# Enhancement of Structural Strength of Universal joint with Beryllium Copper UsingANSYS Structural

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***Abstract***
In this study, an attempt was made to enhance the structural performance of universal joint using finite element analysis. A 3d geometry of universal joint was modeled in Catia v5 and performed static structural analysis on Ansys 14.0. A comparative analysis with original material of universal joint i.e. structural steel and replacement material which is berylliumcopper, was performed. It was found out by static solution of the analysis that berylliumcopper is suitable for manufacturing of universal joint since less total deformation for berylliumcopper when compared with the conventional material of universal joint i.e. structural steel was observed. The values of stresses and strains were found to be optimum as well. The weight was also observed to reduced applying beryllium copper as replacement material. These all contributed to increase the structural performance of universal joint.

**Keywords:** Universal joint, structural performance, finite element analysis, stress-strain behavior, weight optimization.

## 1. INTRODUCTION

A universal joint is a positive, mechanical connection between rotating shafts, which are usually not parallel, but intersecting. They are used to transmit motion, power, or both. The simplest and most common type is called the Cardan joint or Hooke joint. It is shown in *Figure 1*. It consistsof two yokes, one on each shaft, connected by a cross-shaped intermediate member called the spider. The angle between the two shafts is called the operating angle. It Is generally, but n01 necessarily, constant during operation. Good design practice calls for low operating angles, often less than 25°, depending on the application. Independent of this guideline, mechanical interference in the construction of Cardan joints limits the operating angle to a maximum (often about 37½°), depending on its proportions. The figure shown below is a typical diagram of Universal Joint. The parts of a universal joint are shown in exploded view shown below. The two fork ends are assembled co-axially with respect to the centre block. The pins are assembled into the holes provided in the fork end. They are held in position by means of a collar and a collar pin. The assembled view of a universal joint is shown below [1].

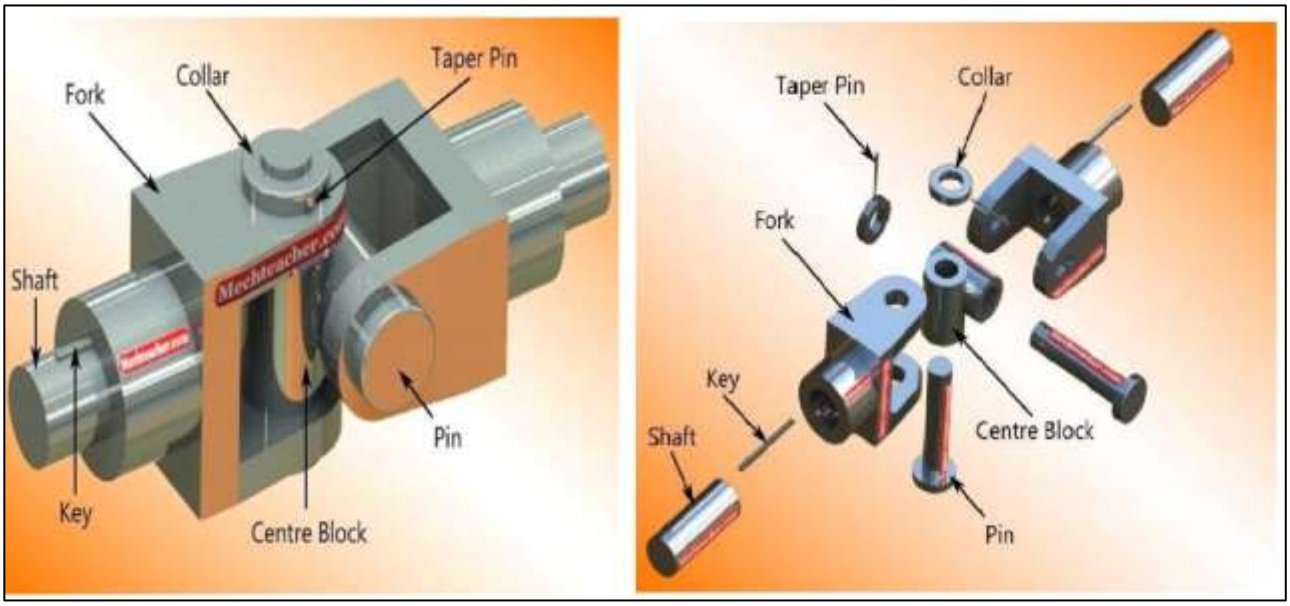


**Fig.1) Universal joint and its components [1].**

## 2. METHODOLOGY

This section discusses the modeling of geometry, meshing, applying boundary conditions, support and loads working on universal joint.

### 2.1 Geometry

The geometry was modeled in Catia v5 as shown below in the figure 2. The geometry was modeled same for both the material i.e. structural steel and beryllium copper.

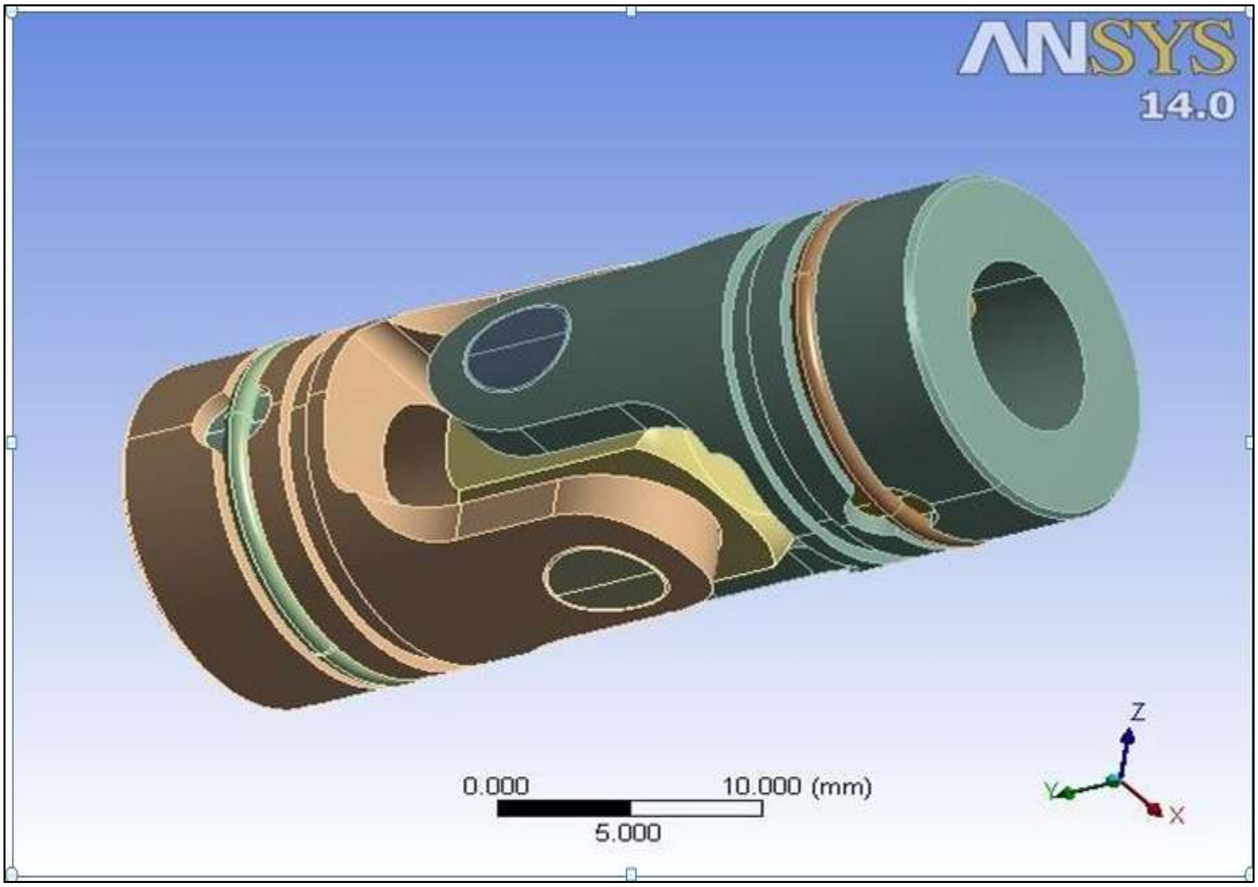


**Fig. 2) 3D geometry of universal joint.**

### 2.2 Meshing

The meshing was done in Ansys workbench14.0. The meshing was done using tetrahedral type elements. The meshing details are shown in below table 1.

Table 1: Details of meshing parameters.

| Meshing details | |
|---|---|
| Elemnt size | 1mm |
| Advanced Size Function | On |
| Curvature Relevance Center | Medium |
| Initial Size Feed | Active Assembly |
| Smoothing | Medium |
| Transition | Slow |
| Nodes | 52523 |
| Elements | 26920 |

The below shown figure 3 shows the meshing of universal joint modeled in Catia v5. The same meshing conditions were adopted for meshing universal joint for structural steel and beryllium copper material.

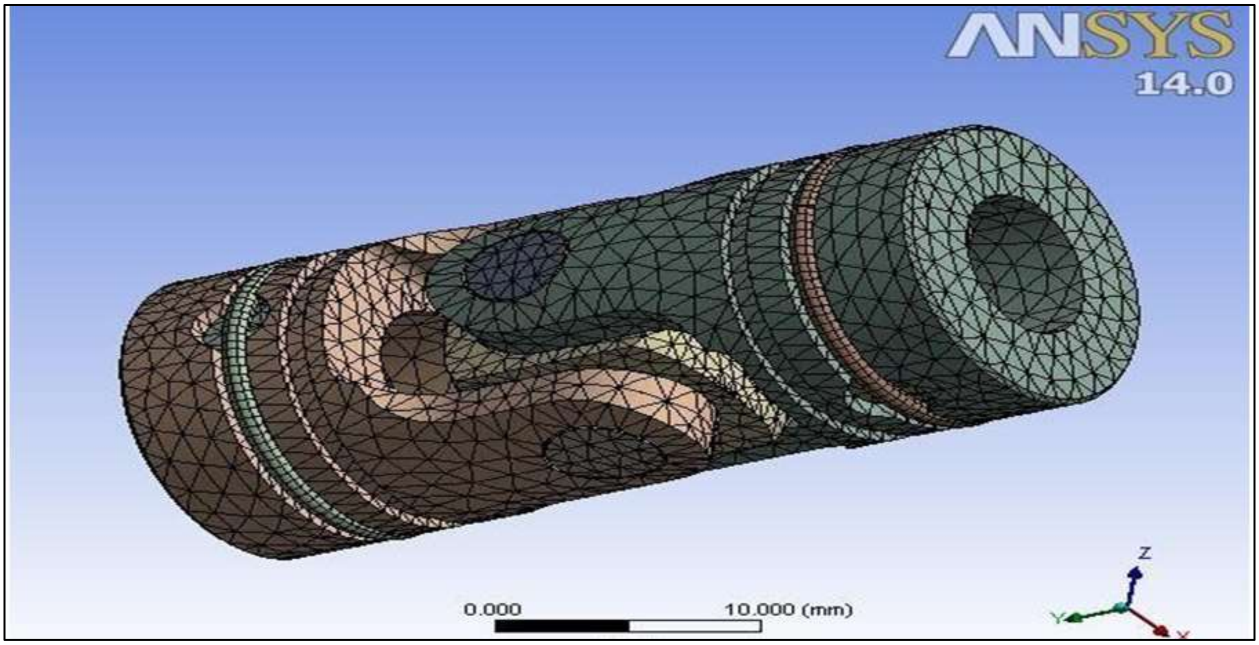


**Figure 3) Meshing of the 3D geometry of universal joint.**

### 2.3 Boundary conditions

The fixed support and various forces were applied on different components of universal joint. The details of support and forces are shown in below figure 4.

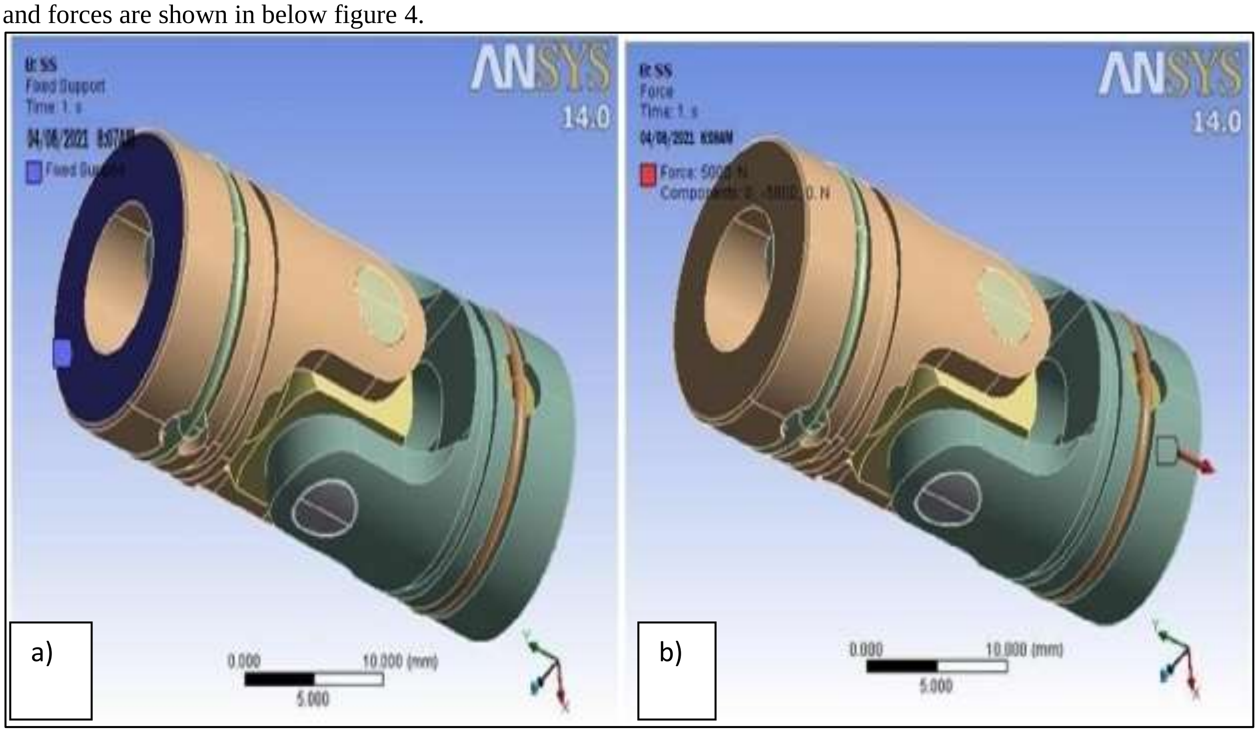


**Figure 4 a) Fixed support at one end of universal joint, b) Force of 5000N acting on other side.**

### 2.4 Material properties

The study incorporated structural steel and beryllium copper materials for comparative study of mechanical strength. The properties of both the materials are given in table 2.

Table 2: Details of Material Properties.

| Material Name → Properties↓ | Structural steel | Beryllium Copper |
|---|---|---|
| Density (kg/ $m^3$) | 7830 | 8500 |
| Modulus of elasticity (GPa) | 210 | 125 |
| Modulus of rigidity (GPa) | 76.923 | 115 |
| Poisson ratio | 0.30 | 0.20 |
| Bulk modulus(GPa) | 166.67 | 166.67 |
| Yield Tensile strength(MPa) | 250 | 965 |
| Ultimate tensile strength(MPa) | 460 | 1280 |

## 3 RESULTS AND DISCUSSIONS

After modeling the geometry, meshing and applying the boundary conditions, the mechanical strength was analyzed in Ansys mechanical 14.0 in terms of equivalent von mises stresses, total deformation and equivalent elastic strain.

The results of equivalent von-mises stresses for structural steel and beryllium copper are shown in below figure 5.

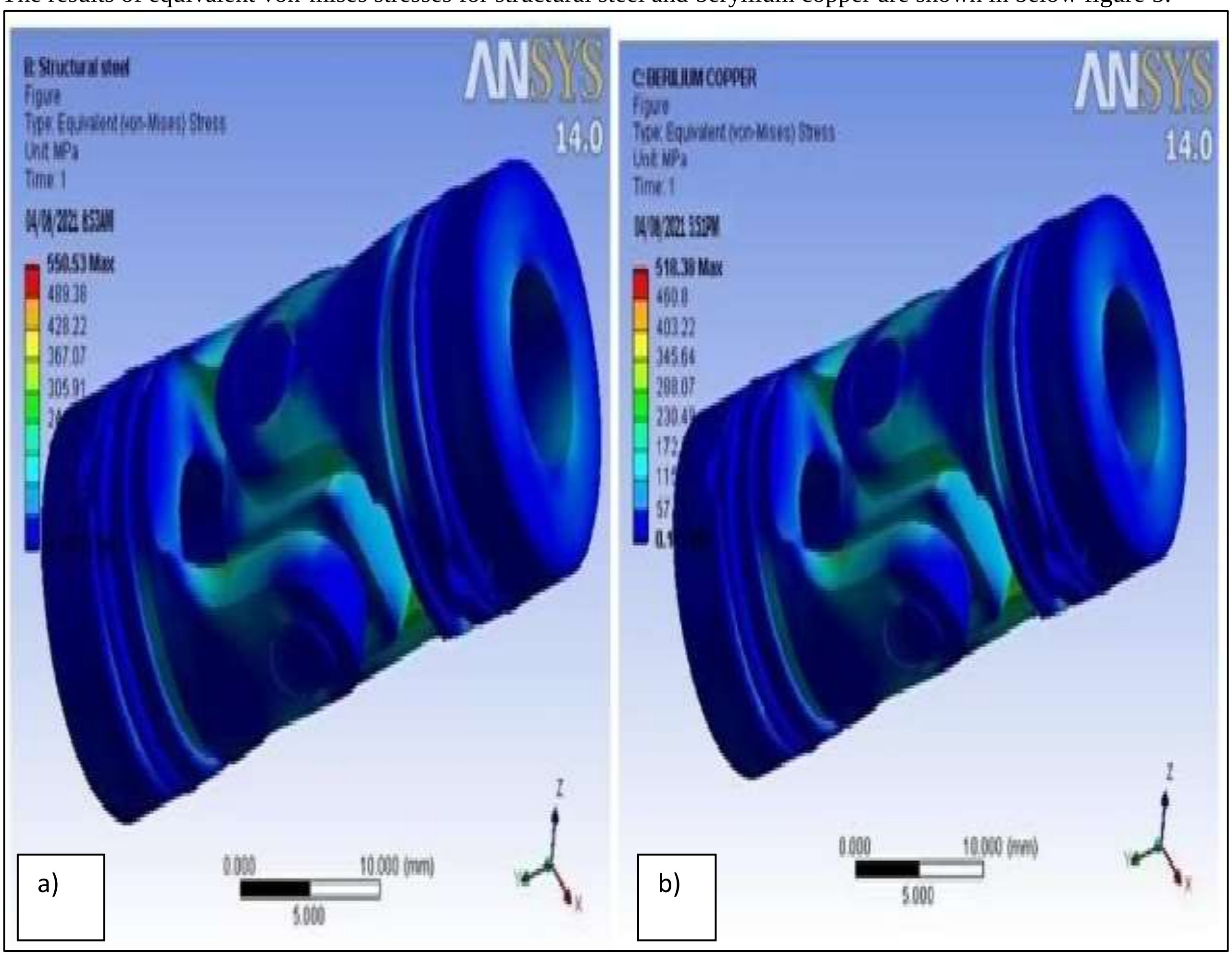


Figure 5) Results of equivalent von-mises stresses for a) structural steel, b) beryllium copper.

The results of total deformations for structural steel and beryllium copper are shown in below figure 6.

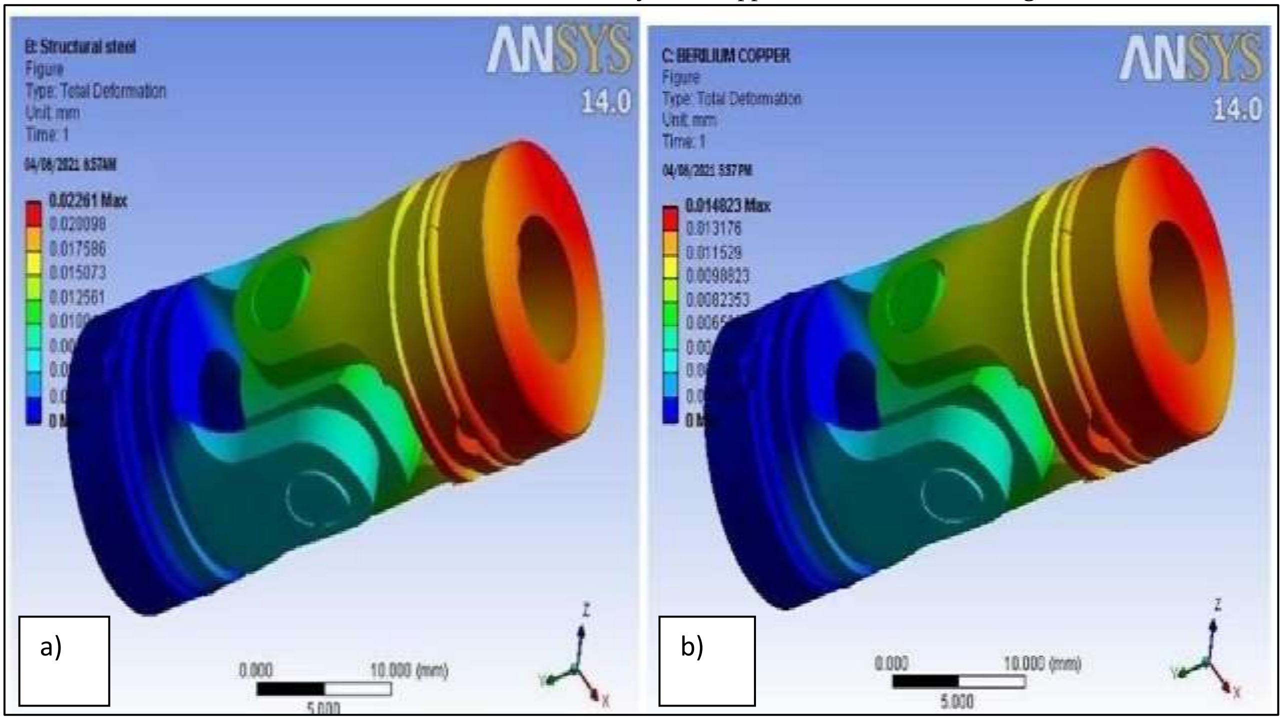


Figure 6) Results of total deformation for a) structural steel, b) beryllium copper.

The results of equivalent elastic strain for structural steel and beryllium copper are shown in below figure 7.

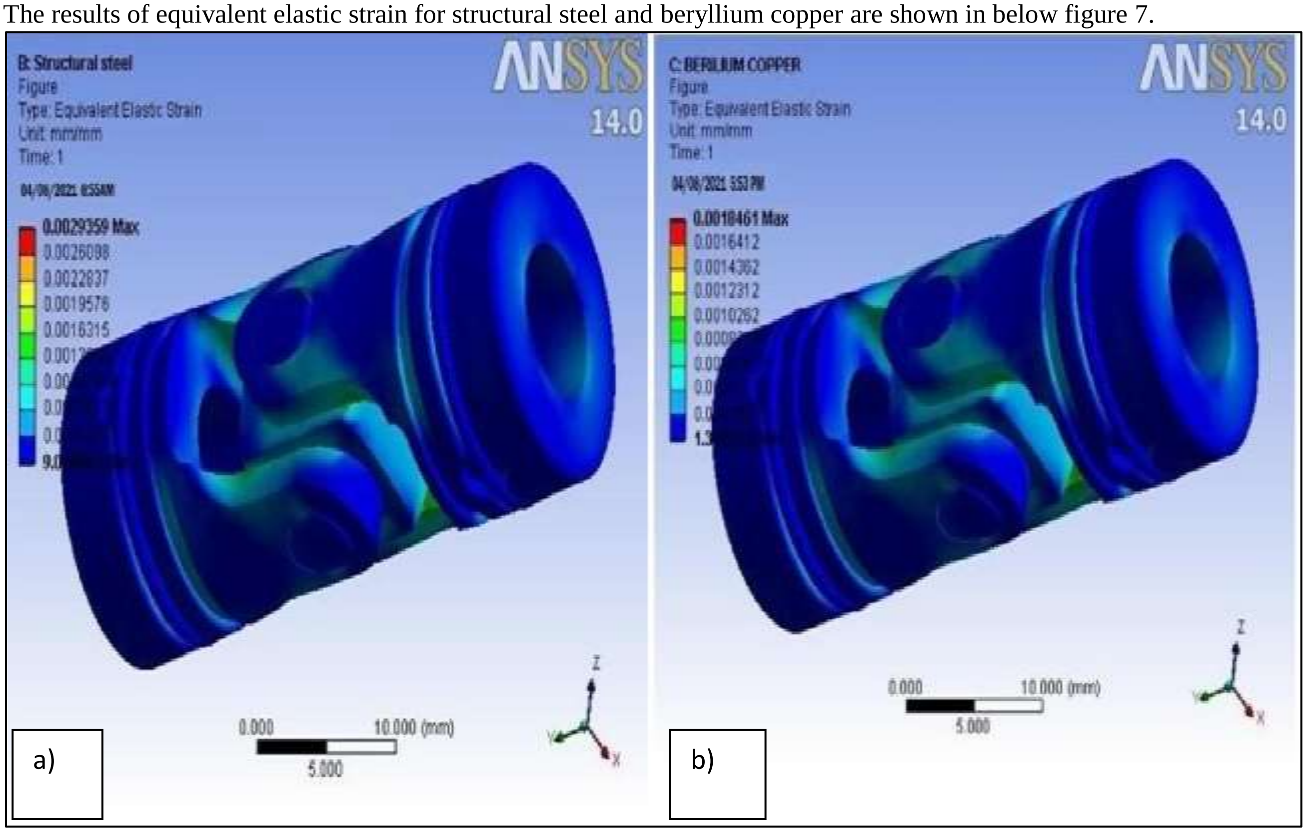


Figure 7) Results of equivalent elastic strain for a) structural steel, b) beryllium copper.

All the results of the analysis of universal joint 3d geometry with the help of Ansys 14.0 are summarized in the following table 3.

Table 3: Summary of all the results obtained from the finite element analysis.

| **Name of material→**<br>**solution↓** | **Structural Steel** | **BerylliumCopper** |
|---|---|---|
| Equivalent stress (MPa) | 550.53 | 518.38 |
| Maximum principal stress(MPa) | 463.59 | 421.66 |
| Minimum principal stress(MPa) | 114.9 | 59.761 |
| Maximum shear stress(MPa) | 309.51 | 291.95 |
| Normal stress(MPa) | 129.52 | 121.21 |
| Shear elastic strain (mm/mm) | 0.0020805 | 0.0012027 |
| Equivalent elastic strain(mm/mm) | 0.0029359 | 0.0018461 |
| Maximum principal elastic strain(mm/mm) | 0.0025079 | 0.0014787 |
| Maximum shear elastic strain(mm/mm) | 0.0040236 | 0.0022739 |
| Minimum principal elastic strain(mm/mm) | -5.6572e-7 | 8.9269e-6 |
| Normal elastic strain(mm/mm) | 0.00041173 | 0.00035001 |
| Directional deformation(mm) | 0.0037791 | 0.0022866 |
| Total deformation(mm) | 0.02261 | 0.014823 |

## CONCLUSION

The structural performance of universal joint was analyzed by a comparative study using conventional material of universal joint structural steel and beryllium copper. The structural analysis was done using Ansys fluent 14.0. It is concluded that beryllium copper has lower value of total deformation when compared to conventional material of universal joint which leads to high structural strength of universal joint. It is also concluded that the values of equivalent stresses and equivalent strains are also less for beryllium copper. So the enhancement of structural strength of universal joint is achieved using beryllium copper.

## REFERENCES

1. Ms. Nilesha Patil, Mrs. Sayli M.Sable and Mr. Kashinath Munde, ―Static Structural Analysis of Universal joint‖, *International Journal of Advanced Technology in Engineering and Science,* vol 4, issue 12, december 2016.
2. Prof. Swati Datey, Amit A. Rangari, Adarsh A. Dongre, Kunal A. Paraskar & Sanket V. Lidbe, ―Analysis of Universal joint used in Mahindra 575 DL‖, *IJARIIE-ISSN(O)-2395- 4396,* Vol-3 Issue-2 2017.
3. Nipun Kumar, Dr. Gian Bhushan and Dr. Pankaj Chandna, ―Analysis of Universal joint of Various Materials using CAE Tools‖, *International Journal of Engineering Technology, Management and Applied Sciences,* Volume 5, Issue 1, January 2017.
4. Kodali. Vikas and Kandula. Deepthi, ―Analysis of Serial Pinned Joints in Composite Materials‖, *International Journal of Computational Engineering Research, Vol, 04, Issue,10, October– 2014.*
5. Shaik.John Bhasha and Hari Sankar Vanka, ―Modeling and Analysis of Universal joint‖, *International Journal & Magazine of Engineering, Technology, Management and Research*, Volume No: 2 (2015), Issue No: 11 (November).
6. Geun-Yeon Kim, Seung-Ho Han and Kwon-Hee Lee, ―Structural Optimization of a universal joint with Consideration of Stiffness and Durability Requirements‖, *The Scientific World Journal,* 2014.

7. Ms. Nilesha U. Patil, Mrs. Rupali S. Sewane and Mr. Kashinath H. Munde, ―Optimization of Universal joint by using FEA‖, *International Conference on Ideas, Impact and Innovation in Mechanical Engineering)*, Volume: 5 Issue: 6, 2017.
8. Mahesh P. Sharma, Denish S. Mevawala, Harsh Joshi and Devendra A. Patel, ―Static Analysis of Steering universal joint and Its Shape Optimization‖, *IOSR Journal of Mechanical and Civil Engineering, PP 34-38, 2014.*
9. Ms.Nilesha U. Patil, Prof.P.L.Deotale, Prof. S.P.Chaphalkar, A.M.Kamble & Ms.K.M.Dalvi5, ― Application Of Taguchi Method For Optimization Of Universal joint‖ *International Journal of Recent Trends in Engineering & Research (IJRTER) ,Volume 03, Issue 11; November - 2017 .*
10. Pankaj Dulani and S. A. K. Jilani, ―Diameter and Spiral Thickness Optimization of Universal joint Using Neural Network‖, *International Journal of Science and Research*, Volume 5 Issue 2, February 2016.
11. Miss. Yogini .V. Deore ,Prof. J.R.Mahajan K, Mr. Vinay Patil & Mr. Balasaheb Ugale, ― A Static Structural Analysis Of Universal joint‖, *International Journal Of Advanced Research In Engineering & Management (Ijarem) ,Pp. 10-22*, Vol. 03, Issue 04, 2017.
12. Dinesh Shinde And Kanak Kalita, ―FE Analysis Of Universal joint Pin Used in Tractor Trailer‖, ARPN Journal Of Engineering And Applied Sciences, Vol. 10, No. 5, March 2015.
13. Abhishek Mandal & Utkarsh Sharma, ―Static Structural Analysis of Universal Joint to Study the Various Stresses and Strains Developed in Power Transmission Systems‖, *International Journal of Engineering Research & Technology,* Vol. 5 Issue 03, March-2016.
14. Suraj Yadav, Sanket Benade, Sushil Angchekar, Vaibhav Dhokle and Prof. Rakesh Kolhapure, ―Design And Analysis Of Universal joint By Using FEA‖,*Technical Research Organization India*,Volume-4, Issue-6, 2017.
15. Shankar Majhi & Shaheen Beg Mughal, ―Modeling and analysis of universal joint used in tractor‖, *International Research Journal of Engineering and Technology*, Volume: 04 Issue: 07, July -2017.
16. Ravindra S. Dharpure and Prof D. M. Mate, ―Study and Analysis of Pin of Universal joint in Train*", Journal of Emerging Technologies and Innovative Research,* Volume 1 Issue 3.
17. Sourav Das, Vishvendra Bartaria & Prashant Pandey, ―Analysis of Universal joint Of 30C8 Steel For Automobile Application‖, *International Journal Of Engineering Research & Technology*, Vol. 3 Issue 1, January – 2014.
18. Sangamesh B. Herakal, Ranganath Avadhani, Dr.S.Chakradhar Goud, ―Structural Static Analysis Of Universal joint‖, *International Journal Of Engineering Research And General Science*, Volume 4, Issue 2, March-April, 2016.
19. Dhananjay S Kolekar, abhay M. Kalje, swapnil S Kulkarni, ―Design, Development And Structural Analysis Of Universal Joint‖, *International Journal Of Advanced Engineering Research And Studies, Vol 4, issue 4, July-September, 2015/09-12.*
20. Pilla. Anitha and V. Hari Shankar, ―Design And Topology Optimization Of A Steering Universal joint Using FEA‖, *International Journal of Scientific and Research Publications*, Volume 6, Issue 11, November 2016.
21. Nishant Vibhav Saxena And Dr. Rohit Rajvaidya, ―Study & Analysis Of Universal joint With The Replacement Of Material By Using Teflon‖, *Int. Journal Of Engineering Research And Applications,* Vol. 5, Issue 3, (Part -4) March 2015.
22. Vivek Shaw, Tanuj Srivastava, Rohit Ghosh and Dr. Rabindra Nath Barman,‖ Numerical Simulation Of Universal joint Using Finite Element Method: A New Approach Based On Composite, *International E-Journal For Technology And Research,* Volume 1, Issue 5, May 2017.
23. Ashokrao Shinde, Omkar Chandrakant Vibhute, ―Modeling and Analysis of Universal joint, *International Journal of Engineering Research & Technology*, Vol. 6 Issue 07, July – 2017.