

## Generation & Validation of Parametric Model using CAD assisted Techniques

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**Abstract :** In today's global market, introducing new product quickly and cost effectively is a major competitive advantage. With rapid advancement in automation technology increase in efficient design and manufacturing process is necessary. Manufacturers around the world are adopting automated machinery by replacing the traditional manually operated machinery. Almost every component has hundreds of different types and configurations which need to be produced at large quantity. Hence the use of 'traditional design methods' seems inefficient due to lot of manual work and product development time which ultimately increases cost. Therefore, a new system known as 'Parametric Design System' was introduced to meet the increasing demand by carrying computer assisted parametric design. The ability of system to parametrically change Part drawing, Part Design, Assembly, Geometrical and Dimensional parameters in a programmable environment gained popularity in Design Industry. Parametric design systems utilize Feature Based Modelling and Knowledge Based Modelling which provides a wide range of design options for various components according to the required application.

**Keywords:** Parametric Design, Feature Based Modelling, Knowledge Based Modelling

### I. Introduction

The term parametric describes any quantity or value of any shape which expressed in terms of different parameters having certain relation. In simple words, parametric equations are relations which are expressed using different parameters such that the value of the equation can be changed by merely varying a single parameter. Hence in parametric modeling, designers can change entire object by varying only one of its parameters. An important feature of parametric modeling is that whole part or assembly will be updated when designer changes any one parameter since parameters are interlinked with each other. Parametric design system eliminates tedious tasks and iterations involved in traditional design. Hence parametric design system is recognized as an efficient method for time saving. In Product Development, Design process requires maximum amount of time. Hence there is wide range of opportunity in saving time as well as cost in Design process by implementing systematic and accurate methods. Parametric modeling technology has been adopted in mainstream by modern computer-aided design (CAD) and computer-aided manufacturing (CAM) or computer-aided engineering (CAE) systems such as Pro/Engineer (Pro/E), Catia, Solidworks, NX CAD. Numerous studies have been conducted on parametric design systems in order to mitigate time and cost. Necdet Geren [1] designed a parametric platform which uses predefined master model for modeling different types of ball joints in CAD software. Hence repetitive designs of various attributes can be made using a single master model assembly. Shivraj Guru [2] created a user interface using CREO software which enabled generation of gears with different module and number of teeth resulting in reduced production time. Umesh A. Bedse [3] designed a graphical user interface (GUI) by integrating programming software with CREO saving up to 95% of the time compared to the time taken by conventional modeling. This integration reduces repetitive task of engineers providing them with more time for improvement. Akshay Kumar V Kadam [4] developed a user interface in excel integrating it with CAD software which save time and utilizes innovative minds. In developing new products such customization in parametric CAD software has wide applications in industries as well as research field. N. K. Chougule [5] developed a modular approach by integrating MS-EXCEL with CREO which is more beneficial than iterative process along with more complex relationships between various parameters of model. Along with easy understanding and implementation the designing time for desired operation is reduced to a greater extent and subsequently reduces designing cost. Luigi Barazzetti [6] presented a method for generating parametric models from dense point clouds which can reveal the original shape of object. Rivka Oxman[7] presented a research which explores knowledge based modeling by using computational architectural knowledge in accordance with parametric design. Thus, parametric design is recognized as a tool of design thinking. Xun Zhang [8] presented a paper which aims to build the human body model with different sizes of waist using parametric modeling technology. Design and implantation of a feature based parametric model of a human body is done by using OpenGL, VC++, and other techniques. Zhi Quan Chang [9] proposed a systematic method to create realistic body shapes using parametric modeling. This is favorable approach for generation of

complete body despite of incomplete scanned data. Yannick Bodein [10] proposed a method for modeling parts based on functional data which can be used for design of complete parts for any machine. Frederic Demoly [11] proposed method for knowledge based parametric models which can be automatically creating different configurations human hand regardless of structure of the bone. The proposed BioCAD approach has been implemented in Knowledge Based Engineering (KBE) application which is able to model human hand of different configurations. Baishali Goswami [12] proposed a survey paper which reviews work carried out in the field of 3D construction of bi-planner X-RAY images. Some methods of 3D reconstruction only require X-RAY images as inputs. Baradeswaran A. [13] proposed an article which discusses reconstruction of images into 3D models using CAD techniques. The paper aims to outline the importance of the proposed methodology which paves the way for doctors and surgeons for accurate, confident & successful surgery in short time.

## II. Methodology

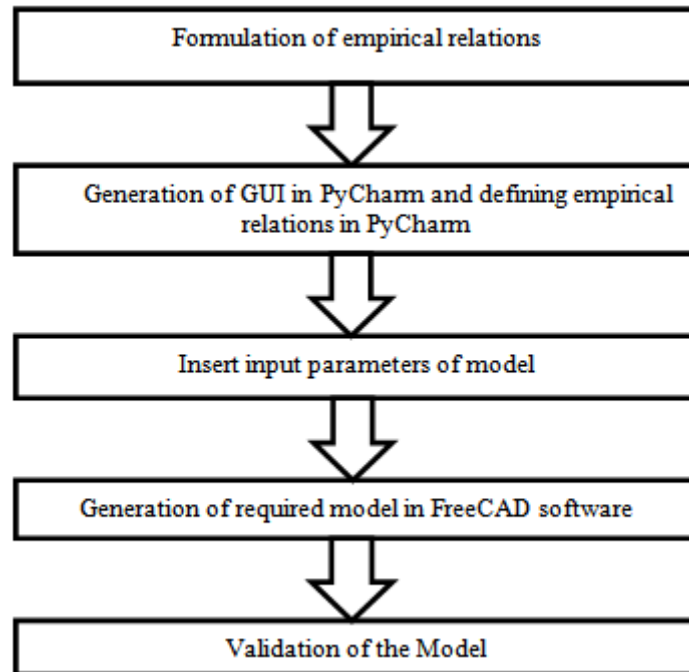


Fig.1 Flow Chart

**STEP 1:** Formulations of Empirical Relations for Required Model - This step deals with formulation of empirical relations for mechanical joints (knuckle joint & cotter joint) in accordance to standard dimensions. K. Madhavan & K. Balveera Reddy [14] have stated the requisite empirical relations. It is very important to note that all the relations established are in terms of diameter of shaft (rod).

**STEP 2:** Generation of GUI and Defining Empirical Relations in PyCharm IDE - Python programming language is used in order to create a GUI. Standard empirical relations are already defined in the program. The generated GUI consists of all the necessary parameters in tabular form.

**STEP 3:** Inserting Input Parameters in GUI - Input parameters are inserted in the GUI. In this case diameter of shaft is input parameter. The GUI will display the values of remaining parameters of the component.

**STEP 4:** Generation of Parametric Model in FreeCAD - The macro of the component is linked with GUI. These automatic generated dimensions shown in the GUI will be inserted in place of the old dimensions present in the macro. After clicking on submit the GUI will accept all the values and make necessary changes in the macro of the component. FreeCAD software will be triggered and joint of required dimension will be created and shown in the FreeCAD software. It is very important to note that this macro is to be saved every time new values are inserted. Execution of this macro will generate the model into Part Design workbench.

**STEP 5:** Validation of the Model - Validation of the model is done by comparing the traditional design of the joint with the parametric design.

### III. Case Study

Proposed study will discuss parametric approach for the design of Cotter joint. Cotter joint is one of the most widely used mechanical joint which connects two rigidly coaxial rods subjected to axial, tensile or compressive forces. A cotter pin is a flat wedge-shaped rectangular cross-section having tapered width which facilitates easy adjustments. The taper may be from one side or both sides depending upon the application. The cotter joint assembly consists of 3 main components: - spigot, socket and cotter pin.

#### Applications: -

1. In cross head of steam engine.
2. Between side spindle and the fork of wall mechanism.
3. Joint between the piston rod and the tail and pump rod.
4. Foundation bolt.
5. Joining of tail rod with piston rod of a wet air pump
6. Connecting two halves of fly wheel (cotter and dowel arrangement)

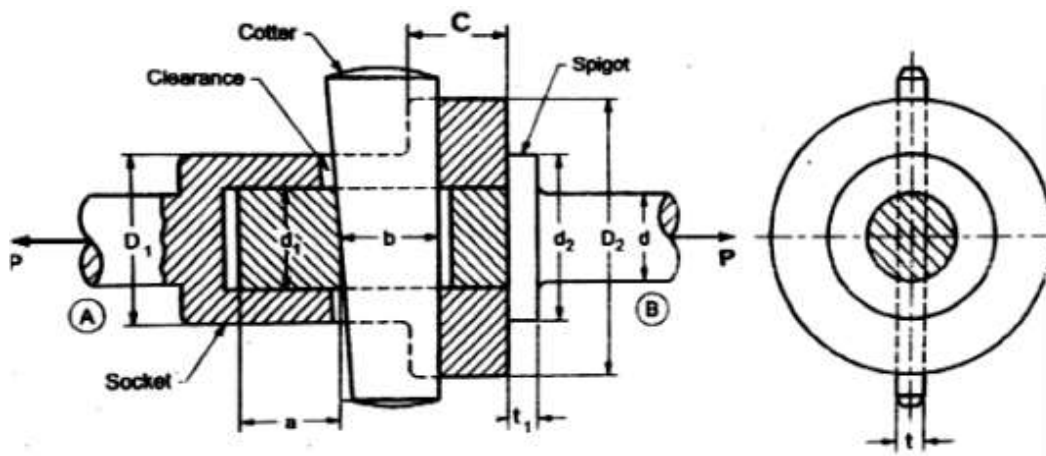


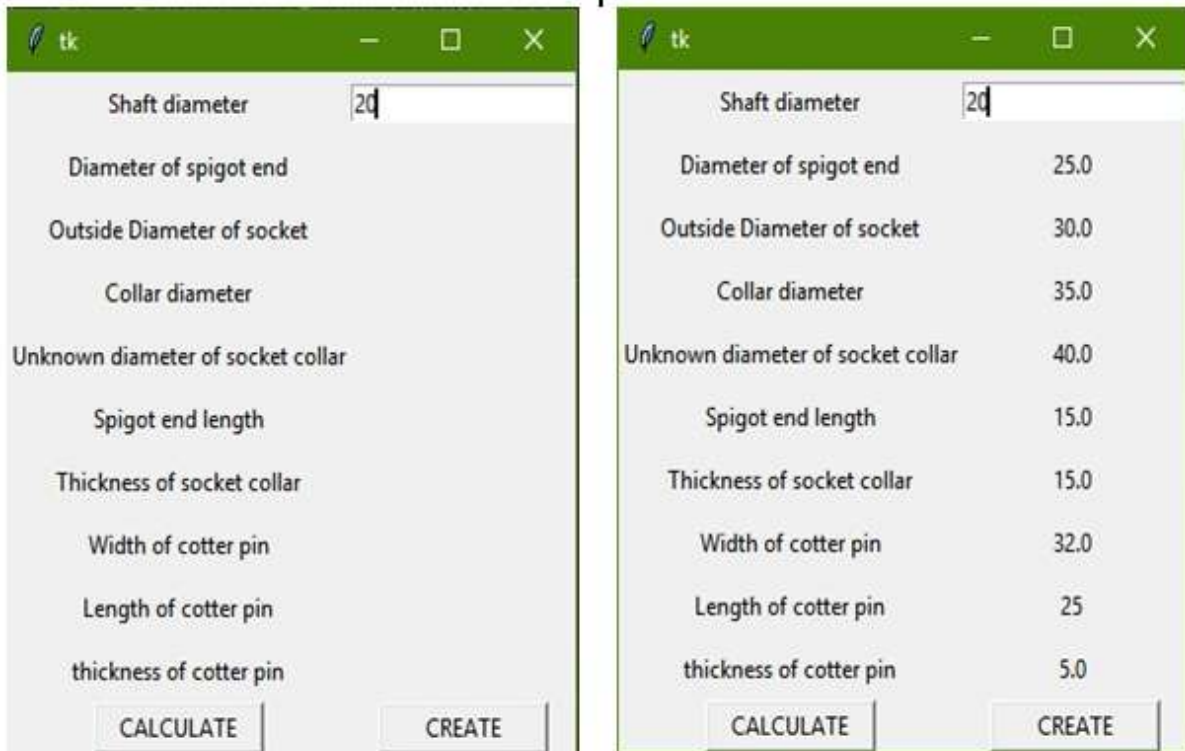
Fig 2 Cotter Joint

Table 1: Nomenclature and Empirical Relations

Design Parameter	Nomenclature	Empirical Relations
Diameter of rod (shaft)	d	d
Diameter of Spigot end	d2	d1=1.25d
Diameter of Spigot collar	d3	d2=1.50d
Diameter of Socket end	d1	D1=1.75d
Diameter of Socket collar	d4	D2=2d
Spigot end length	l1	l1=0.75d
Thickness of socket collar	c	c=0.75d
Width of cotter pin	b	b=1.6d
Length of cotter pin	l	l
Taper of the cotter pin	slope (1:25)	slope (1:25)
Distance from end of slot to spigot end	a	a=0.75d
Thickness of cotter pin	t	t=0.25d

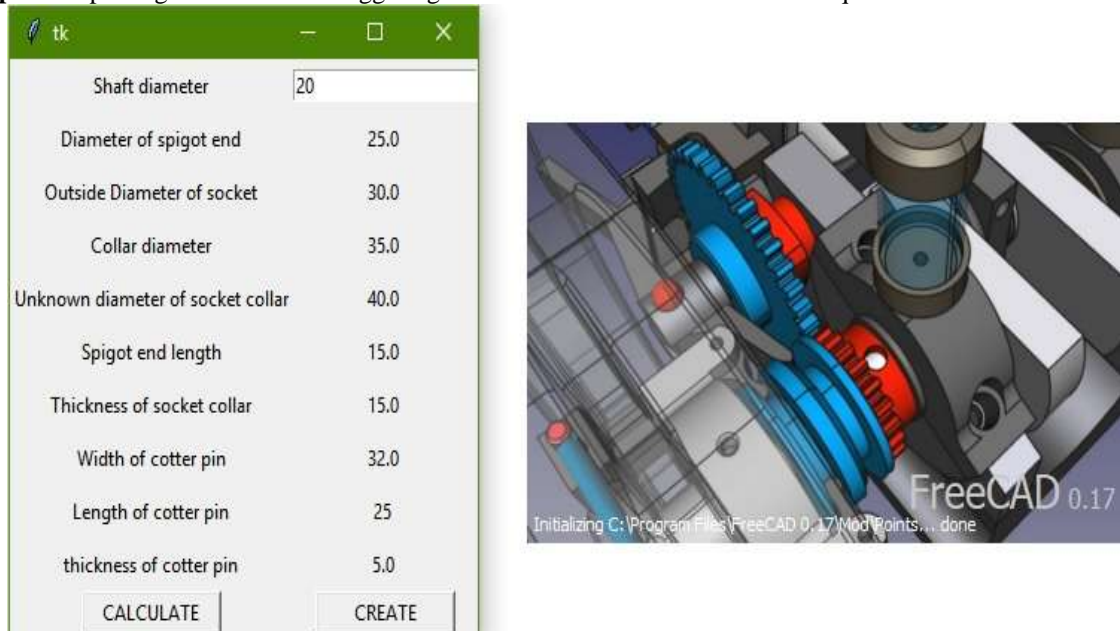
In this study, diameter of shaft is considered to be 20 mm for cotter joint. The traditional design of cotter joint includes calculation of dimensions of various parameters for safe design. Accordingly, empirical relations are formulated so that parametric relations can be established. It is very important to note that the parametric relations established are in terms of diameter of shaft. The program to model the cotter joint is written in Macro Editor of FreeCAD software which will include stepwise procedure of modeling. All the required workbenches and required tools need to be defined systematically in the macro editor. A GUI is to be created for simplifying the process of calculation of different parameters of cotter joint. The GUI is created in PyCharm IDE which will automatically generate values of required parameters through prevalent empirical relations defined in the code. Once the shaft diameter is entered in the GUI, all the other required parameters are generated. On clicking the create button for required model the dimensions of the concerned model with old values will get replaced with new values in the macro. On execution of macro, the model will be generated in the respective workbench of FreeCAD. If any individual needs to change any dimension, he/she can do it by changing the dimension in Macro editor of FreeCAD and executing it again.

**Step1** - Inserting the values of Shaft diameter and calculating the required values



**Fig. 3** Graphical user interface of cotter joint in PyCharm software

**Step 2** – Replacing old values and triggering FreeCAD to show the model with required dimensions



**Fig 4** Execution of Graphical user interface and triggering FreeCAD

**Step 3-** Showing assembly in FreeCAD

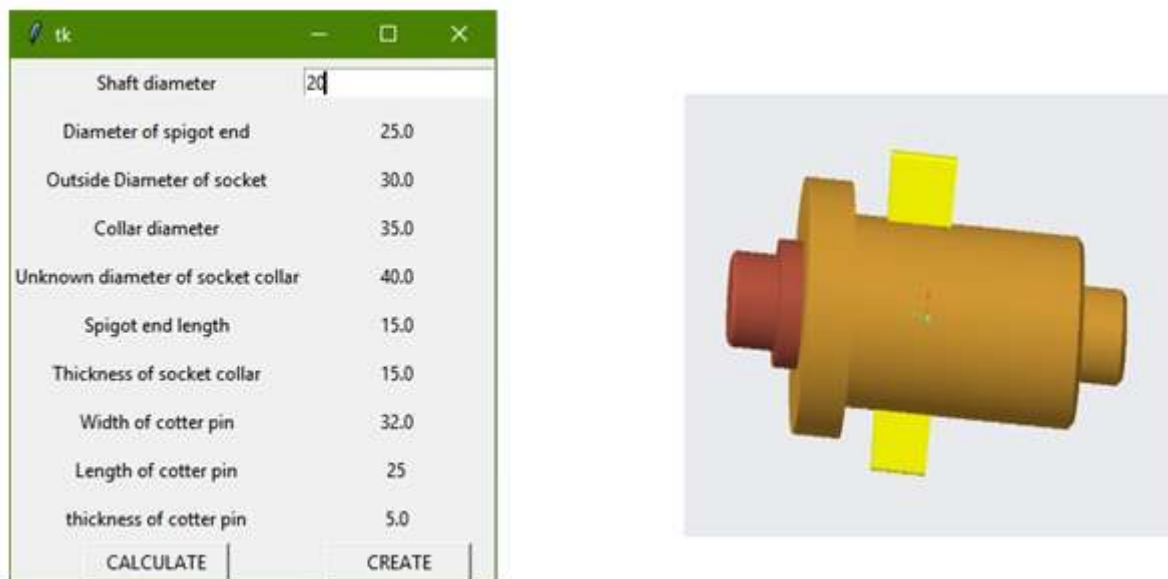


Fig 5 Generation of Cotter joint assembly in FreeCAD

#### IV. Conclusion

Design comprises of about 70% of the total production time thereby has wide scope for time reduction. Parametric system is capable of designing mechanical components with varying parameters & configurations in less time. GUI can be created in PyCharm using various programming languages such as Java, VB.net, Python, C#. In proposed study design and modeling of cotter joint was done by interfacing FreeCAD with PyCharm IDE using Python programming language. It is seen that cotter joint of varying dimensions can be modeled accurately by establishing empirical relations with less production time. Results show that one can save considerable amount of time by undertaking such modular approach over traditional design system. This reduces the tedious repetitive tasks & the time is also saved. Finite element analysis of cotter joint can also be done in FreeCAD (using analysis workbenches) or any other analysis software. Implementation of such approach reduces the necessity for an individual to become familiar with the software. Also, such system is highly suitable in industrial applications for designing family of parts with different shapes and configurations. Hence such approach for automation of design based on parametric systems interfaced with external programming software is simple and has wide scope in various applications

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**Conflict of interest** The authors declare that there is no conflict of interests regarding the publication of this paper.

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