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# Design and Analysis of Bulk Head Plate for mounting the Power Take Off unit

**Karthik Kumar M[1], G H Manjunath Achar[2], Chowda Reddy V[3]**

[1]*PG Student, Department of Mechanical engineering, JNN College of Engineering, Shimoga, Karnataka, India*
[2]*Assistant. professor, Department of Mechanical engineering, JNN College of Engineering, Shimoga, Karnataka, India*
[3] *Manager, R&D, BEML Ltd , New Thippasandra, Bangalore, Karnataka, India.*

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Abstract - *Bulk head plate (BHP) assembly is being welded to the chassis in between engine compartment and crew compartment and provides necessary mountings for engine compartment of the recovery vehicle. New development has been made to mount Power Take Off unit (PTO) onto the Bulk head plate; Power take off unit is basically a gearbox with one input shaft and two output shafts used to tap mechanical power from Power pack for recovery operations. There is large input power from the engine to Power Take Off unit. The Bulk Head Plate has to withstand the overhang weight of the Power Take Off unit and Hydraulic aggregates mounted on Power Take Off unit. Therefore Bulk head plate has to be strengthened by providing stiffeners. Stiffeners are used to increase the bending strength of the plate. Deflection on the Bulk Head Plate should not exceed the limiting value (deflection should be less than 1mm) to avoid the misalignment of the shaft. The Bulk Head Plate has been fixed all the sides. The effect of stiffeners position and design of final stiffener has been carried out. The elements used are Hexa, Penta and rigid elements and the load is applied at centre of gravity of the Power Take Off unit and Hydraulic aggregates. Finite Element Analysis has been carried out.*

***Key Words: Bulk Head Plate (BHP), Power Take Off unit(PTO), Stiffeners.***

## 1. INTRODUCTION

Plates are two dimensional structural elements which are used extensively in Mechanical structures. Bulk Head Plate will be in between Power pack and the Power take off unit. Power pack is the main power source of the vehicle hydraulic pump which is driven by Power Take Off unit, which is coupled to the Main engine shaft. Hydraulic pump provides the hydraulic fluid under pressure to various aggregates of the vehicle. Electronic control signals will provide the relevant feedback signals for stable operation of the system. The weight of the Power Take Off aggregates are heavier and it is mounted on the Bulk Head Plate and the plate must withstand the overhang weight of the PTO and it should not deflect above the limiting value which leads to the misalignment of shaft between the Power Take Off unit and the Main engine. In order to avoid the misalignments the plate has to be strengthened and analyzed to avoid the failures. Devesh Pratap Singh Yadav et al.[1] analyzed the effect of stiffeners position on vibration analysis of plates, Vanam BCL et al.[2] presented the Static analysis of an isotropic rectangular plate using finite element analysis, Osadebe NN et al.[3] presented Bending analysis of isotropic rectangular plate with all edges clamped, Harun Rashid et al.[4] presented Free Vibration analysis of Eccentric and Concentric isotropic stiffened plate. The present work deals with the Bending analysis of the Bulk Head Plate and the element being considered as a plane stress condition. Modeling is done by using Catia V5 software. Meshing is done by using Hyper mesh 9.0 software and results are viewed in Hyper view post-processor. Static structural analysis is carried out to check for the deflections and Modal analysis is carried out to check for the resonance of the Bulk Head Plate.

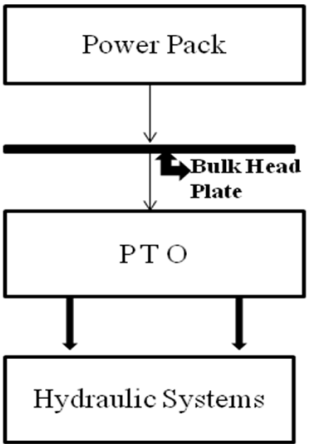



**Fig 1.1** Flow Chart of Bulk Head Plate assembly.

## 2. LOAD CALCULATION OF THE BULK HEAD PLATE

Weight of PTO: 270 kg

Weight of Hydraulic pumps mounted on PTO: 120 kg

Total weight on Bulk head plate: 270+120 = 390 kg

Maximum 'g' loads coming to PTO during vehicle movement: 6g loads

Load P = 6×390 × 9.81 = 23000 N

Torque load: 900000N-mm

## 2.1. BOUNDARY CONDITIONS

### 2.1.1 LOCATION OF CG

Load is applied at Centre of gravity of Power take off unit and Hydraulic pumps mounted on Bulk Head Plate as shown in the Figure 2.1 and 2.2 and the plate been fixed all the sides.Table.1 shows the co-ordinates of loading point.

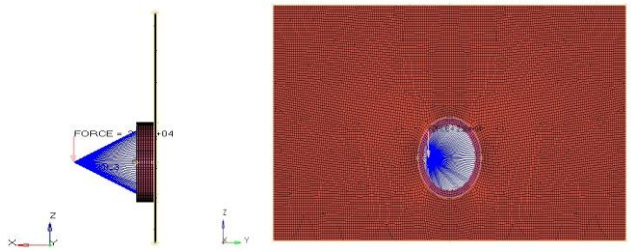


Fig 2.1: Right Profile View Fig2.2: Front View of Bulk Head Plate

**Table 1.** Co-ordinates of Point of application of loading

| | |
|---|---|
| X | 185 |
| Y | -116 |
| Z | 0 |

## 3. DESIGN OF BULK HEAD PLATE.

The Bulk Head Plate is modeled as shown in the Figure 3.1.

Thickness of the plate = 8mm

Width of the Plate = 1940 mm

Height of the Plate = 1016 mm

Hole diameter = 280 mm

Material = Mild Steel

**Material properties**:

Modulus of elasticity = 210GPa

Poisson's ratio = 0.3

Density = 7800 kg/m$^3$.

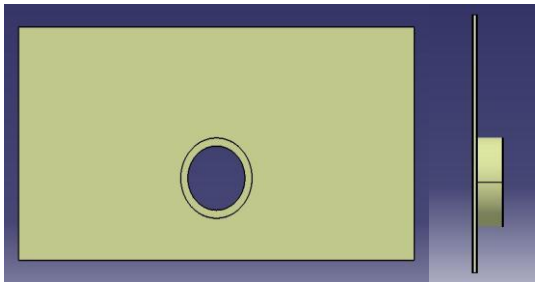


**Fig 3.1** Bulk Head Plate

### 3.1.1FINITE ELEMENT ANALYSIS OF BULK HEAD PLATE

The CAD Model of Bulk Head Plate is saved in IGES format and FE analysis was carried out. The displacement plate is shown in the Figure 3.2

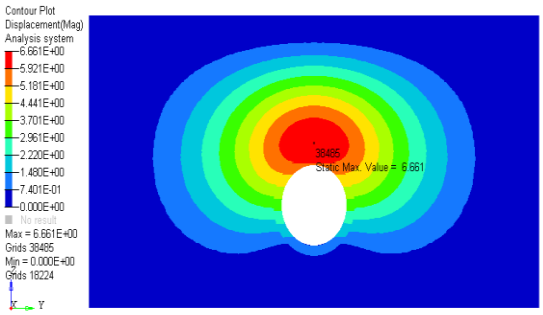
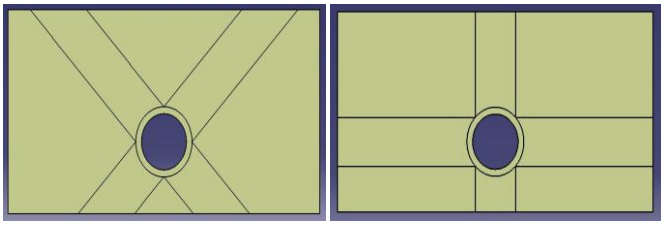



**Fig 3.2:** Displacement plot of Bulk Head Plate

## 4. DESIGN OF BULK HEAD PLATE WITH STIFFENERS IN 45° AND 90° POSITIONS

To strengthen the Bulk Head Plate the stiffeners were placed at 90° and 45° positions and modeled as shown in the Fig 4.1. The thicknesses of the stiffeners are 12mm. Both plate and stiffener are made of same material.

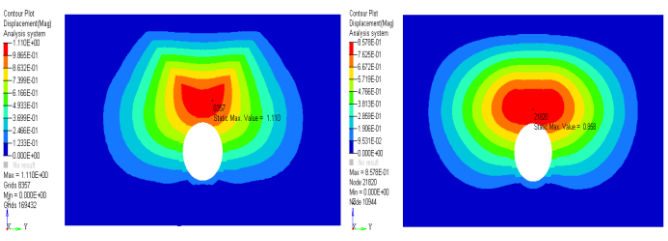


a. 45° Stiffener b. 90° Stiffener

**Fig 4.1:** Bulk Head Plate with different stiffener positions

## 4.1 FE ANALYSIS OF BHP WITH STIFFENERS IN 45$^0$ AND 90$^0$ POSITIONS

The Displacement plot of Bulk Head Plate with stiffener placed in 90° and 45° positions is shown in Figure 4.2a and 4.2b respectively.



a. 45° Stiffener b. 90° Stiffener

**Fig 4.2:** Displacement of Bulk Head Plate with different stiffener positions

## 5. ALTERNATE STIFFENER DESIGN OF STIFFENER FOR BULK HEAD PLATE.

The 90° and 45° stiffener position has sharp edges near the circumference of hole, where the stress concentration will be more. Also, under the dynamic condition of the structure, Power Take Off unit will exert the torque load on the bulk head plate. Hence, to effectively withstand the self load of PTO due to harsh terrain conditions where the vehicle operates, torque load and to reduce the stresses and deflection, an alternate design of stiffener has been carried out to strengthen the plate.

### 5.1DESIGN OF BULK HEAD PLATE WITH INCREASED THICKNESS

To design an alternate stiffener on the Bulk Head Plate for least displacements, the thickness of the bulk head plate has been increased from 8mm to 20mm as shown in the Figure 5.1

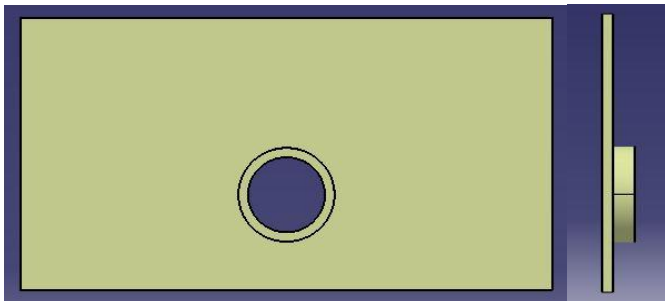


**Fig 5.1:** Bulk Head Plate with increased thickness.

### 5.1.1 FINITE ELEMENT ANALYSIS.

The Displacement of Bulk Head Plate with increased thickness is shown in Figure 5.2

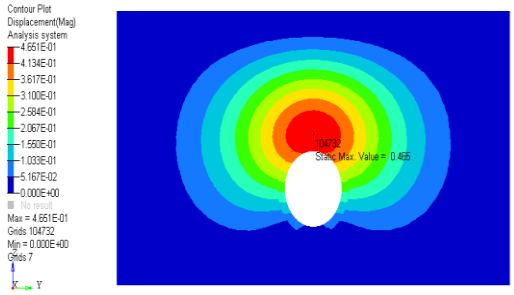



**Fig 5.2:** Displacement of Bulk Head Plate with increased thickness

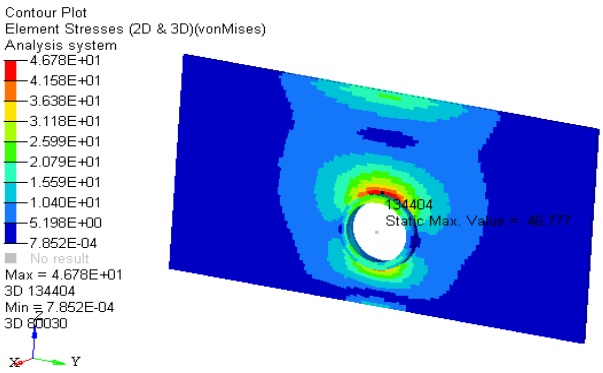



**Fig 5.3:** Von-Mises stress in Bulk Head Plate with increased thickness

### 5.2 DESIGN OF FINAL STIFFENER FOR BULK HEAD PLATE.

By observing the stress contour of the Bulk Head Plate the material will be removed at low stress level region and considering brackets to mount the Power take off Unit, the final stiffener design is shown in the Figure 5.4.

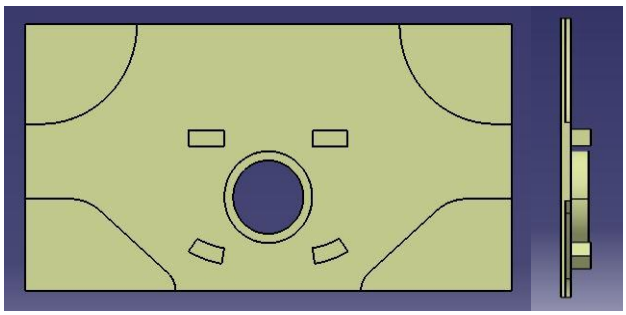


**Fig 5.4:** Final stiffener design of Bulk Head Plate

### 5.2.1 FE ANALYSIS OF BULK HEAD PLATE WITH FINAL STIFFENER DESIGN.

Considering the self weight of the Power Take Off unit mounted and its torque load on the brackets under dynamic conditions the displacement plot is shown in the Figure 5.5.

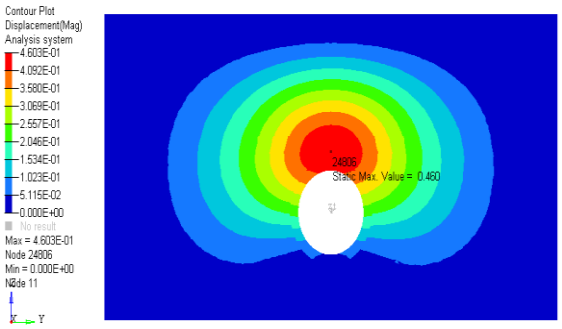
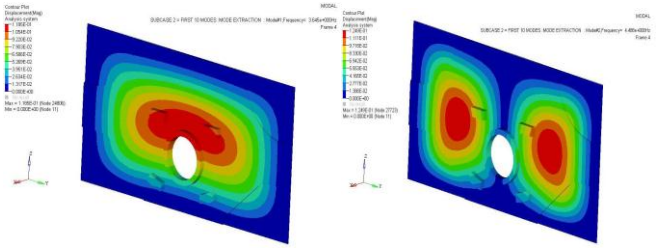


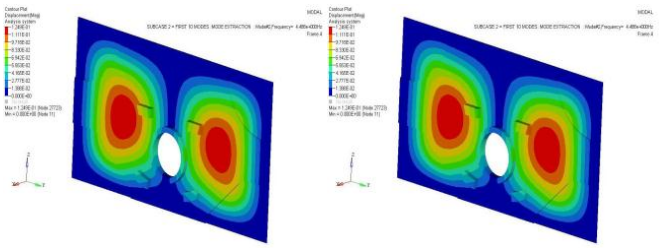

**Fig 5.5:** Displacement of Bulk Head Plate with final stiffener design

## 6.MODAL ANALYSIS RESULTS OF BULK HEAD PLATE.

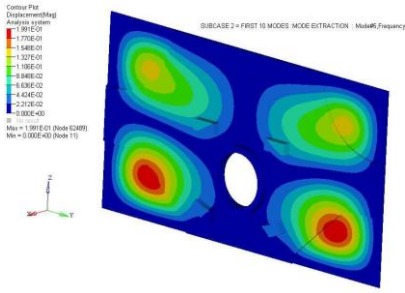
**1st Mode:** Frequency 3.64 Hz **2nd Mode:** Frequency 4.66Hz



**3rd Mode:** Frequency 6.69Hz **4th Mode:** Frequency 8.80 Hz



**5th Mode:** Frequency 8.86 Hz



## RESULTS AND CONCLUSION

In this work, the bulk head plate has been designed and analyzed to with stand over hang weight of power take off unit and hydraulic aggregates mounted on it. Static analysis results are shown in table 2 and Modal analysis results are presented in table 3.

**Table 2:** Static analysis results of Bulk Head Plate.

| Sl. no | Particulars | Displacement (mm) |
|---|---|---|
| 1 | Plate without Stiffener | 6.67 |
| 2 | 45° Stiffener | 1.11 |
| 3 | 90° Stiffener | 0.85 |
| 4 | Bulk Head Plate with increased thickness | 0.466 |
| 5 | Bulk Head Plate with final stiffener design | 0.460 |

**Table 3:** Modal analysis results of Bulk Head Plate.

| Mode Number | Natural Frequency (Hz) |
|---|---|
| 1 | 3.65 |
| 2 | 4.48 |
| 3 | 6.69 |
| 4 | 8.80 |
| 5 | 8.86 |

The Bulk Head Plate without stiffener has larger deflection, thus it has been strengthened by providing proper stiffeners. Stiffeners were added in different positions ($45^0$ and $90^0$). $90^0$ stiffener yielded least deflection and stresses in the plate. Further, to compensate the self load, torque load and also to reduce stresses at sharp edges of stiffeners near the flange, alternate design of stiffener has been carried out to strengthen the plate. To mount the PTO to the exact position on the Bulk Head Plate, 4 Brackets were welded on the Bulk Head Plate so that the deflection has been reduced to 0.4603 mm. Finally, modal analysis was carried out to check the resonance. It was found that the first ten Natural frequency of the structure is far away from operating frequency of 40Hz and hence the structure is found to be safe from resonance. Hence, it is concluded that this optimized position of the stiffener gives the least deflection of 0.4603mm and is considered to be the best design of Bulk Head Plate for mounting the Power Take Off unit.

## ACKNOWLEDGEMENT

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