AN ASSIGNMENT REPORT ON

FUNCTIONAL GAUGE DESIGN

Submitted by

MRITYUNJAYA AADITYAA R S

(17IMUH007)

IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS OF THE PROGRAMME

DESIGN FOR MANUFACTURE AND ASSEMBLY

April 2020

PSG INSTITUTE OF ADVANCED STUDIES

COIMBATORE -4

i. ABSTRACT

This report contains detailed method about finding the tolerance zone of a part and designing functional gauge for that tolerance zone as per dimensions based on GD&T method. The product chosen here is centerplate bolt pattern lug nut hole from a tyre, for which the functional gauge is designed as per TPT principles. The 2-D and 3-D drawings are designed from the dimensions found and then dimensioning is done as per GD&T method. The report contains steps to design a functional gauge, functional gauge 2-D drawing, 3-D drawing and assembly of gauge with the part. This will clearly tell how the gauge will look in real life. After designing the gauge, appropriate material for the gauge is selected. Thus, created a functional gauge for the component.

ii. TABLE OF CONTENTS

iii. LIST OF ILLUSTRATIONS

1. INTRODUCTION

DFMA is a vast field of subject which combines two methodologies that is Design for Manufacturing (DFM) and Design for Assembly (DFA), From these concepts, one the concept is True Position Tolerance (TPT) which is part of Geometrical, Dimensioning and Tolerancing method. These concepts are used in order to produce prefect component in a manufacturing industry without an error. Using these concepts, when represented in drawing sheet the staffs who are responsible for the manufacturing section will clearly understand about the component given to them. GD&T are represented in symbols and each symbol has its own uniqueness. The TPT helps to eliminate the bad parts and it also eliminates borderline good parts. A Functional gauge is specially made for a component that can be used as many times until it wears for checking the component. In order to design a functional gauge, the true position tolerance which is a part of GD&T is used to find the tolerance zone at MMC. Based on the tolerance zone the functional gauge dimension is found. This method will help to improve the productivity of the manufacturing industry and will help to give an efficient product from the industry.

2. FUNCTIONAL GAUGE

Functional gauges are used to find the geometrical tolerance of a component when its geometrical tolerance is mentioned in maximum material condition (MMC). It is a specialized gauge which is designed only for a single component and cannot be used for any other component, this makes it unique from other gauges. This consumes less time for checking the component and more productive, but this cannot be used for checking parts of a job shop type as it makes an expensive functional gauge, for that type of parts, paper layout gauging is used.

ADVANTAGES:

- It is an alternative method for surface plate, co-ordinate measuring etc.
- Minimum time for checking a component and the process can be repeated for a greater number of times.
- No highly skilled labor is required.
- These gauges will never accept a bad part.

DISADVANTAGES:

- It rejects the borderline good components.
- It requires maintenance, storage area.
- Most importantly, if the part is revised then the functional gauge should be reworked.

3. GEOMETRIC, DIMENSIONING AND TOLERANCE (GD&T)

GD&T in engineering drawing is a way of communication to understand a part's tolerance and how precise and accurate a part should be machined by a machine by representing as symbols in the drawing sheet. These are provided in the feature control frame using reference datum.

One of the GD&T method used here is True Positioning Tolerance (TPT) ⌖, which is used in drawing in order to give a tolerance zone for a specific feature (a hole or a shaft). This method makes sure that the production will be economical and effective in industries. It also provides constant integration and interpretation of a design, in inspection for a part. It helps the machine staff to know what he must do clearly by representing each feature in their respective symbols such as perpendicularity, symmetrical, parallel symbols, TPT etc.

4. TRUE POSITION TOLERANCE(TPT)

SYMBOL - ⌖

This True Position Tolerance is shown in a feature control frame for a feature intimating a zone tolerance, the material condition and a reference datum for that characteristic. It is used to describe about the exact center location of the feature with relation to the reference datum.

A TPT feature can be identified by a circle which is represented as a zone of tolerance for that feature. There are some important points to be noted before applying TPT to any component. They are,

- The tolerance hole should not be taken from the tolerance of co-ordinates, instead they are represented in a hole size dimension and in a control feature frame.
- The basic co-ordinate values are boxed.

TPT helps the functional gauge to give a tolerance within which area it is allowed, then the component is accepted and in TPT, tilt is allowed which is benefit of this characteristic.

For a functional gauge, TPT helps in providing a space of bonus tolerance which helps in the case of LMC (Least Material Condition). There are different types of assembly process such as Floating Fastener assembly, Fixed fastener assembly, these all have specific formulas in order to find the zone tolerance of a feature. Generally, Worst case conditions are used to find tolerances, considering, such as

- Features are at MMC.
- Tilt of feature is in opposite direction.

Here, when it is to find for a hole, the shaft size is taken as such (M14= Ø 14 mm), whereas for the hole, the MMC condition is taken. Above specifications are used to find the diametrical play (D_p). A diametrical play is used to find the diametrical clearance, when the inner diameter moves to the extreme ends of the outer diameters.

$$\mathbf{D_p = MMC\ of\ hole - MMC\ of\ shaft}$$

For floating fastener, the formula for finding tolerance is,

$$\mathbf{T_1 + T_2 \leq 2 \times D_p}$$

When working clearance (w_c) is given,

$$\mathbf{T_1 + T_2 + \boldsymbol{w_c} \leq 2 \times D_p}$$

Where, T_1 = True Position Tolerance of plate 1;

T_2 = True Position Tolerance of plate 2

w_c = working clearance

True Position Tolerance for floating fastener assembly,

$$\mathbf{T = H - F}$$

For fixed fastener, the formula for finding tolerance of plate is,

$$\mathbf{T_1 + T_2 \leq D_p}$$

When working clearance (w_c) is given,

$$\mathbf{T_1 + T_2 + \boldsymbol{w_c} \leq D_p}$$

True Position Tolerance for fixed fastener assembly,

$$\mathbf{T = \frac{H - F}{2}}$$

Where,

H-Diameter of hole at MMC

F-Diameter of shaft at MMC

To calculate functional gauge pin, the formula is,

Functional Gauge (Pin size) = Hole Ø at MMC – TPT of hole at MMC

Advantage of true position tolerance is, the tilt can be found,

Maximum tilt = LMC of Hole – Pin gauge Diameter

5. PROCEDURES TO DESIGN A FUNCTIONAL GAUGE

1. Select a component from a product.
2. Measure the required dimensions in that part.
3. Check for fixed or floating fastener in the component
4. Calculate the MMC and LMC of hole and shaft is considered as standard.
5. Find the Diametrical play(D_p).
6. Find the TPT.
7. Find the pin gauge diameter.
8. Find the maximum tilt.
9. Design the 2-D model of the pin gauge with dimensions based on GD&T.
10. Design the 3-D model.

6. EXPERIMENTAL WORK

TO DESIGN A FUNCTIONAL GAUGE INTO A 2-D AND 3-D MODEL FOR A SELECTED COMPONENT

My objective is to design a functional for a selected component from a product and to make a 2-D and 3-D model of it using the suitable software's.

All Diagrams are made from PAINT software.

DESIGN OF FUNCTIONAL GAUGE:

The numbering is based on the steps,

STEP 1: To select a component from a product.

PRODUCT: CAR TYRE

PART: CENTRE PLATE OF RIM(TYRE)

DESIGNED FUNCTIONAL GAUGE FOR: CENTERPLATE BOLT PATTERN LUG NUT HOLES

Fig.1. tyre

Fig.2. Centre plate- Bolt pattern lug nuts hole

STEP 2: MEASURE THE REQUIRED DIMENSIONS:

Lug nut hole size: M14

Shaft size: M12

Final finishing process done for the holes: Internal grinding.

Tolerance based on the hole size and fine grinding operation (IT-6), based on this the tolerance values are,

Hole – Ø 14.00-14.011mm

All these above values are taken from design data book.

STEP 3: To check for fixed or floating fasteners in the part:

The part has fixed fasteners, so using the formula of fixed fasteners.

STEP 4: To calculate the MMC and LMC:

MMC of hole = Ø 14.00mm

LMC of hole = Ø 14.011mm

Shaft taking it as standard size, M12 = Ø 12mm

STEP 5: To find the Diametrical play (D_p):

for fixed fasteners, the formula for the diametrical play is,

$$\mathrm{D_p} = \text{MMC of hole} - \text{MMC of shaft}$$

$$= 14 - 12$$

$$\mathbf{D_p = 2mm}$$

TPT for fixed fastener assembly,

$$\mathrm{T} = \frac{\mathrm{H} - \mathrm{F}}{2}$$

$$T = \frac{14 - 12}{2}$$

$$\mathbf{T = 1mm}$$

CASES:

CASE 1:

$$\mathrm{T_1} = 0; T_2 = 0$$

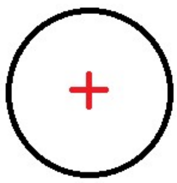

Fig.3. Case 1

CASE 2:

$$T_1 = 0; T_2 = \frac{T}{2} = \frac{2}{2} = 1\text{mm}$$

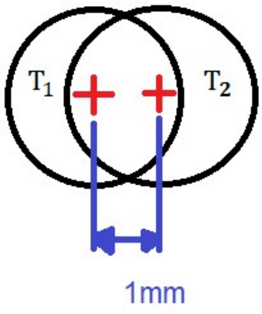

Fig.4. Case 2

T_2 moves towards right.

CASE 3:

$$T_1 = \frac{T}{2} = 1\text{mm}; T_2 = \frac{T}{2} = \frac{2}{2} = 1\text{mm}$$

T_1 and T_2 moves 0.5 mm from its center in opposite direction (the worst case).

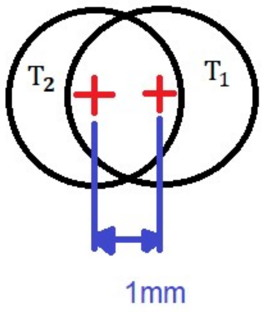

Fig.5. Case 3

STEP 6: To find the TPT of T_1 and T_2:

For fixed fastener, the formula for finding tolerance of plate is,

$$T_1 + T_2 \leq D_p$$

When working clearance (w_c) is given,

$$T_1 + T_2 + w_c \leq D_p$$

w_c is taken as 0.03mm,

$$1\text{mm} + T_2 + 0.03 \leq 2\text{mm}$$

$$\textbf{When, } \mathbf{T_1 = 1mm; T_2 = 0.97mm}$$

$$\mathbf{T_1 = 0.97mm; T_2 = 1mm}$$

So, the plate 1 ($T_1 = 1$mm)is my center plate and going to design a functional gauge based on the tolerance zone found.

STEP 7: Find the pin gauge diameter:

Functional Gauge (Pin size) = Hole Ø at MMC – TPT of hole at MMC

= 14 – 1

Functional Gauge (Pin size) = Ø 13mm.

STEP 8: Find the maximum tilt:

Maximum tilt gap = LMC of hole – pin gauge size (Diameter)

= 14.011 – 1

Maximum tilt gap= 1.011mm

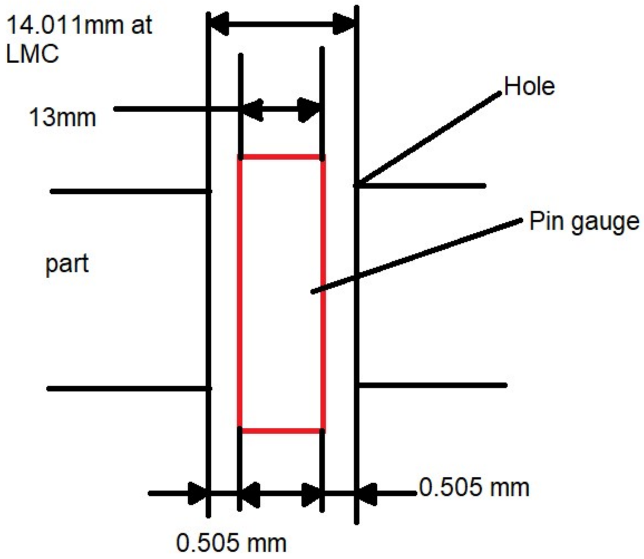

Fig.6. Pin gauge and tilt gap

STEP 9: To design the 2-D model of the pin gauge (Functional gauge) with dimensions based on GD&T:

Software Used: AutoCAD (2019)

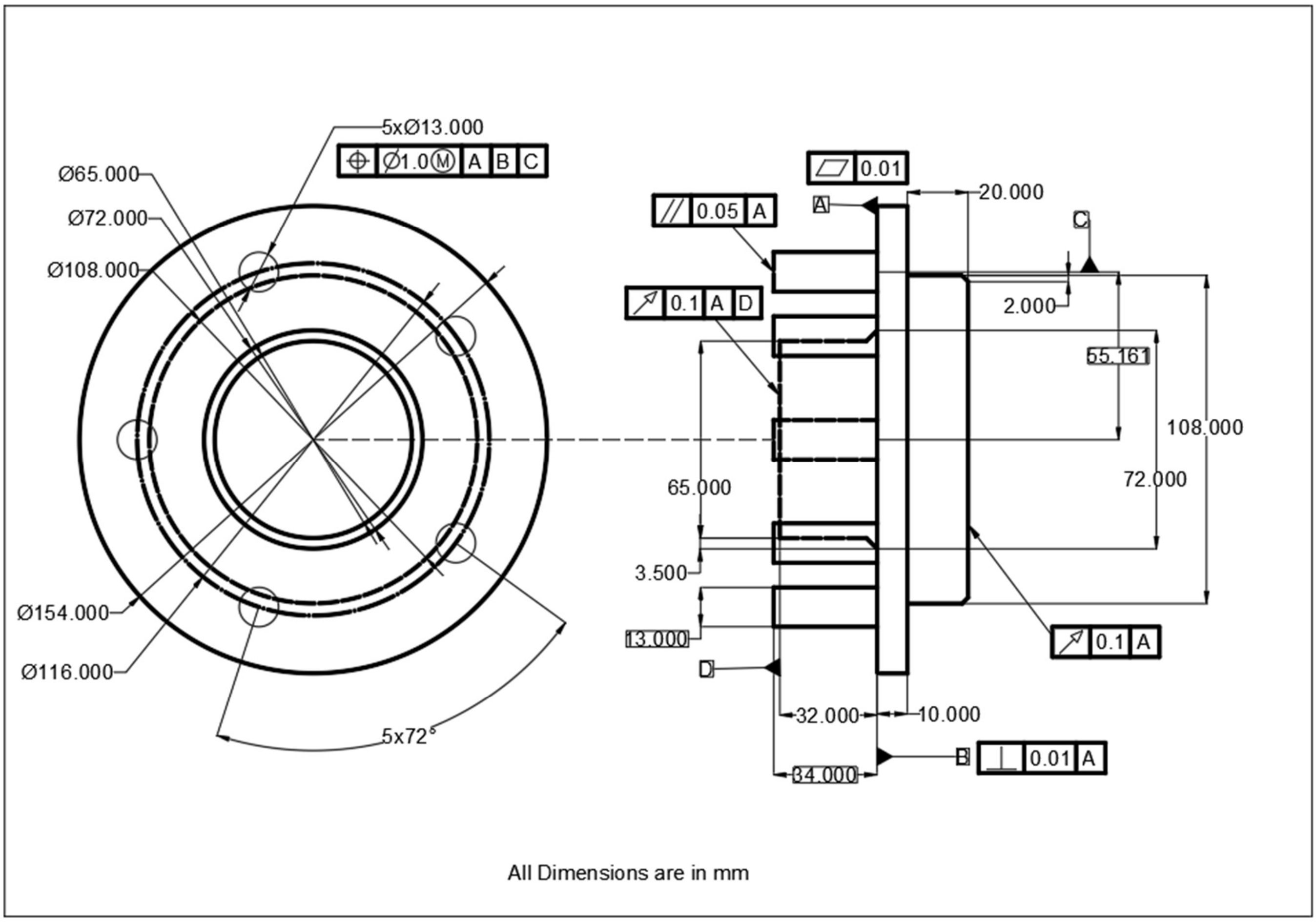

Fig.7. Functional gauge for the centerplate bolt pattern lug nuts holes, Dimensions as per GD&T

STEP 10: To design the 3-D model:

Software used: Creo Parametric 5.0

Rusted Red - center plate- Bolt Pattern Lug Nuts

Pale Green – Functional Gauge

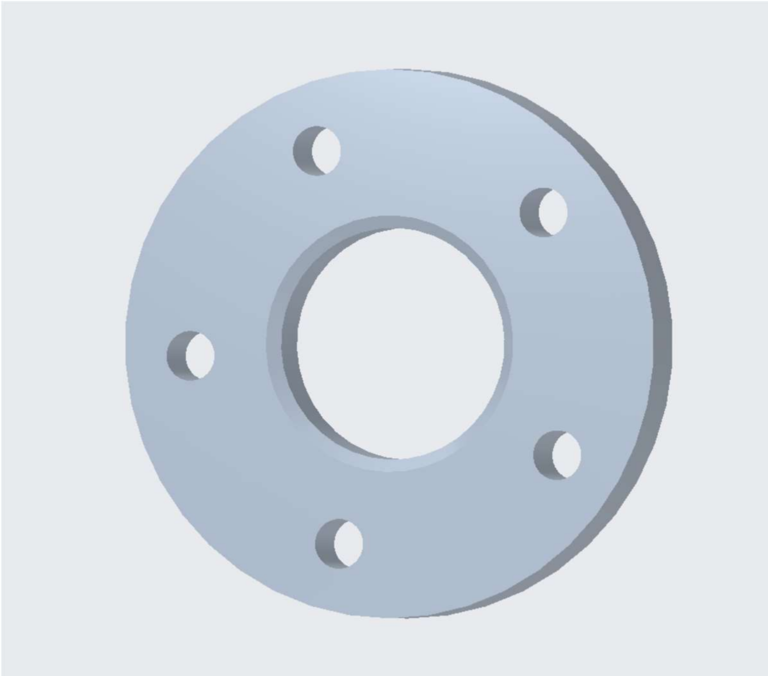

Fig.8. Centerplate bolt pattern lug nut holes

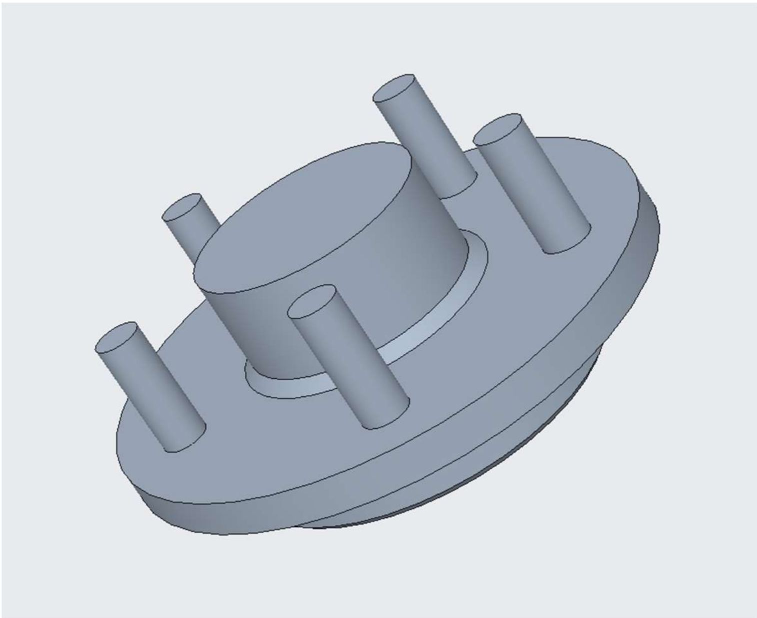

Fig.9. Functional Gauge

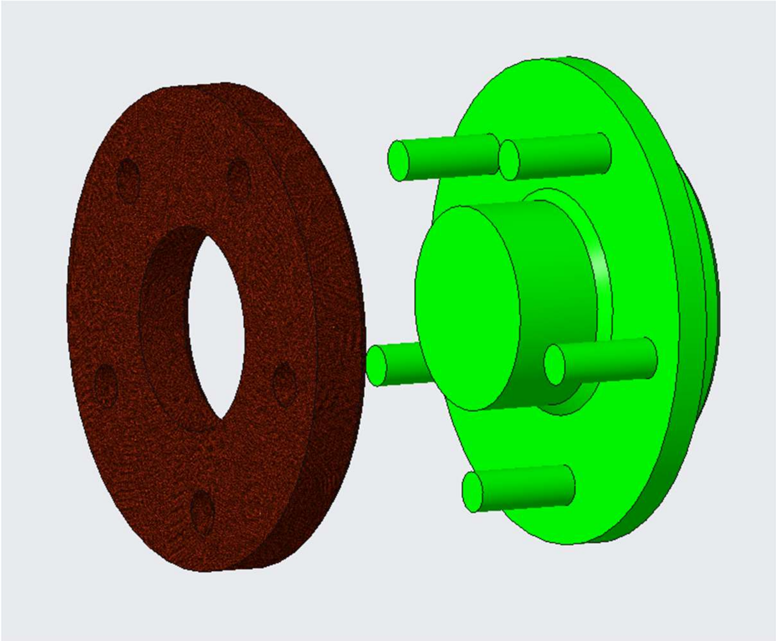

Fig.10 Exploded view of assembly

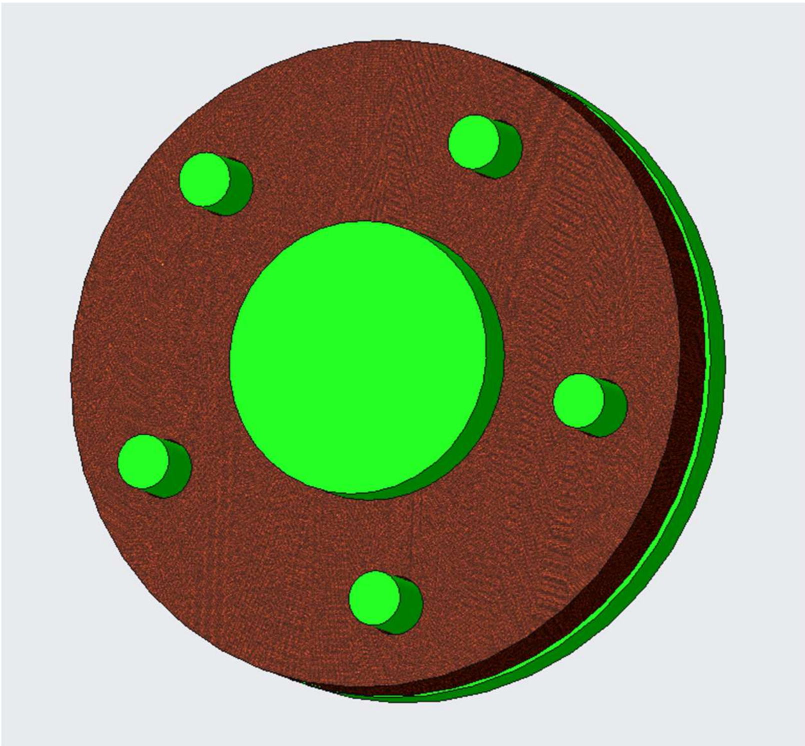

Fig.11. Assembled gauge and plate

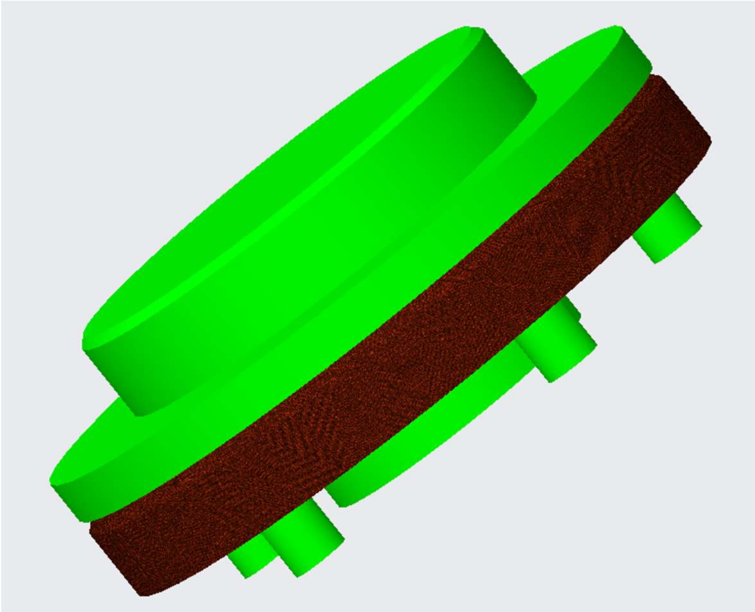

Fig.12. Assembled gauge and plate

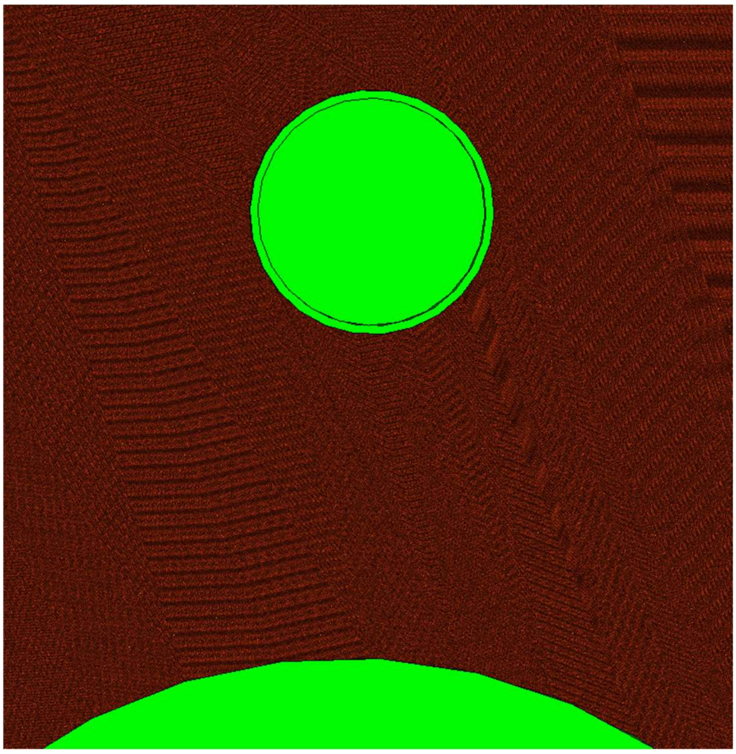

Fig.13. This shows the tilt gap for the gauge pins

The functional gauge is designed as per the requirements of TPT conditions and the dimensioning is done based on the GD&T methods.

MATERIAL OF FUNCTIONAL GAUGE:

The material of the part is chosen based on the following criteria,

- Material of the part taken.
- Based on the number of times the gauge will be used.
- Environmental condition based on where the gauge will be used.
- Based on whether the gauge will contact the part or not.
- A characteristic part of a gauge that will be used.
- A planned usage of gauge.

Assigned materials for the functional gauge are,

Gauge body: Plow steel.

This material is chosen i.e. plow steel as it has high wear resistance, high toughness, medium machinability which is necessary for this gauge body.

Pin material: A2 steel which has a composition of c-1%, Cr-5%, Mo-1%.

This material is chosen as it has medium toughness, high wear resistance and medium machinability. Here the medium toughness is required in order to absorb the energy and to deform without fracturing when something happens while checking the centerplate of the tyre.

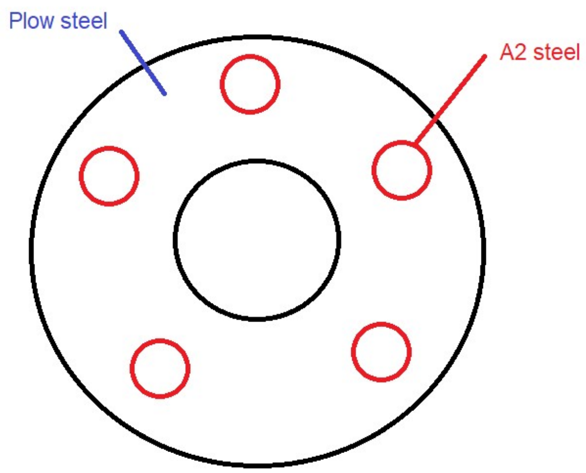

Fig.14. Material for the gauge

7. CONCLUSION:

Hence, for the chosen product (centerplate bolt pattern lug nut holes), the functional gauge is calculated and designed as per the True Position tolerance principle and designing of the gauge is done in both 2-D as well 3-D models using suitable software's, and dimensioning is done as per GD&T method. From this project, I was able to get an in-depth knowledge about True Position Tolerance and how to apply GD&T principle for the dimensions of the part drawing.

8. REFERENCE:

1. https://www.gdandtbasics.com/true-position/
2. https://en.wikipedia.org/wiki/Geometric_dimensioning_and_tolerancing
3. https://www.imao.biz/catalog/en/imageindexlists2/?categorycode=$SMEOFS,$SME

9. ACKNOWLEDGEMENT:

I thank Prof. V. Vijay Anand, Department of Mechanical Engineering, PSG Institute of Technology, Coimbatore, for giving me this wonderful opportunity to be a part of this assignment project and guiding me in every aspect of this project.