

Modelling and Analysis of Steering Lever Link of a Tractor

Srilekha Aurulla ¹, G. Gopala Krishna ²P.G. Student, Department of Mechanical Engineering, J.B. Institute of Engineering and Technology, Telangana, India¹Associate Professor, Department of Mechanical Engineering, J.B. Institute of Engineering and Technology,
Telangana, India²

ABSTRACT: The system governing the angular movement of front wheels of tractor is called steering system. The design of the steering system should be such that it should cause minimum wear on the tyres of the wheels. The steering lever link is an integral part of a tractor steering system. The steering lever link helps to convert the rotary motion given at the wheel to angular motion at road. It is mounted on the rigid beam axle connected to one of the wheels of the tractor. Modeling of steering lever link of a tractor is done in modeling software CATIA V5 R20 and this link is analyzed by using ANSYS 15.0 software. The materials selected for analysis of steering lever link of a tractor are EN 19 alloy steel and 304 Stainless Steel and are compared with Grey cast iron which is generally used material for manufacturing steering lever link. This paper presents the static and modal analysis of steering lever link of a tractor to check its deformation, maximum stress and natural frequencies by using three materials.

KEYWORDS - Steering Lever Link, CATIA, ANSYS, Deformation, Vonmises stress, Natural frequency

I. INTRODUCTION

The steering system is required to control the direction of motion of the vehicle. This is done through a series of links used to convert the rotation of the steering wheel into change of angle of the axis of the steering wheels. The steering lever link is an integral part of a tractor steering system it facilitates the conversion of rotary motion given at the wheel to angular motion at the road. Steering lever link is mounted on the rigid beam axle connected to one of the wheels of the tractor and it is positioned by means of kingpin. The motion of the vehicle being steered needs to become straight ahead when the force on the steering wheel is removed.

When the operator turns the steering wheel, the motion is transmitted through the steering shaft to tyre angular motion of the pitman arm, through a set of gears. The angular movement of the pitman arm is further transmitted to the steering arm through the drag link and tie rods. Steering arms are keyed to the respective kingpins which are integral part of the stub axle on which wheels are mounted. The movement of the steering arm effects the angular movement of the front wheels. In another design, instead of one pitman arm and drag link, two pitman arms and drag links are used and the use of tie rod is avoided to connect both steering arms.

II. RELATED WORK

A. LITERATURE REVIEW

Manik et al. [1] had done FEA of Tie rod of steering system of car to check its natural frequencies, maximum stress and deformation.

Guru Brahananda reddy et al. [2] designed and analyzed the steering lever link for a tractor. The link is analyzed for both its strength as well as rigidity. The concentration of stresses at critical sections is also found out and a comment on the overall safety of the steering lever link is made.

Mahesh et al. [3] designed a steering knuckle arm and optimized its shape which accommodates dual caliper mounting for increasing brake efficiency and reducing a stopping distance of a vehicle.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

Ghang Qin et al. [4] had presented a hierarchical optimization procedure for the optimal synthesis of a double-axle steering mechanism used in truck with dynamic loads is presented.

George Campbell et al. [5] tested on a large scale finite element model of a tie rod in NASTRAN Version 68. The static buckling load of a tie rod is analyzed. The results of the finite element modal are compared with experimental results.

B. GEOMETRIC MODELLING

The CAD model of steering lever link of a tractor is done by using CATIA V5 R20 software. CATIA V5 R20 is an interactive Computer Aided Design and Computer Aided Manufacturing system. The CAD function automates the normal engineering, design and drafting capabilities found in today's manufacturing companies. The geometric model of steering lever link of tractor is shown in fig. 1.

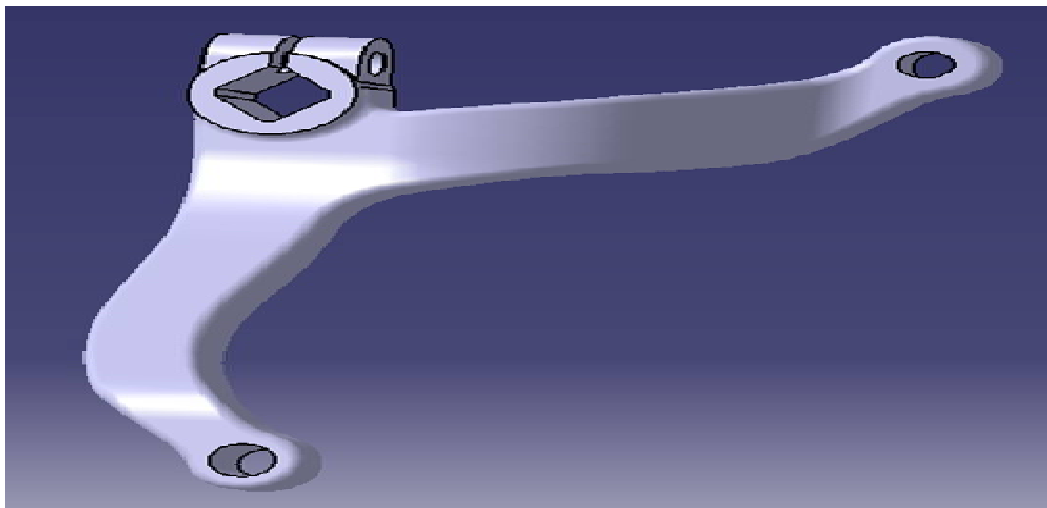


Fig. 1 Geometric modelling of steering lever link of a tractor

C. ANALYSIS OF STEERING LEVER LINK

The CAD model of steering lever link is then imported to ANSYS software for further analysis. The basic approach for ANSYS software can be divided into three parts

- Pre processor
- Solution and
- Post processor

After assigning material properties and structural properties to the model, meshing is done. Meshing is the process of dividing the model into finite number of finite sized elements. The element type used for analysis of steering lever link of a tractor is SOLID 92 (8 Noded hexa element). The size of the mesh is 1.5. The meshing is generated using the mapped mesh in ansys option. The force of 9000N is acting in the y-direction on the top limb of the link. There is also a moment of 9 Kg-m acting along the z-axis passing through the kingpin. The lower limb of the link, which is connected to the tie-rod, is constrained in the x-direction. The meshing and application of loads and boundary condition of steering lever link of tractor are shown in fig. 2.

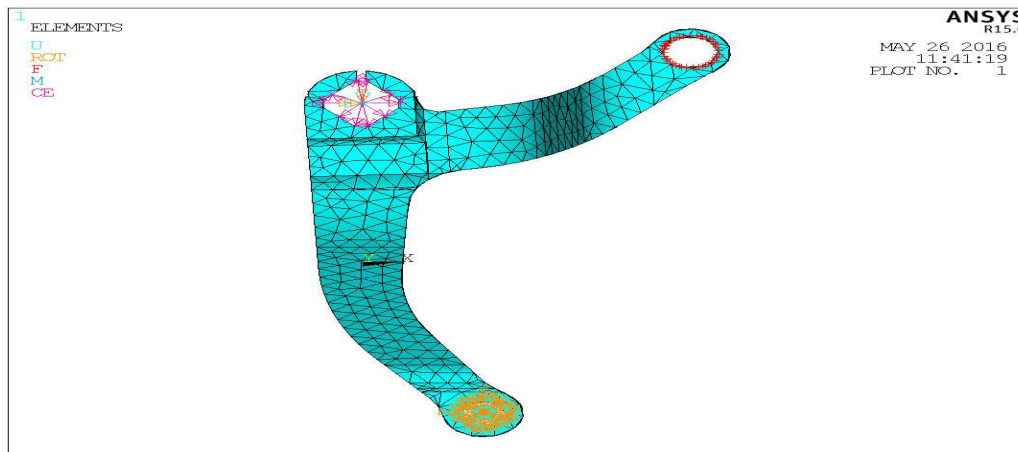


Fig. 2 Meshing and application of loads and boundary conditions of steering lever link of tractor

D. MATERIAL SELECTION

The most commonly used material for steering lever link of a tractor is Grey cast iron. The reason for using grey cast iron is its high strength, highly reliable and durable. The materials selected for steering lever link of a tractor are 304 stainless steel and EN 19 alloy steel, which are compared with grey cast iron. Stainless steel 304 alloy is selected because it has good corrosion resistance property. EN 19 alloy steel is a high quality alloy steel, renowned for its good ductility and shock resistance and its resistance to wear properties. The chemical composition of grey cast iron and EN 19 alloy steel are shown in table 1. The various material properties of grey cast iron, 304 stainless steel and EN 19 alloy steel are shown in table 2.

Table 1 chemical composition of grey cast iron and EN 19 alloy steel

Element content	C	Si	Mn	S	P	Cr	Mo	Fe	Ni
Grey cast iron	2.7 – 4.0	1.8 – 3.0	0.8	Max 0.07	Max 0.02	-	-	-	-
304 stainless steel	Max 0.08	Max 1.0	Max 2.0	Max 0.03	Max 0.045	18 – 20	-	63.3 – 74	8.0 – 10.5
EN 19 alloy steel	0.36 – 0.44	0.10 – 0.40	Max 0.7 – 1.0	Max 0.040	Max 0.035	0.90 – 1.2	0.25 – 0.35	-	-

Table 2 various material properties of grey cast iron, 304 stainless steel and EN 19 alloy steel

Material / Property	Density , g/cc	Brinell hardness	Modulus of elasticity , GPa	Poissons ratio	Ultimate tensile stress, MPa	Yield stress, MPa	Endurance limit , MPa
Grey cast iron	7.2	160	140	0.26	150-450	98-200	60-180
304 stainless steel	8.0	123	200	0.29	505	215	252.5
EN 19 alloy steel	7.85	197	210	0.3	850-1000	700	425-500

III. RESULTS AND DISCUSSIONS

Structural analysis results give the deformations, vector sum of displacement, stresses like von mises stress, principal stresses. Modal analysis determines the vibration characteristics like natural frequencies and mode shapes.

A. STATIC ANALYSIS

Static analysis results of steering lever link of tractor are viewed by using grey cast iron, 304 stainless steel and EN 19 alloy steel materials are shown in fig. 3, 4 and fig. 5. Fig. 3, 4, 5 (a) shows the deformation in steering lever link (b) shows the vector sum of steering lever link and (c) shows the Vonmises stress obtained in steering lever link.

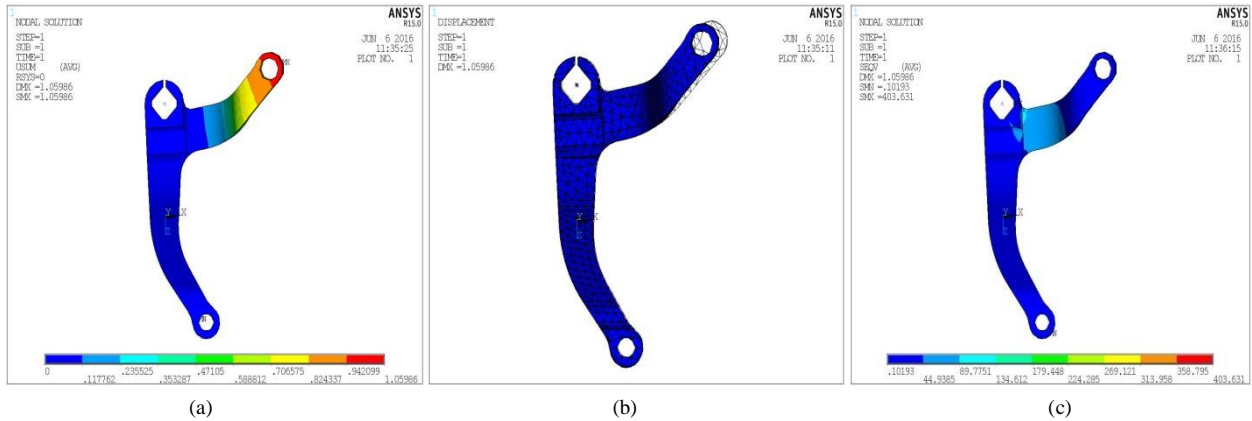


Fig. 3 Static analysis results of steering lever link using Grey Cast iron (a) deformation in steering lever link is 1.059mm (b) vector sum in steering lever link is 1.059mm (c) Vonmises stress obtained in steering lever link is 403.63MPa

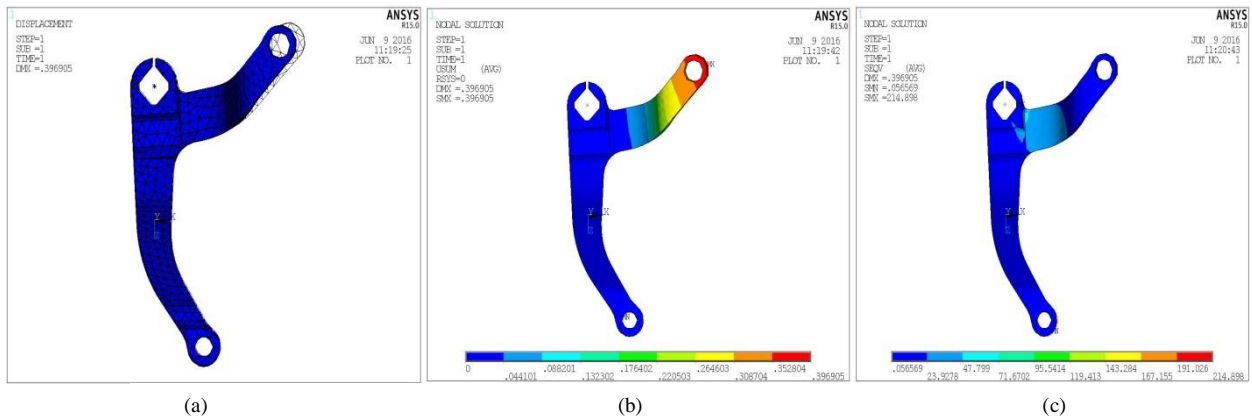


Fig. 4 Static analysis results of steering lever link using 304 stainless steel (a) deformation in steering lever link is 0.396mm (b) vector sum of steering lever link is 0.396mm (c) Vonmises stress obtained in steering lever link is 214.89MPa

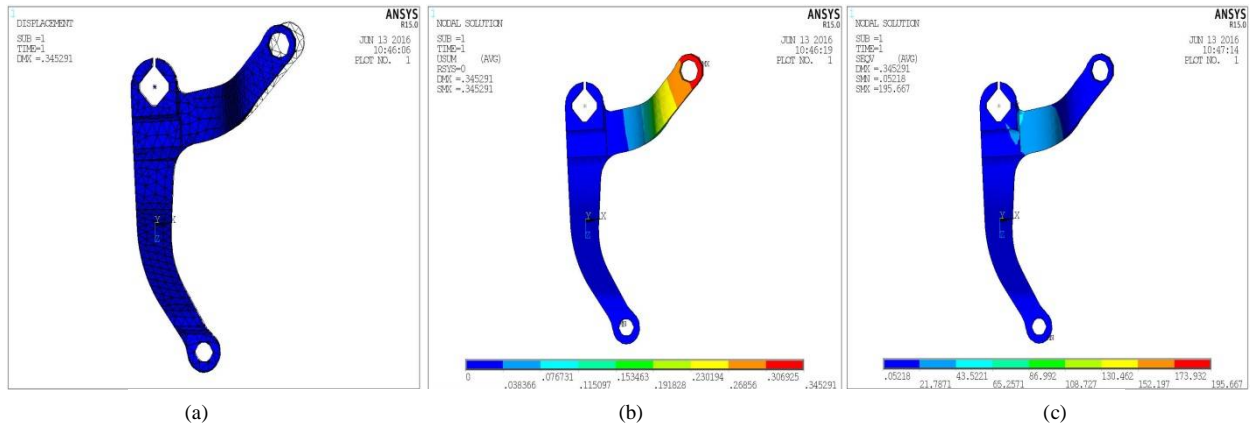


Fig. 5 Static analysis results of steering lever link using EN 19 alloy steel (a) deformation in steering lever link is 0.345mm (b) vector sum in steering lever link is 0.345mm (c) Vonmises stress obtained in steering lever link is 195.66MPa

B. MODAL ANALYSIS

Modal analysis results of steering lever link of tractor are viewed by using grey cast iron material in fig. 6 and fig. 7 shows the modal analysis results of steering lever link by using 304 stainless steel and fig. 8 shows the modal analysis results of steering lever link by using EN 19 alloy steel material.

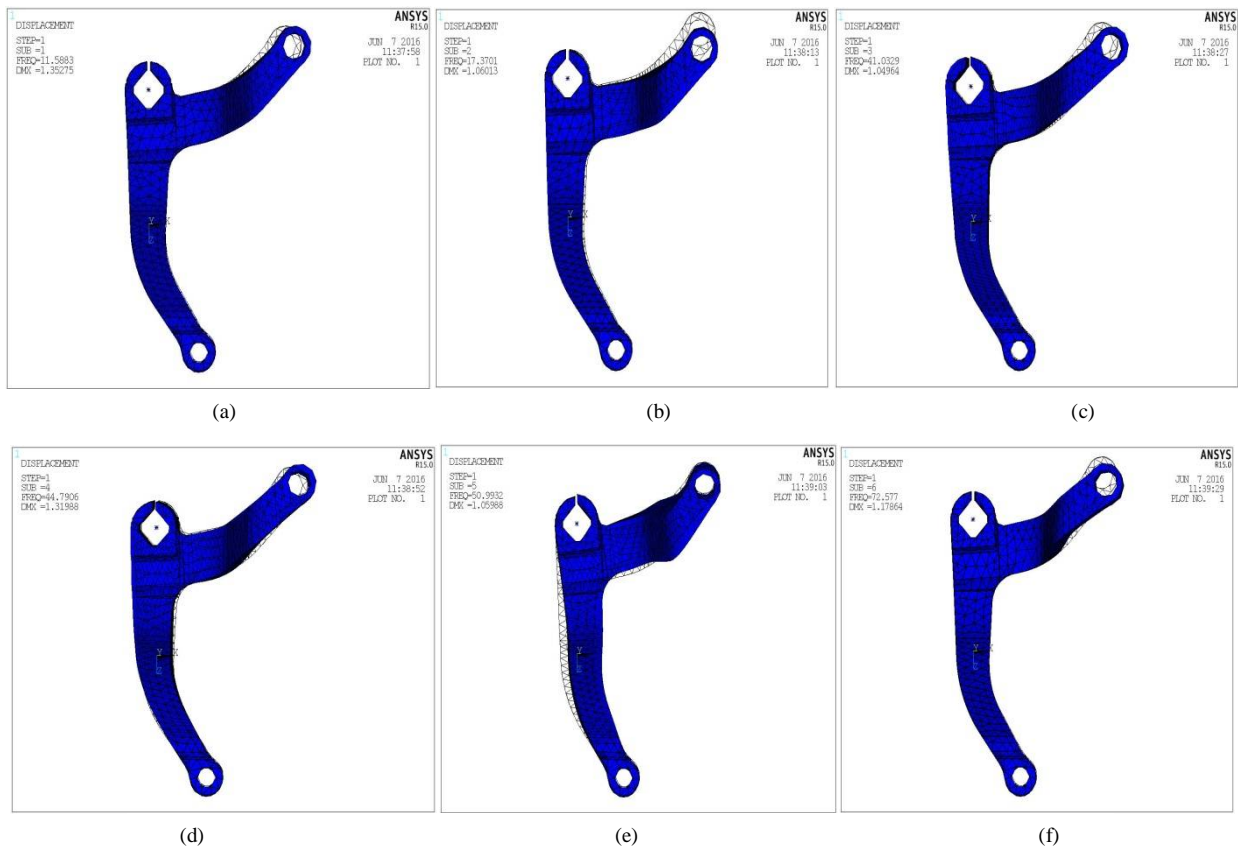
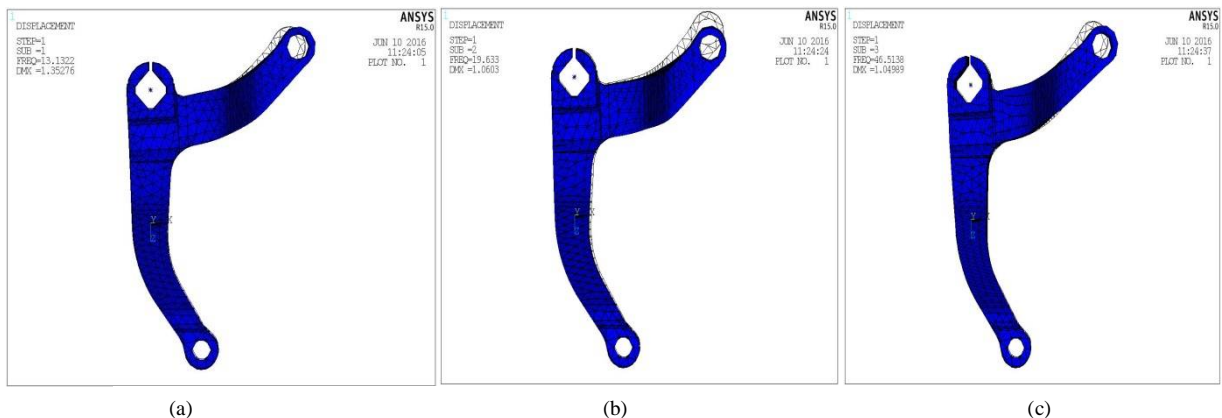


Fig. 6 Modal analysis results of steering lever link using grey cast iron (a) natural frequency at 1st mode shape is 11.58Hz (b) natural frequency at 2nd mode shape is 17.37Hz (c) natural frequency at 3rd mode shape is 41.03Hz (d) natural frequency at 4th mode shape is 44.79Hz (e) natural frequency at 5th mode shape is 50.99Hz (f) natural frequency at 6th mode shape is 72.57Hz



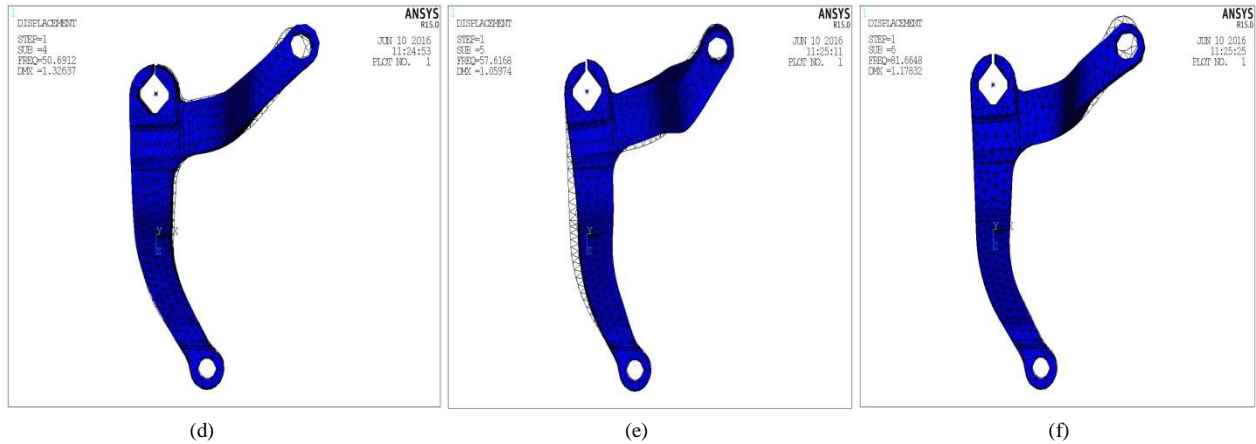


Fig. 7 Modal analysis results of steering lever link using 304 stainless steel (a) natural frequency at 1st mode shape is 13.13Hz (b) natural frequency at 2nd mode shape is 19.63Hz (c) natural frequency at 3rd mode shape is 46.51Hz (d) natural frequency at 4th mode shape is 50.69Hz (e) natural frequency at 5th mode shape is 57.61Hz (f) natural frequency at 6th mode shape is 81.66Hz

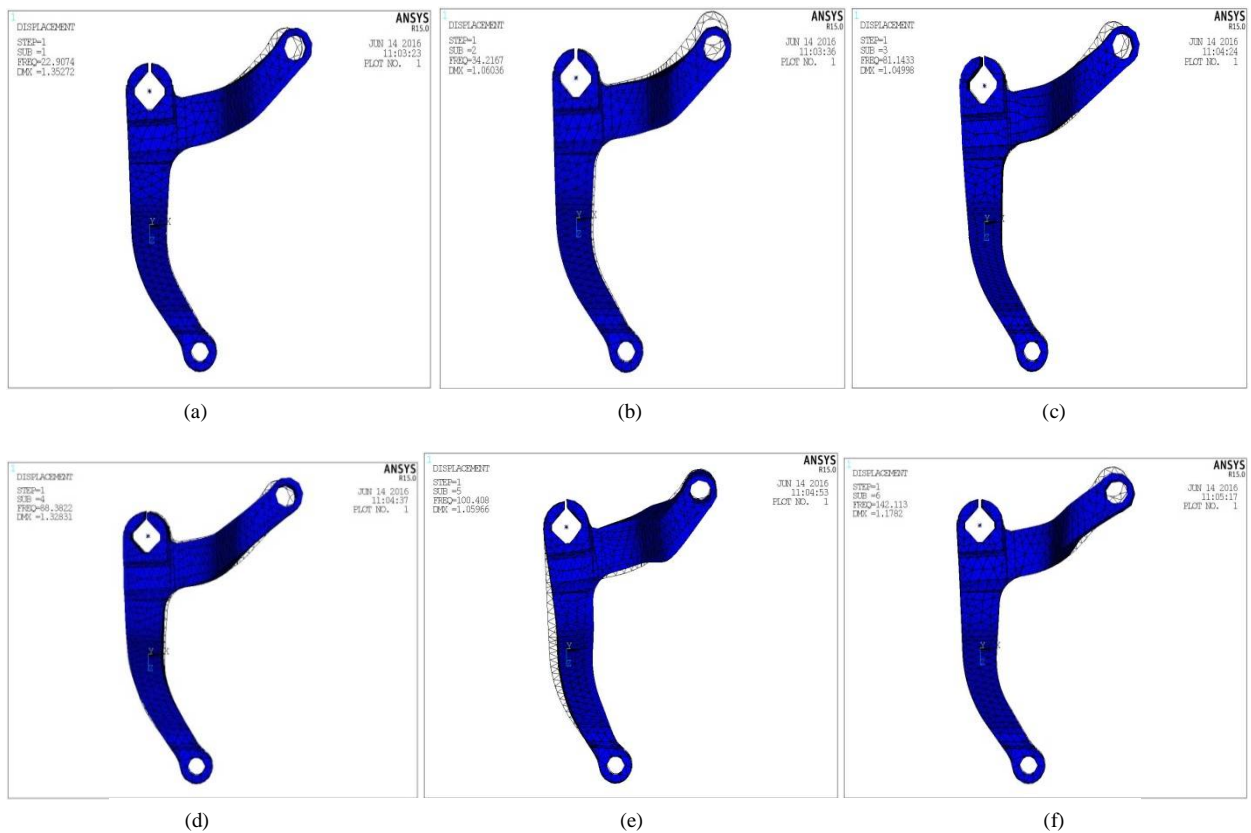


Fig. 8 Modal analysis results of steering lever link using EN 19 alloy steel (a) natural frequency at 1st mode shape is 22.90Hz (b) natural frequency at 2nd mode shape is 34.21Hz (c) natural frequency at 3rd mode shape is 81.14Hz (d) natural frequency at 4th mode shape is 88.38Hz (e) natural frequency at 5th mode shape is 100.40Hz (f) natural frequency at 6th mode shape is 142.11Hz

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

Table 3 static analysis results comparison

Material /Results	Deformation, mm	Vector sum, mm	Vonmises stress, MPa
Grey cast iron	1.059	1.059	403.63
304 stainless steel	0.396	0.396	214.89
EN 19 alloy steel	0.345	0.345	195.66

Table 4 modal analysis results comparison

Natural frequency, Hz / Mode Shape	1	2	3	4	5	6
Grey cast iron	11.58	17.37	41.03	44.79	50.99	72.57
304 stainless steel	13.13	19.63	46.51	50.69	57.61	81.66
EN 19 alloy steel	22.90	34.21	81.14	88.38	100.40	142.11

Static analysis results of steering lever link of a tractor are compared in table 3 and Modal analysis results of steering lever link are compared in table 4. The following results are drawn from the present work:

1. The Brinell hardness of EN 19 alloy steel is 197 which is greater than the Brinell hardness of grey cast iron which is 160 and 304 stainless steel which has Brinell hardness of 123.
2. The Modulus of elasticity of en 19 alloy steel is 190GPa which is greater than modulus of elasticity of grey cast iron which is 140GPa. Therefore en 19 alloy steel is more stiffness.
3. The deformation in EN 19 alloy steel is 0.345mm in static analysis which is less than the deformation in 304 stainless steel which is 0.396 and deformation in grey cast iron which is 1.059 mm
4. The Von mises stresses of EN 19 alloy steel obtained in static analysis is 195.66 MPa which is less than the Von mises stresses of 304 stainless steel which is 214.89 MPa and grey cast iron which is 427.882 MPa.
5. From the frequencies obtained from the Modal analysis it is observed that the Eigen values or natural frequencies of EN 19 alloy steel are 142.11 Hz which are much greater than the frequencies of 304 stainless steel which are 81.66 Hz and grey cast iron which are 72.57 Hz.

IV. CONCLUSIONS

The EN 19 alloy steel is best material from grey cast iron, 304 stainless steel and EN 19 alloy steel which is concluded from the following conclusions

1. The Brinell hardness of EN 19 alloy steel is 18.7 % greater than the Brinell hardness of grey cast iron. The Brinell hardness of 304 stainless steel is 23.1 % lesser than Brinell hardness of grey cast iron. Therefore EN 19 alloy steel is more durable.
2. The deformation in EN 19 alloy steel is 67.4 % less than the deformation in grey cast iron. The Deformation of 304 stainless steel alloy is 62.6 % less than the deformation in grey cast iron. Therefore EN 19 alloy steel has more stiffness than 304 stainless steel alloy and grey cast iron.
3. The Vonmises stresses of EN 19 alloy steel is 51.5% less than the Vonmises stresses of grey cast iron. The Vonmises stress of 304 stainless steel alloy is 46.7% less than grey cast iron.
4. The yield stress of EN 19 alloy steel obtained in static analysis is 195.66 MPa and is within the allowable stress limits of Yield stress which is 700MPa.
5. From the frequencies obtained from the Modal analysis it is observed that the Eigen values or natural frequencies of EN 19 alloy steel are 48.9% greater than the frequencies of grey cast iron. The Eigen values or natural frequencies of 304 stainless steel alloy are 11.1 3 % greater than grey cast iron.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

REFERENCES

- [1] Guru Brahmananda reddy M, A. Nalini Deepthi, Ashraf Shaik, R.Suman, Design and analysis of steering lever link of a tractor .International journal of Eminent engineering technologies, Volume 4, issue 2 Nov 2015.
- [2] Manik A. Patil, Prof. D. S. Chavan, Prof. M. V. Kavade, Umesh. S. Ghorpade, FEA of tie rod of steering system of car, International journal of application or Innovation in Engineering and management, Volume 2, Issue 5, May 2013.
- [3] Mahesh P. Sharma , Denish S. Mevawala, harsh Joshi ,Devandra A. Patel, Static analysis of steering knuckle and its optimization, ISOR-JMCE.
- [4] Ghang Qin, Ying Sun, Yunqing Zhang Omej, Analysis and optimization of the double-axle steering mechanism with dynamic loads, The Open Mechanical Engineering Journal, 2012, 6, (Suppl 1-M2) 26-39
- [5] George Campbell and Wen Ting, "Buckling and geometric nonlinear analysis of a tie rod in NASTRAN VERSION68", Light Truck Divison, Ford Motor Company.
- [6] Michael Adam Kaiser, "Advancements in the Split Hopkinson Bar", Test Faculty of the Virginia Polytechnic Institute, Blacksburg, Virginia May 1, 1998.
- [7] <http://ecoursesonline.iasri.res.in/mod/page/view.php?id=126239> Tractor systems and control.
- [8] R.H. Macmillan The mechanics of tractor – implement performance
- [9] Bekker, M.G. (1956) The theory of land locomotion - the mechanics of vehicle mobility. (University of Michigan Press).
- [10] Sergio Lagomarsino, Chiara Calderini, The dynamical identification of the tensile force in ancient tie-rods, Department of Structural and Geotechnical Engineering, University of Genoa, Via Montallegro 1, 16145 Genova, Italy, 17 January 2005
- [11] Bhagwat Kalyani Bhimrao, S.B. Belkar, Swapnil S. Kulkarni, Topology optimization of steering knuckle arm using finite element method, International journal of scientific research and management studies. Volume 2, Issue 8, pg: 346-351
- [12] Liljedahl, J.B., Turnquist, P.J., Smith, D.W. and Hoki, M. (1989): Tractors and their power units. 4th Edition (Van Nostrand), Chapter 1.