CUSTOMIZATION OF 2-STAGE SPUR GEAR BOX USING V.B. ENVIRONMENT IN CATIA

Abhijit Biradar1,Raviraj Kadam2,Vaibhav Kole 3,Omkar Mail 4 , Prof. S.N. Hublikar 5

Department of Mechanical EngineeringATS SBGI,Miraj,Maharashtra, India,Country

1(*Student,Department of Mechanical EngineeringATS SBGI,Miraj, Maharashtra,India,Country***)**
2(*Student,Department of Mechanical Engineering ATS SBGI,Miraj, Maharashtra,India,Country***)**
3(*Student,Department of Mechanical Engineering ATS SBGI,Miraj, Maharashtra,India,Country***)**
4(*Student,Department of Mechanical Engineering ATS SBGI,Miraj, Maharashtra,India,Country***)**
5(*Professor,Department of Mechanical Engineering ATS SBGI,Miraj, Maharashtra,India,Country***)**

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

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.

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.

MATIRAL & MATHODOLOGY

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.

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 usingforms.

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)

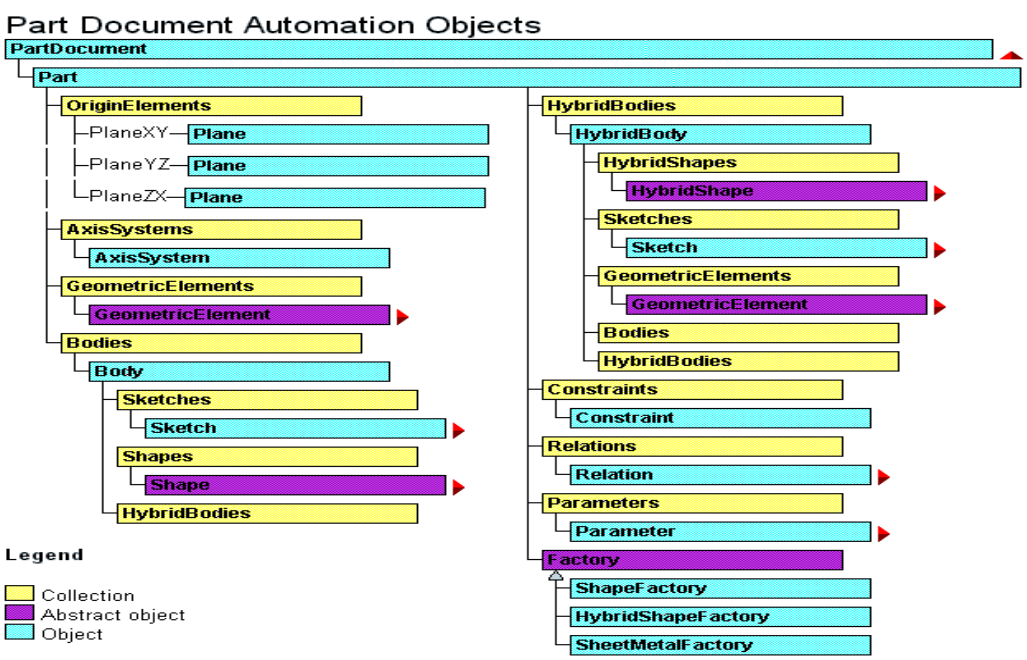

Fig 1: Part Modeling Object Tree

International Journal of Advanced Technology in Engineering and Science
Vol. No. 10, Issue No. 06, June 2022
www.ijates.com
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Methodology

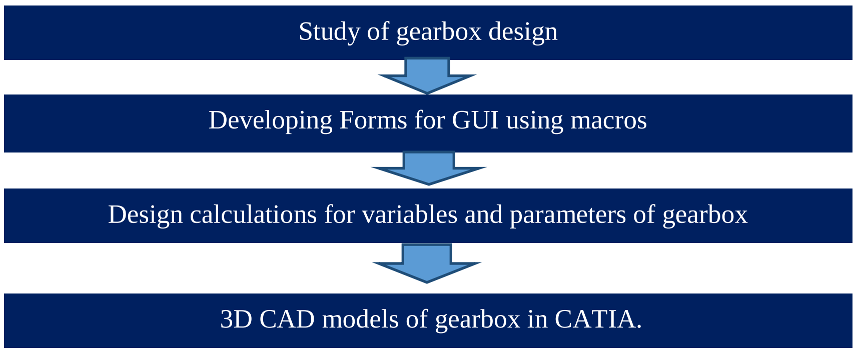

Fig 2: Methodology

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.

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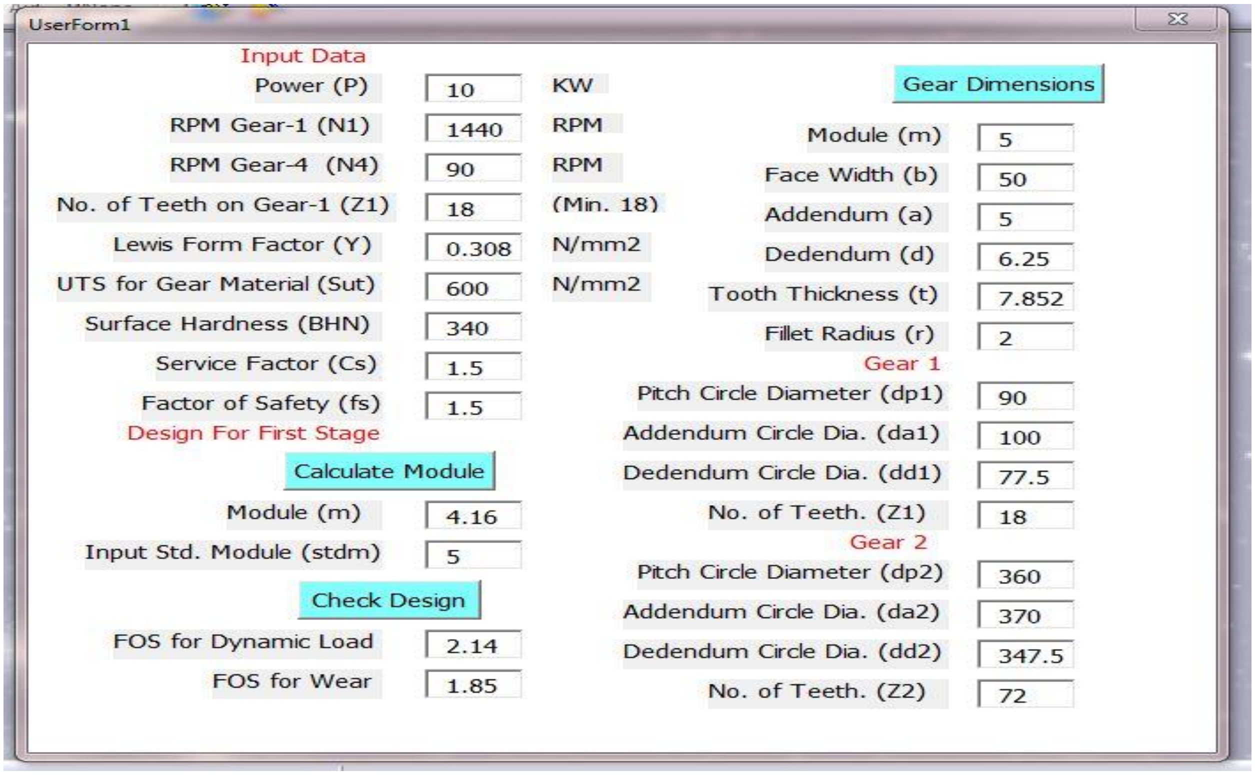

Figure 3: Developed GUI

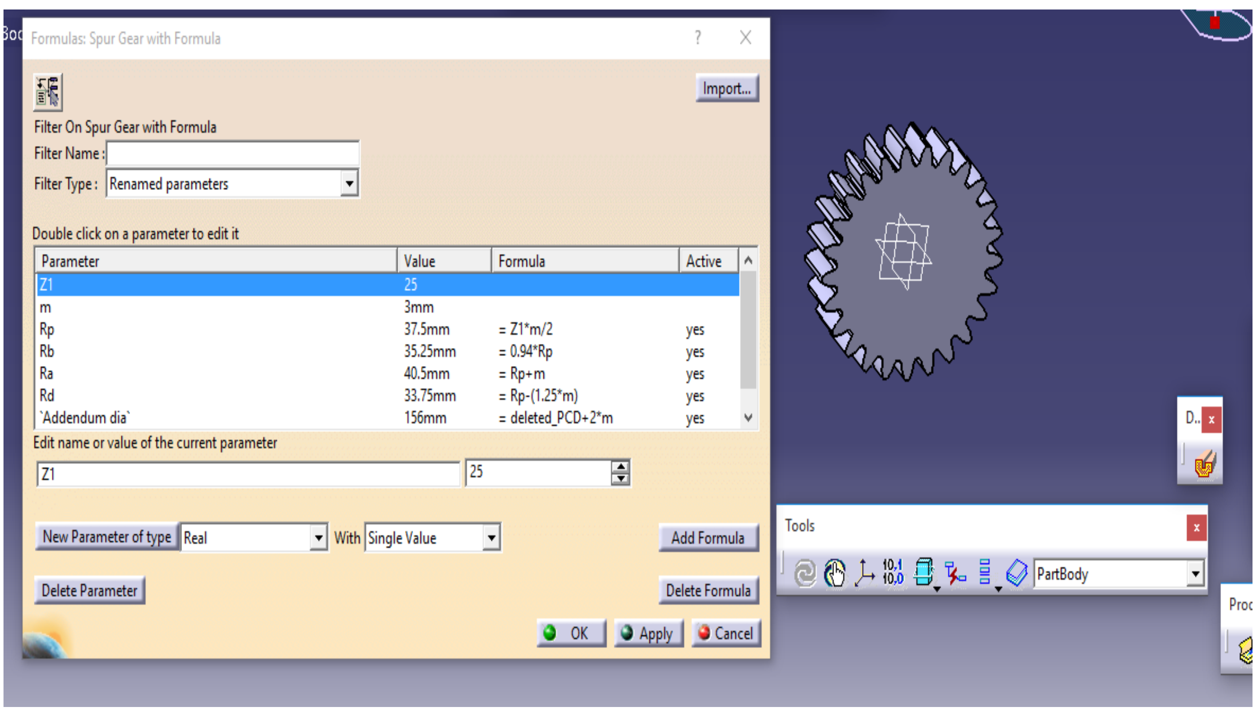

Figure 4: Spur gear with formula

Design calculations

		Notation	Value	Unit
	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	
	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			
A	**Module Based on Beam Strength**			
	Velocity Factor	Cv	0.375	
	Permissible bending stress for gear teeth	□b	200	N/mm2
	Torque transmitted by Gear 1	Mt	66305.96223	Nmm
	Module step-1		19096117	
	Module step-2		22.50	
	Module step-3		5987520.000	
	Module step-4		71.760	
	Module Based on Beam Strength	m'	4.16	
B	**Selection of Module & FOS For Beam Strength & Wear Strength**			

	Standardized Module	stdm	5	
	Pitch Circle diameter for Gear 1	dp1	90	mm
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
	Velocity Factor	Cv	0.30654	
	Effective load	Peff	7210.1987	
	Beam Strength	Sb	15400.000	N
	FOS Considering Dynamic load	Fsb	2.1359	
B2	**FOS For Wear or Pitting Failure**			
	Total transmission ratio	i	16	
	Speed reduction at each stage	i1	4.000	
		Z2'	72.000	
	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	
	Load stress factor	K	1.8496	
	Wear strength for Gear	Sw	13317.12000	N
	FOS for wear load	Fsw	1.84698	

IF Fsw is less than 1, Message Box Increase Module

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

Gear Dimensions

Module	m	5	mm
Face Width	b	50	mm
Addendum	a	5	mm

Dedendum	d	6.25	mm
Tooth Thickness	t	7.854	mm
Fillet radius	r	2	mm
Gear 1			
Pitch Circle diameter	dp1	90	mm
Addendum Circle diameter	da1	100	mm
Dedendum Circle Diameter	dd1	77.5	mm
Number of teeth	Z1	18	
Gear 2			
Pitch Circle diameter	dp2	360	mm
Addendum Circle diameter	da2	370	mm
Dedendum Circle Diameter	dd2	347.5	mm
Number of teeth	Z2	72	

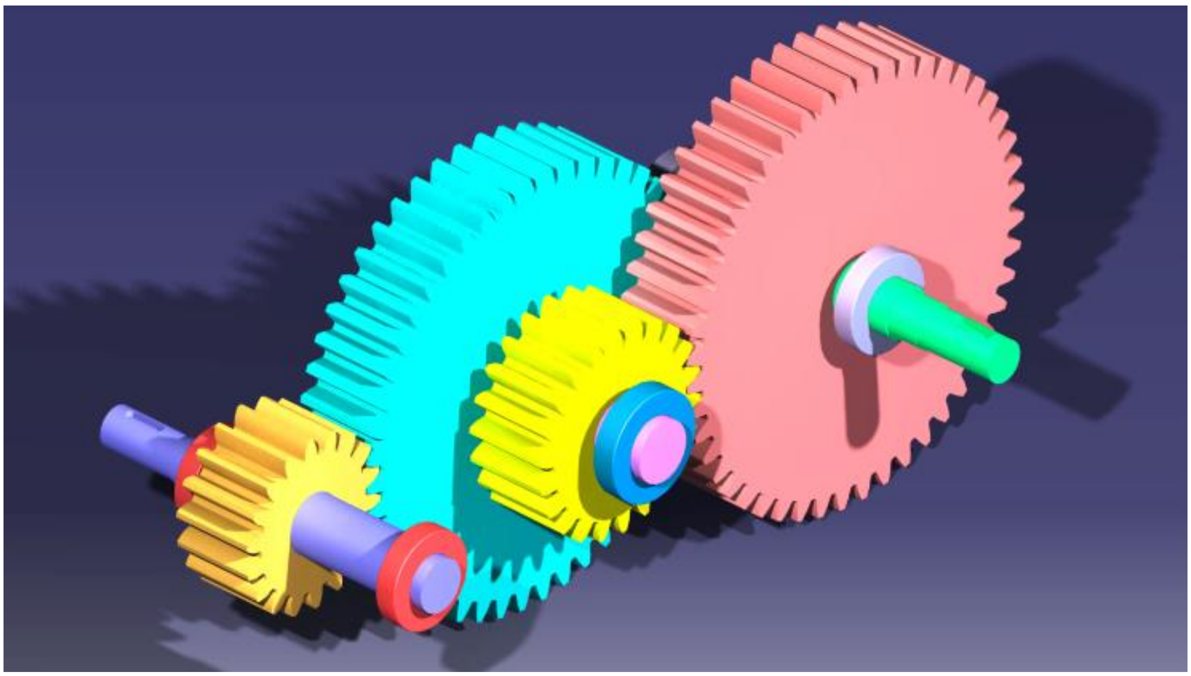

Figure 5: model for assembly of gearbox

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	

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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		
	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	

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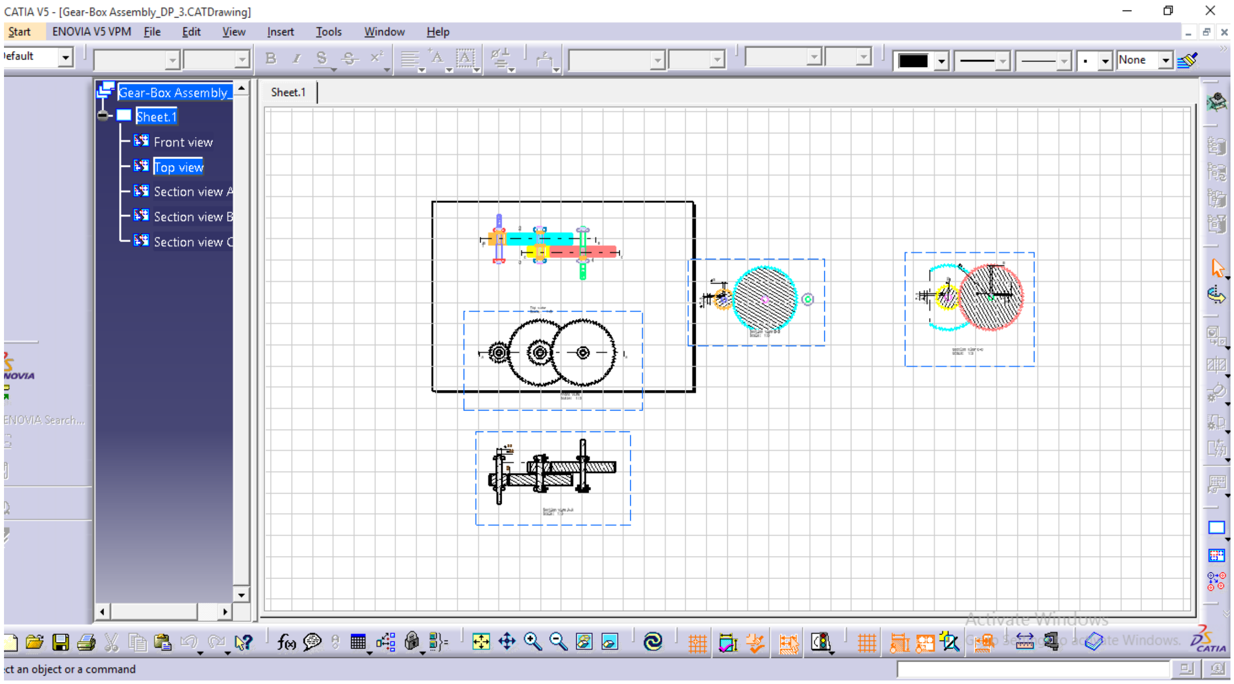

Fig 6: Drafted View of Gearbox

RESULT

Time estimation of reduced product design timeThis project's major goal is to reduce product design and modelling time for existingproduct requirements by using the same parametric features of components for varied pecifications. The time spent on product design and modelling accounts for 60-70percent of total project time. Because we use parametric modelling, we can cut down on design and modelling time. When we compare the time required withcustomization to the time required without customization, we can see that the timerequired is substantially reduced, from approximately 26 hours to 4 minutes, as shown

	Time Estimate for Calculations and Model without Customization	
Sr.No.	**Particular**	**Time in Minute /Hrs**
	Gear 1 Module Calcualtion	30 min
	FOS For Considering Dynamic load	15
	FOS For Wear or Pitting Failure	15
1	**Gear Dimensions for Gear 1**	15
2	**Total Calculation time for 4Gears**	5 Hrs (75 mins. for each)
3	**Total time for shaft 1,2,3 calculations**	6 Hrs (120 mins.for each)
4	**Total time for bearing calculation 1,2,3**	5 Hrs (75 mins.for each)
	Total Calculation time	5+6+5 = 16 Hrs
1	**Total Modeling time for 4 gears**	3 Hrs (45 mins.for each)
2	**Total Modeling time for 3 Shaft**	1 Hrs (20 mins.for each)
3	**Total Modeling time for 3 bearings,4 spacers,3 Keyways**	3 Hrs (18 mins.for each)
4	**Assembly time for gear box**	3 Hrs
	Total Modeling time	3+1+3+3= 10 Hrs
	Total Calculation and Modeling time	16+10 = 26 Hrs
	Time estimate with Customization	
1	**Time Required for user form feeding input**	2 mins
2	**Time Required for export data and assembly update**	2 mins.
	Total time	4 mins.

Fig 7 . Time Estimating chart.

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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