛛 🕑 🕑 斗 🐘 🖶 🎉 🚆 🥥 PartBody	•
	Delete Parameter			Delete Politidia	1	Proc
			🔾 ОК 🌘 .	Apply 🧧 🥥 Cancel		

Figure 4: Spur gear with formula

A. Design Calculations

	Notation	Value	Unit		£	
		value	Ullit		formula	
Input Data						
Power to be transmitted	Р	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				
			Maximum torque or		• • •	
Service factor	Cs	1.5	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						



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B Strength Image: constraint of the strength of the								
Permissible beaking stress Sut3 Image: Stress in the	В.							
for gear tech Ib 200 Nmm2 Sur/3 I For gear tech M1 66305.96223 Nmm $(60°10^{6})^{(2)}(2°3.142°N)$ I Module step-1 19096117 $60^{9}10^{9}(5).142°N$ I I Module step-3 5987520.000 $Z1^{N}1^{N}C^{N}(hm)^{o}(h^{9}T)^{0}N^{O}N^{O}N^{O}N^{O}N^{O}N^{O}N^{O}N^{O$		-	Cv	0.375		3/(3+v)		
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Module step-3 5987520.000 $Z1*N1*Cv*(hm)*:h*V$ Image: Considering and the velocity of the velocit		Module step-1		19096117		60*10^6/3.142		
Module step-3 5987520.000 $Z1^{1}N1^{+}Cv^{+}(hm)^{+}D^{+}V$ Image: Constraint of the step of the		Module step-2		22.50		P*Cs*fs		
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		Load stress factor		1.8496				
		Wear strength for Gear	Sw	13317.12000	Ν	Sw= b*Q*dp1*K		
			Fsw	1.84698		Fsw=Sw/Peff		



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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

Module
m
5
mm
(b/m)*m

b	50	mm
а	5	mm
d	6.25	mm
t	7.854	mm
r	2	mm
dp1	90	mm
da1	100	mm
dd1	77.5	mm
Z1	18	
dp2	360	mm
da2	370	mm
dd2	347.5	mm
Z2	72	
	a d t r dp1 da1 dd1 Z1 dp2 da2 dd2	a 5 d 6.25 t 7.854 r 2 dp1 90 da1 100 dd1 77.5 Z1 18 dp2 360 da2 370 dd2 347.5

					1	1		
			E.g.					
					tb			
						mpl		
(1 /)*		.1		1		x f	or	
(b/m)*m		tt	omg -		mg tb-	-		
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0.4*m		tł	or					
		tł	odp1g					
dp1+2*a		tbda1] [
dp1-2*d		tbdd1						
		tł	oZ1g					
		tł	odp2g					
dp1+2*a		tł	oda2					
dp1-2*d		tł	odd2					
		tł	Z2g	1				

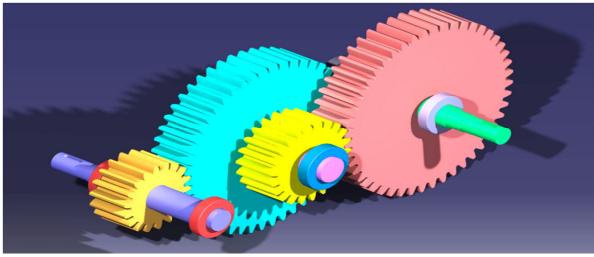


Figure 4: model for assembly of gearbox



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D	Shaft Salaation				
D.	Shaft Selection Shaft 1				
	Center Distance between Gear1 &				
	Gear2	C1	225	mm	(dp1+dp2)/2
	Center Distance between Gear3 &	01			
	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 00	-		
	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 N	Ftc* tan20
	Resultant force at C	Fac	1568.030	N	Ftc/ Cos20
	Resultant force at C	гсі	1308.030	IN	3.142/4*dp1*dp1*b* (7.85*10^(-
	Weight of Spur Gear 1	Ws1	24.499	Ν	6))*9.81
	Total Resultant Force at C	Fc	1592.528		
	Reactions at A	Ra	796.264	Ν	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		
	Distance Between Bearing and Spur	L2	160	mm	
	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	Ν	Mt/(dp2/2)
	Weight of Gear 2	Wg2	389.9790136	11	(ap2 2)
	Total force at Gear 2	FG	758.345	N	
		10	100.010	11	



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Tangential Force at Gear 3 (H) Weight of Gear 3	FtH Wg3	1473.466 24.37369	N N	Mt/(dp3/2)
Total force at Gear 3	FH	1497.840		
Taking moment at E. Force at F.	RF	1212 066004	N	(FG*LEG+
Taking moment at E, Force at F Force at E	RF RE	1312.966004 943.219	N N	(FH*(LEG+LGH)))/L2 FG+FH-RF
Porce at E	KL.	943.219	1	1,0+1,11-10,
Bending moment at G	MG	42444.85418	Nmm	RE*LEG
Bending moment at F	MH	59083.4702	Nmm	RE*LEH-FG*LGH
C				
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	
Sh - & 2				
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	Ν	Mt/(dp4/2)
Axial Force at Gear 14	Fak	134.074	Ν	Ftk* tan20
Resultant force at k	FrK	392.007	Ν	Ftk/ Cos20
Weight of Gear 4	Wg4	389.979		
Total Force at Gear 4	Fk	781.986	Ν	
Reaction at J	RJ	293.245	Ν	FK*LIK/L3
Reaction at I	RI	488.742	Ν	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	10	20.00		
Dia	d3	30.00	mm	
Bearing Selection				
for Shaft-1 Diameter at bearings		25	mm	
Selected Bearing Number		6005	11111	
Selected Dearing Pulliber		0005		

Е.



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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	Ν	Ra
Axial Load at Bearing A	Faa	0	Ν	
RADIAL LOAD RATING FOR				
BEARING	Х	1		
AXIAL LOAD RATING FOR				
BEARING	Y	1		
EQUIVALENT DYNAMIC				
BEARING LOAD	Pb	1194.396078		(XF _r +YF _a)*Ks
Desites life in Descalations	I.D.	000.00	N (° 11'	C 1
Bearing life in Revolutions	LRev	989.00	Millions	s of revolutions

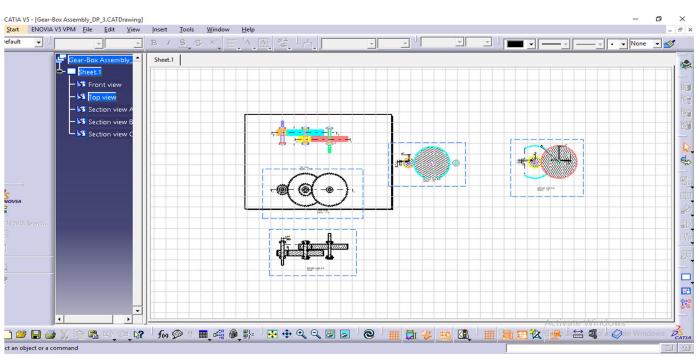


Fig 5: Drafted View of Gearbox

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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