FINITE ELEMENT ANALYSIS OF NCI, GCI AND EN 18 MATERIALS CAMSHAFTS

Neeraj Saraswat, Dr. P.S. Chahuan and Juber Hussain

IPS College of Technology & Mgmt Gwalior (M.P) India

ABSTRACT: *Finite element analysis of the camshafts assembly of different materials with different meshing conditions has been conducted in the present work. Camshafts of Grey Cast Iron, Nodular Cast Iron and EN 18 materials have been considered for analysis in the present work. SolidWorks and ANSYS Software have been used for drafting and FEA analysis of camshaft respectively. The effect of different meshing elements i.e. 10mm, 50mm and 100mm has also been studied. From the results, it has been found that with decrement in the element size, number of nodes and elements increases continuously showing a fine meshing. The effect of different magnitude of load has also been analysed. During analysis, it has been varied from 1kN-1000kN by multiple of 10. Analysis has been done on the basis of deformation, stress and strain generating in the camshaft. It has been found that with increment in the load, deformation and stress generating in the camshaft assembly increase continuously indicating large deformation. It has also been found that the total deformation in the camshaft of EN 18 material is less compared to grey cast iron and nodular cast iron. Camshaft made of nodular cast iron weighs less compared to the camshaft made of grey cast iron and EN 18.*

KEYWORDS: Camshaft, FEA, Material, Element Size.

INTRODUCTION

A cam is a mechanical member used to impart desired motion to a follower by direct contact. The cam may be rotating or reciprocating whereas the follower may be rotating, reciprocating or oscillating. A cam and follower combination belongs to the category of higher pairs. [1]

- A driving member known as the cam.
- A driven member called the follower

Cam can be classified according to the shape, according to the follower movement and according to the constraint manner of the follower. [2]

LITERATURE REVIEW

The several literatures have been reviewed related with analysis of camshaft assembly.

Bayrakceken et al in 2006 [3] conducted the fracture analysis of camshaft assembly of an automobile made of nodular cast iron. They conducted the chemical analysis of the material by using a spectrometer, and found that material is graphite cast iron usually known as ductile iron. They also conducted the scanning electron microscopy (SEM) analysis of the material to find out the reasons for fracture of the material. Fig. below shows the view of the camshaft reviewed by them.

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

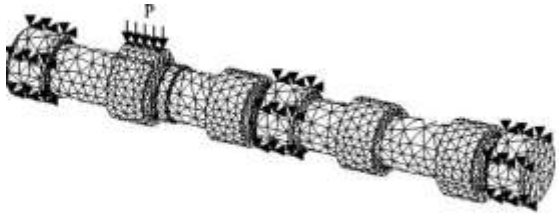


Fig. 1 View of the camshaft studied

Dhavale and Muttagi in 2012 [4] reviewed the modelling and fracture analysis of a camshaft. They studied the multiple degree of freedom and single degree of freedom model of cam follower. They studied that fracture analysis plays an important role in many branches of science like manufacturing, electronics, medical and aerospace.

Wanjari and Parshiwanikar in 2013 [5] studied the failure of the camshaft. They studied that there are two types of arrangements single overhead cams and double overhead cams. They told that in double overhead arrangement one head has two cams and are usually utilized in case of engines having four or more valves per cylinder.

Thorat et al in 2014 [6] conducted the design and analysis of the camshaft utilizing finite element analysis. They targeted their study towards solving a problem of finding exact loads in case of rotating elements. They utilized ANSYS Modal analysis for their work to find out the stress and strain acting on the assembly.

Suhas and Haneef in 2014 [7] conducted the contact fatigue analysis of 6 station 2 lobe camshaft assembly using finite element analysis. They targeted their work to study the hexa-meshing effect, load acting on the shaft, resonance frequency, contact pressure between cam-lobe and plunger , bearing support analysis, load distribution, load calculation based on the spring tension, inlet and outlet fuel pressure.

Jaiganesh et al in 2014 [8] performed manufacturing of PMMA camshaft by rapid prototyping. Rapid prototyping involves 3D computer-aided-design and computer-aided-manufacturing (CAD-CAM) techniques help in quick manufacturing of the products. They used stereo-lithography rapid prototyping techniques to manufacture the camshaft because this process is faster and simpler in manufacturing. Kumar et al in 2015 [9] utilized finite element analysis to study the vibration generated in the camshaft. They targeted their study towards analysing the vibration generated in different camshafts during their work period. They also tried to find out the materials which show no effects on the engine efficiency and also show minimum natural frequency. Different materials considered by them are chilled cast iron, billet steel, EN24 and EN8D.

Chanagond and Raut in 2015 [10] conducted the roller cam finite element analysis by optimising its surface contact area. They targeted their study towards reducing the amount of friction generating between the cam and roller. In general there is a line contact between the cam and roller which increase the friction and reduces the efficiency of the engine in order to reduce the amount of friction between the cam and roller some modifications have been done by them on the cam roller assembly to convert the line contact into point contact in order to reduce the amount of friction generating in the assembly.

Ramadhas et al in 2015 [11] conducted the dynamic analysis of cam and follower by finite element analysis. They utilized FEA software ANSYS 14.5 to study the cylindrical cam and

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

follower arrangement for low speed conditions. They conducted both static and dynamic analysis of the cam and follower assembly during a packaging assembly. Perez et al in 2015 [12] conducted the task analysis and ergonomics evaluation of the camshaft production operation in an industry located in central region of Mexico.

Bongale and Kapilan in 2016 [13] conducted the finite element analysis of camshaft assembly for static and dynamic condition. They modelled the geometry in the Solidedge software and used Hypermesh for meshing of the camshaft assembly.

Ansari et al in 2017 [14] conducted the finite element structural analysis of camshaft of an automobile. They utilized Pro-E and CAE software for geometric modelling of the camshaft assembly and ANSYS for stress, strain and deformation analysis. From the results they found that aluminium metal matrix composites are good material for camshaft assembly based on the deformation and stress generated.

METHODOLOGY

The present work focuses on

1. Drafting of camshaft on SolidWorks.

2. Stress, strain and deformation analysis using ANSYS of GCI, NCI and EN 18. Load applied on the camshaft is varied between 1kN to 1000kN by multiple to 10.

3. Effect of meshing method with three element sizes (10mm, 50mm and 100mm)

4. Comparison of results obtained from FEA to serve the accurate research data for future work.

Fig. 2 illustrates the camshaft assembly drawn on the SolidWorks. Total numbers of 8 cams have been drawn in the present drawing.

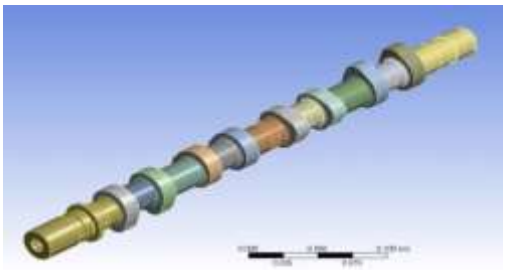


Fig. 2 Geometry of the camshaft assembly

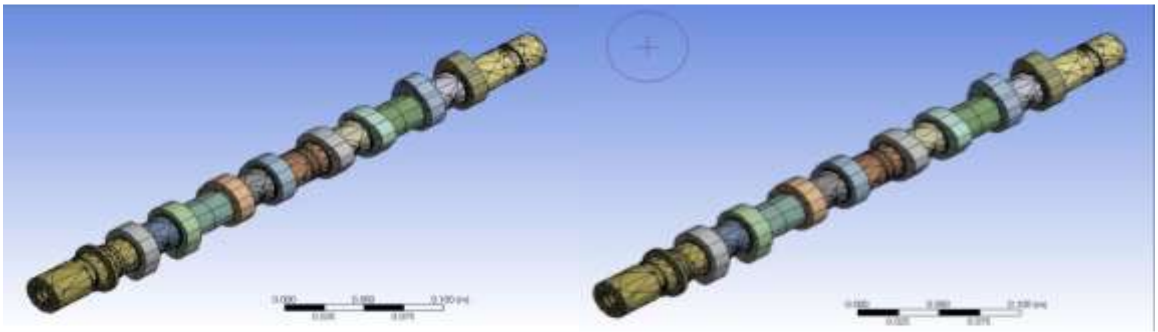
In the present work, nodular cast iron, grey cast iron and EN18 materials are considered as material. Properties of these materials are shown in table 1.

Table 1. PROPERTIES OF MATERIALS CONSIDERED

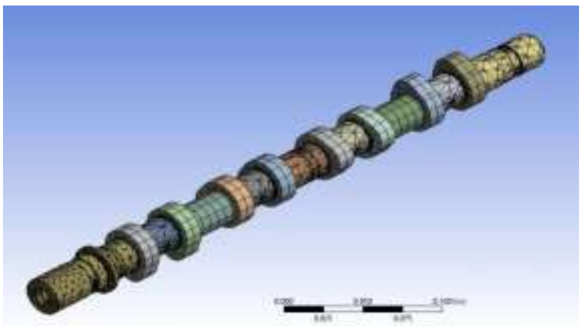
Properties	NCI	GCI	EN18
Density (kg/m^3)	7100	7200	7800
Expansion coefficient (1/K)	1.1×10^{-5}	1.1×10^{-5}	1.26×10^{-5}
Young modulus (GPa)	180	140	210
Poisson's ratio	0.29	0.26	0.3
Tensile yield strength (MPa)	6.7×10^{8}	2.8×10^{8}	2.5×10^{8}
Tensile ultimate strength (MPa)	9.2×10^{8}	4.5×10^{8}	4.6×10^{8}

Meshing of the camshaft

In finite element analysis, one of the important steps is the meshing. To study the effect of the meshing, different sizes of elements are considered. Sizes of elements considered in the present work are 100mm, 50mm and 10mm. Fig. 3 shows the effect of the size of element on the camshaft assembly. Table 2 shows the effect of the size of element on number of nodes and number of elements. It may be observed from the fig. and table 2 that with decrement in element size number of nodes and number of elements are increasing continuously.



(a) 100mm (b) 50mm



(c) 10mm

Fig. 3 Meshed view of camshaft for different size of elements

Table 2. EFFECT OF SIZE OF ELEMENTS

Element size	Number of nodes	Number of elements
100mm	21191	10625
50mm	21389	10696
10mm	33188	17023

ANALYSIS OF THE CAMSHAFT

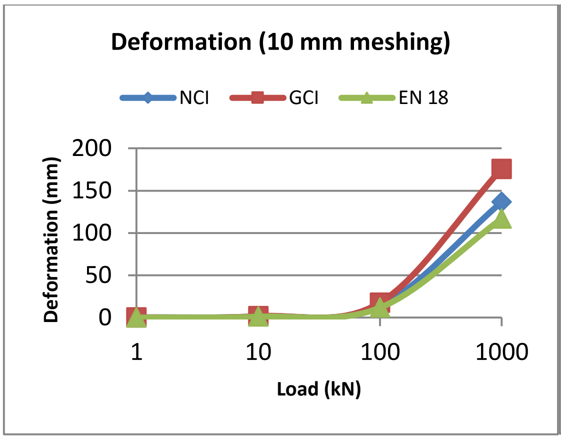
Table 3 shows the deformation generated in the camshaft made of NCI, GCI and EN18 for different size of elements and load values.

Load (KN)	NCI (10 mm) (mm)	GCI (10 mm) (mm)	EN 18 (10 mm) (mm)
1	0.13649	0.17575	0.11692
10	1.3649	1.7575	1.1692
100	13.649	17.575	11.692
1000	136.49	175.75	116.92
Load (KN)	**NCI (50 mm) (mm)**	**GCI (50 mm) (mm)**	**EN 18 (50 mm) (mm)**
1	0.13496	0.17282	0.1156
10	1.3496	1.7282	1.1560
100	13.496	17.282	11.560
1000	134.96	172.82	115.60
Load (KN)	**NCI (100 mm) (mm)**	**GCI (100 mm) (mm)**	**EN 18 (100 mm) (mm)**
1	0.13463	0.17341	0.11531
10	1.3463	1.7341	1.1531
100	13.463	17.341	11.531
1000	134.63	173.41	115.31

Fig. 4 represents the comparison of the deformation generated between the nodular cast iron (NCI), grey cast iron (GCI) and EN 18. Loads are considered on the horizontal axis while on the vertical axis corresponding deformation is plotted. Comparison is done for different meshing size and for different loading condition. Three element sizes considered are 100mm, 50mm and 10mm while four loading values considered are 1kN, 10kN, 100kN and 1000kN. From the figures, it can be seen that with increment in the load, deformation increases. From the figures, it can also be observed that effect of increment in the load is visible when load is

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

increased from 100kN to 1000kN, while for small load values, deformation generated is almost same for NCI, GCI and EN 18. From the figures, it can be observed that deformation generated is less in camshaft of EN 18 material as compared NCI and GCI camshafts. This trend is observed for all values of meshing methods. Effect of meshing method is not visible in the results as the deviations between the results are very less.



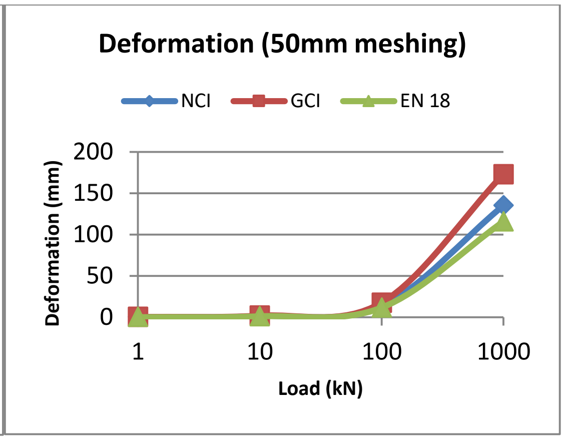


Fig. 4 (a) Fig. 4 (b)

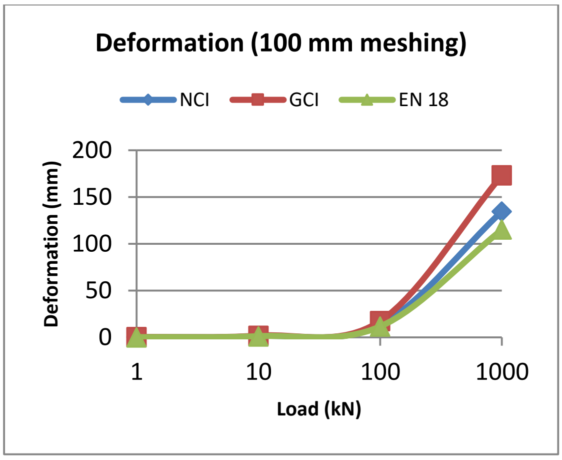


Fig. 4 (c)

Fig. 4 Comparison of deformation between NCI, GCI and EN 18

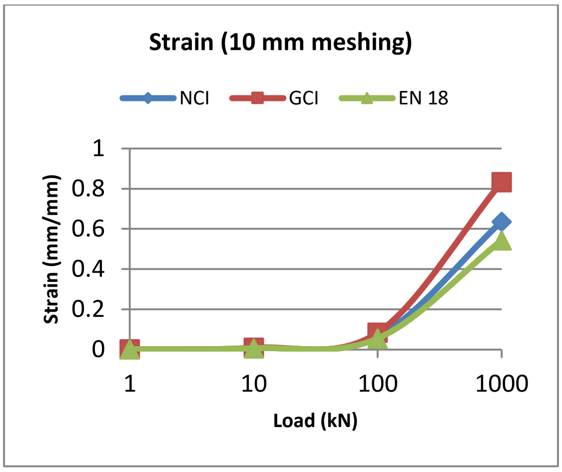
Table 4. STRAIN VALUES OF NCI, GCI AND EN 18

Load (KN)	NCI (10 mm)	GCI (10 mm)	EN 18 (10mm)
1	0.00063649	0.00083242	0.00054216
10	0.0063649	0.0083242	0.0054278
100	0.063649	0.083242	0.054278
1000	0.63649	0.83242	0.54278
Load (KN)	**NCI (50 mm)**	**GCI (50 mm)**	**EN 18 (50mm)**
1	0.0006384	0.083898	0.00054278
10	0.006384	0.0083898	0.0054278
100	0.06384	0.083898	0.054278
1000	0.6384	0.83898	0.54278
Load (KN)	**NCI (100 mm)**	**GCI (100 mm)**	**EN 18 (100mm)**
1	0.00063792	0.00083838	0.00054236
10	0.0063792	0.0083838	0.0054236
100	0.063792	0.083838	0.054236
1000	0.63792	0.83838	0.54236

Table 4 shows the strain generated in the camshaft made of NCI, GCI and EN 18 for different size of elements and load values.

Load (KN)	NCI (10 mm) (MPa)	GCI (10 mm) (MPa)	EN 18 (10mm) (MPa)
1	96.152	96.685	95.982
10	961.52	966.85	959.82
100	9615.2	9668.5	9598.2
1000	96152	96685	95982
Load (KN)	**NCI (50 mm) (MPa)**	**GCI (50 mm) (MPa)**	**EN 18 (50mm) (MPa)**
1	99.911	101.57	99.303
10	999.11	1015.7	993.03
100	9991.1	10157	9930.3
1000	99911	101570	99303
Load (KN)	**NCI (100 mm) (MPa)**	**GCI (100 mm) (MPa)**	**EN 18 (100mm) (MPa)**
1	99.825	101.49	99.216
10	998.25	1014.9	992.16
100	9982.5	10149	9921.6
1000	99825	101490	99216

Table 5 shows the stress generated in the camshaft made of NCI, GCI and EN 18 for different size of elements and load values.



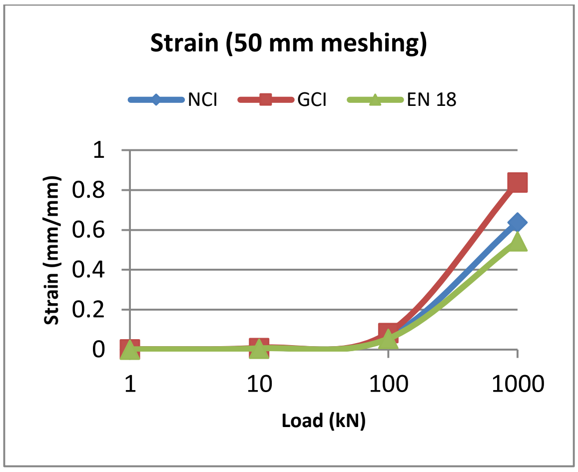


Fig. 5(a) Fig. 5(b)

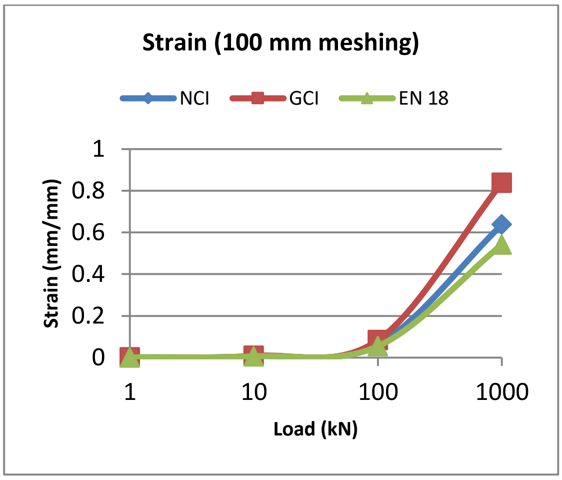


Fig. 5(c)

Fig. 5 Comparison of maximum strain generated between NCI, GCI and EN 18

Fig. 5 represents the comparison of the strain generated between the nodular cast iron (NCI), grey cast iron (GCI) and EN 18. On the horizontal axis load values are considered while on the vertical axis maximum strain generated is plotted. Comparison is done for different loading conditions and for different meshing sizes. Four loading values considered are 1kN, 10kN, 100kN and 1000kN and three element sizes considered are 100mm, 50mm and 10mm. From the figures, it can be seen that with increment in the load, strain increases. From the figures, it can also be observed that effect of increment in the load is visible when load is increased from 100kN to 1000kN, while for small load values strain generated is almost same. From the figures, it can also be observed that strain generated is less for camshaft made of EN 18 compared to the camshaft made of NCI and GCI. This trend is observed for all values of meshing methods. Effect of meshing method is not visible in the results as the deviations between the results are very less.

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

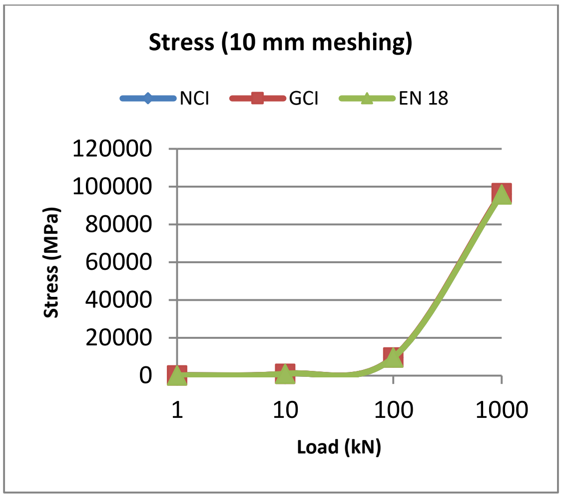


Fig. 6(a)

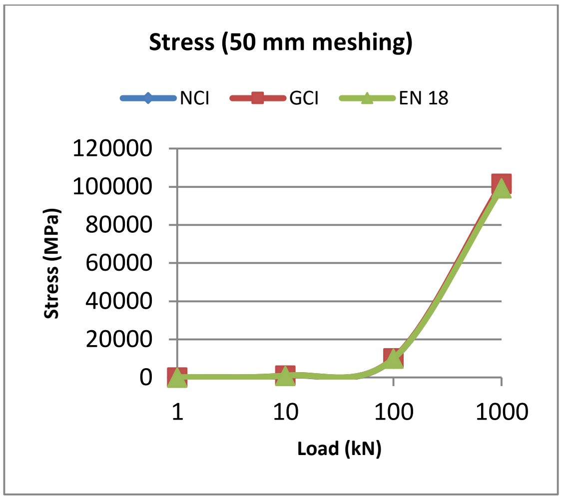


Fig. 6(b)

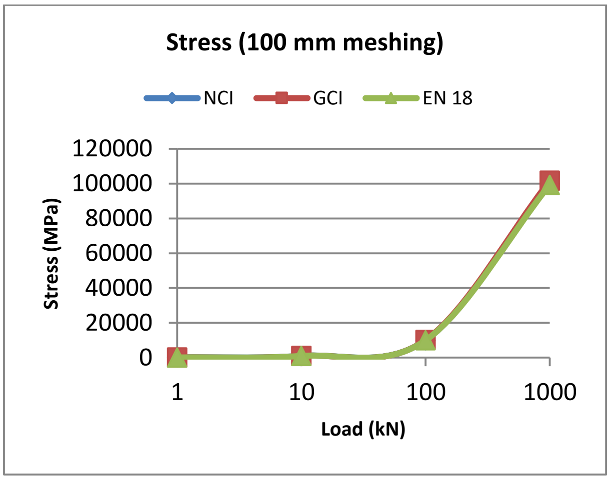


Fig. 6(c)

Fig. 6 Comparison of stress generated between NCI, GCI and EN18

RESULTS

Following Results are obtained through analysis,

With increment in the load, amount of deformation, strain and stress increases.

Effect of increment in load is visible between the range from 100-1000kN.

Camshaft made with EN18 shows least deformation, strain and stress generated compared to the camshaft made of NCI and GCI.

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

CONCLUSIONS

Following conclusions are made by the research,

Camshaft is critical part of the engine assembly.

Finite element analysis of the camshaft assembly can help in getting the accurate results.

Decrement in element size increases the number of nodes and elements, and makes the meshing fine.

EN 18 is new material which can be used to make camshaft and is good in comparison with Nodular Cast Iron and Grey Cast Iron.

FUTURE RESEARCH

Effect of Nonlinearity can be included in the solution procedure.

Effect of thermal stress can be included while solving the problem.

Effect of other materials like steel and alloys can be included for more better comparative study.

REFERENCES

[1] Preben W. Jensen, 1987, Cam Design and Manufacture: 2nd ed., Marcel Dekker, Inc., New York and Basel.
[2] Robert L. Norton P. E., 2009, Cam Design and Manufacturing Handbook: 2nd ed., Industrial Press, New York.
[3] Bayrakceken H., Ucun I., and Tasgetiren S., 2006, Fracture analysis of a camshaft made from nodular cast iron, Engineering Failure Analysis, Vol. 13, pp. 1240-1245.
[4] Dhavale A. S. and Muttagi V. R., 2012, Study of Modeling and Fracture Analysis of Camshaft: A Review, International Journal of Engineering Research and Applications, Vol. 2, Issue 6, pp. 835-842.
[5] Wanjari R. V. and Parshiwanikar T. C., 2013, Failure of Camshaft, International Journal of Innovative Technology and Exploring Engineering, Vol. 2, Issue 6, pp. 248-250.
[6] Thorat S. G., Dubey N., Shinde A., Fulpagare P. and Suryavanshi M., 2014, Design and Analysis of Camshaft, Proceedings of 11th IRF International Conference, 15 June 2014, Pune, India.
[7] Suhas K. S. and Haneef M., 2014, Contact Fatigue Analysis using Finite Element Analysis for 6 Station 2 Lobe Cam Shaft, Indian Journal of Applied Research, Vol. 4, Issue 7, pp. 185-187.
[8] Jaiganesh V., Christopher A. A. and Mugilan E, 2014, Manufacturing of PMMA Cam Shaft by Rapid Prototyping, Procedia Engineering, Vol. 97, pp. 2127 – 2135.
[9] Kumar D., Goyal A., Barmola A., Kushwaha N. and Singha S., 2015, Vibration Analysis of The Camshaft Using Finite Element Method, National Conference On Knowledge, Innovation In Technology And Engineering, 10-11 April 2015, Pp. 251-254.

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

[10] Chanagond A. G. And Raut L. B., 2015, Finite Element Analysis of Roller Cam by Optimisation of Surface Contact area, International Journal of Advanced Engineering Research and Studies, Vol. 4, Issue 2, pp. 5-6.
[11] Ramadhas R., Boopathi S. V. and Dinesh K. R., 2015, Dynamic Analysis of a Cylindrical Cam and Follower using Finite Element Analysis, International Journal on Recent Technologies in Mechanical and Electrical Engineering, Vol. 2, Issue 4, pp. 46-53.
[12] Perez J. N. S., Arellano J. L. H. and Garcia M.C. N., 2015, Task Analysis and Ergonomic Evaluation in Camshaft Production Operations, Procedia Manufacturing, Vol. 3, pp. 4244-4251.
[13] Bongale V. and Kapilan N., 2016, Static and Rotor Dynamic Analysis of Camshaft using Finite Element Analysis, International Journal for Ignited Minds, Vol. 3, Issue 6, pp. 102-109.
[14] Ansari Z., Anwar M. and Ahmed M. Y., 2017, Finite Element Structural Analysis of Automobile Camshaft, International Journal for Research in Applied Science & Engineering Technology, Vol. 5, Issue 2, pp. 464-468.