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Analysis and Study of Cam and Follower through ANSYS and Artificial Neural Network

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ABSTRACT
The life prediction of cam and follower with static and dynamic analysis by finite element analysis (FEA) are studied in this paper. The performance of machine or engine depends on the appropriate working and life of cam and follower. The current cam and follower mechanism in four stroke engines employed a knife edge follower. In static analysis different types of stress developed in cam and follower are considered and in dynamic analysis natural frequency or vibration analysis with respect to given loading condition. The modeling, static and dynamic analysis of Cam and follower is done by using ANSYS 14.0 and life prediction of cam and follower is done by ANN.

KEYWORDS*: Static Analysis, Dynamic Analysis, FEA, ANSYS, ANN.*

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I. INTRODUCTION

A cam is a rotating mechanical element which gives reciprocating or oscillating motion to another element known as follower. Cam makes a higher kinematic pair with follower. Cam mechanisms are widely used because with them, different types of motion can be possible. Cam can provide unusual and irregular motions that may be impossible with the other types of mechanisms. In other word, the cam may be defined as a mechanical member used to impart desired motion to a follower by direct contact. Cam mechanism transforms a rotational or oscillating motion to a translating or linear motion. The variety of different types of cam and follower systems depends on the shape of contacting surfaces of the cam and the profile of the follower. Cams are widely used in automatic machines, internal combustion engines, machine tools, printing control mechanisms and so on. Jevzy Zajaczkowski (2005) has Presented a mathematical model of a cam-driven pattern mechanism by setting differential equations describes the behavior of the system motion of the cam and the follower taking into account the elasticity of its elements and the inertia forces resulting from the oscillatory motion of the pattern cause the speed of driving the cams to fluctuate. Khalil Sherafatnia (2007) has presented Automatic assembly machines have many cam-driven linkages that provide motion to tooling, the dynamic behavior of the components includes both the gross kinematic motion and self induced vibration motion developed. They used solid works CAD software (Pro/Engineering). A three-mass two-degree of freedom dynamic model was created in Simulink taking in a count the impact and the over-travel event of cam follower system machine to obtain improved performance. Advanced Engine Technology (2009) shows that for high-performance engines its need cam shaft design system for computing programs for the design of different types of valve trains. This system is the development of high-quality valve acceleration curves that comply with the hydrodynamic fringe conditions of the charge cycle while providing an oscillation-attenuated valve train which subjected to little dynamic stress. Vasian Paradorn (2009) has presented a mathematical model of a cam-driven pattern mechanism by setting differential equations describes the behavior of the system motion of the cam and the follower taking into account the elasticity of its elements and the inertia forces resulting from the oscillatory motion of the pattern cause the speed of driving the cams to fluctuate. In order to improve the mechanical efficiency of the mechanism, an attempt is made to study the static and dynamic analysis of cam at low speed. In static analysis to study the deflection of cam and follower with respect to angular velocity and in dynamic analysis to calculate natural frequency with respect to given loading condition.

II. MATERIAL AND METHODOLOGY

a). Material - In the present analysis material taken is aluminium alloy and chilled grey cast iron. Aluminium alloy is the alloy in which aluminium is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. Aluminium alloys have properties such as cheap, low density, light weight, high thermal and electrical conductivity, moderate strength, high resistance to corrosion etc. Application in aircraft industries, automotive parts, electrical wiring, decorative purposes, drink cans, window frames etc. Grey cast iron is one of the type of cast iron. It is a ordinary commercial iron having 1.4 to 4.3 % carbon and 0.3 to 5% silicon plus manganese, sulphur and phosphorus. Carbon present in grey cast iron is in the form of free graphite which is grey in colour hence it is known as grey cast iron. Presence of graphite in grey cast iron impart them very good vibration damping capacity. The quick cooling is generally called chilling and the grey cast iron so produced is known as chilled grey cast iron. The surface of chilled iron castings is extremely hard. The depth and hardness of chilled portion may be controlled by adjusting the composition of the metal. Chilled grey cast iron have properties such as low ductility, high thermal conductivity, high compressive strength, low tensile strength, excellent machinability, excellent castability, high wear resistance etc. The applications of chilled grey cast iron are in gears, flywheels, water pipes, engine cylinders, brake discs etc.

b). Stress Analysis - Analysis of cam and follower is done in ANSYS 14.0 software by different stress parameters and natural frequency. Various stresses are Equivalent stress (von-mises), shear stress, maximum shear stress and stress intensity. The Cam and Follower is analyzed in ANSYS in three steps. First is pre-processing which involves modeling geometric clean up, element property definition and meshing. Next step includes solution of problem, which involves imposing boundary conditions on the model and then solution runs. Next in sequence is post processing which involves analyzing the results plotting different parameters like stress and natural frequency.

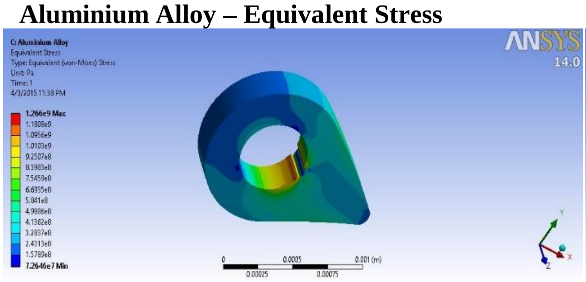
c). Mode Shape - Analysis of both material of cam and follower is performed by ANSYS 14.0 software to determine the vibration characteristics such as natural frequencies and mode shapes. The natural frequencies and mode shapes are important parameters in the design of a cam and follower.And from static analysis check out various deformation and stresses on cam and follower mechanisms.

d). Artificial Neural Network - An artificial neuron network (ANN) is a computational model based on the structure and functions of biological neural networks. ANNs have three layers that are interconnected. The first layer Neurons. Verification of the result is done through ANN consists of input neurons. Those neurons send data on to the second layer, which in turn sends the output neurons to the third layer. An artificial neural network (ANN) is composed of interconnected artificial neurons that mimic some properties of biological Neurons.

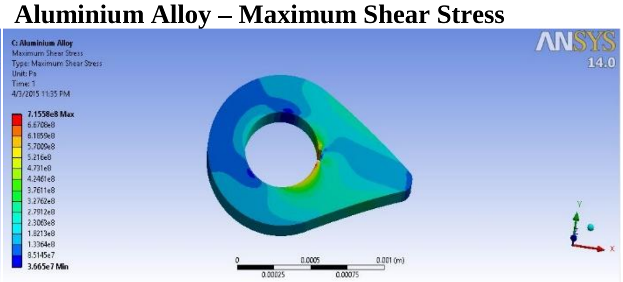
III. PROBLEM DESCRIPTION

In order to predict the life of cam and follower for both material, an attempt is made to study static analysis and dynamic analysis of cam and follower through ANSYS 14.0 software by considering various types of stresses as well as natural frequency and life prediction through ANN.

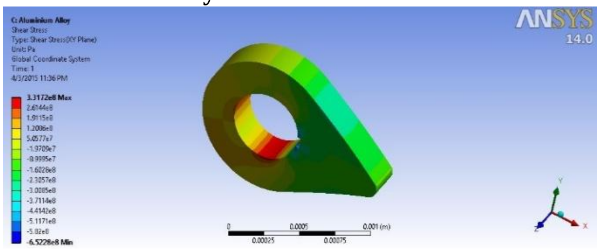
Aluminium Alloy – Equivalent Stress



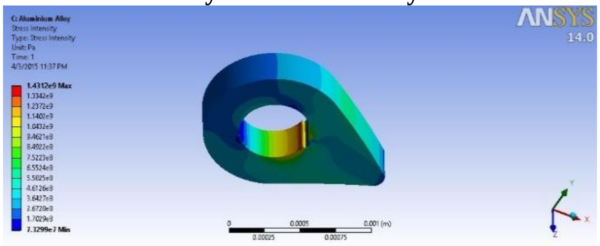
Aluminium Alloy – Maximum Shear Stress



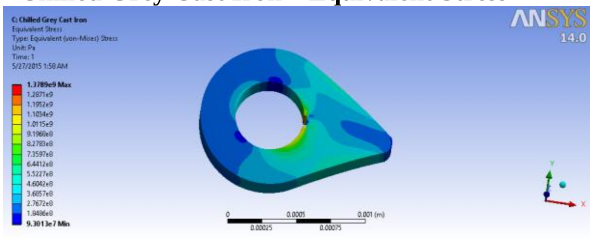
Aluminium Alloy – Shear Stress



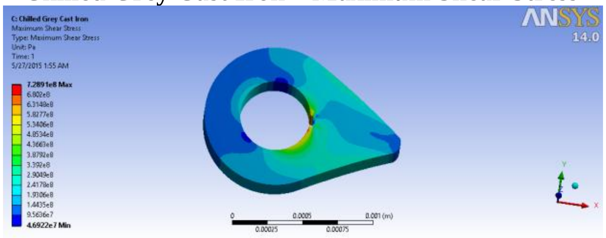
Aluminium Alloy – Stress Intensity



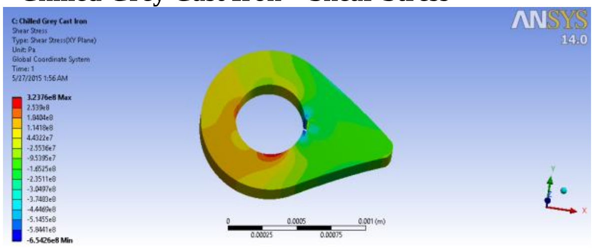
Chilled Grey Cast Iron – Equivalent Stress



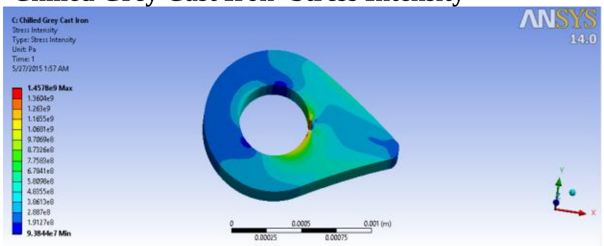
Chilled Grey Cast Iron – Maximum Shear Stress



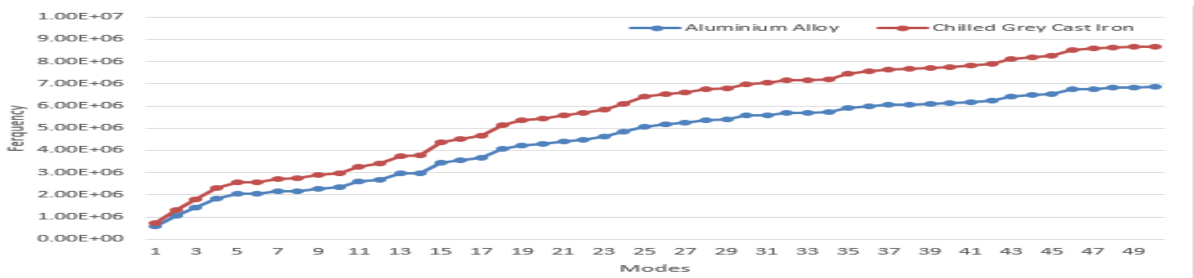
Chilled Grey Cast Iron – Shear Stress



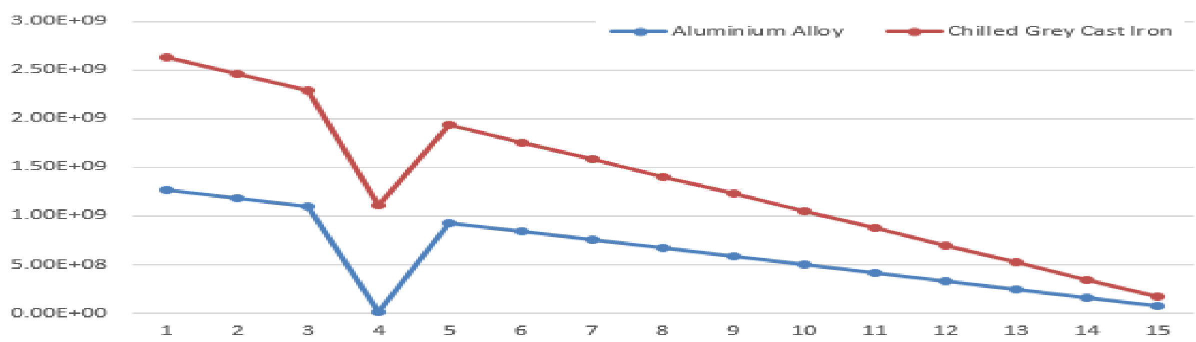
Chilled Grey Cast Iron- Stress Intensity



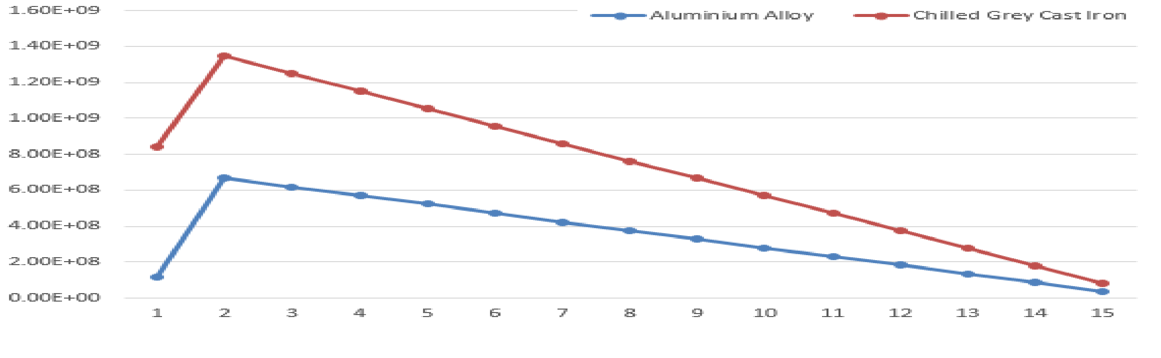
Natural Frequency Vs Mode Shape of Aluminium Alloy and Chilled Grey Cast Iron Cam



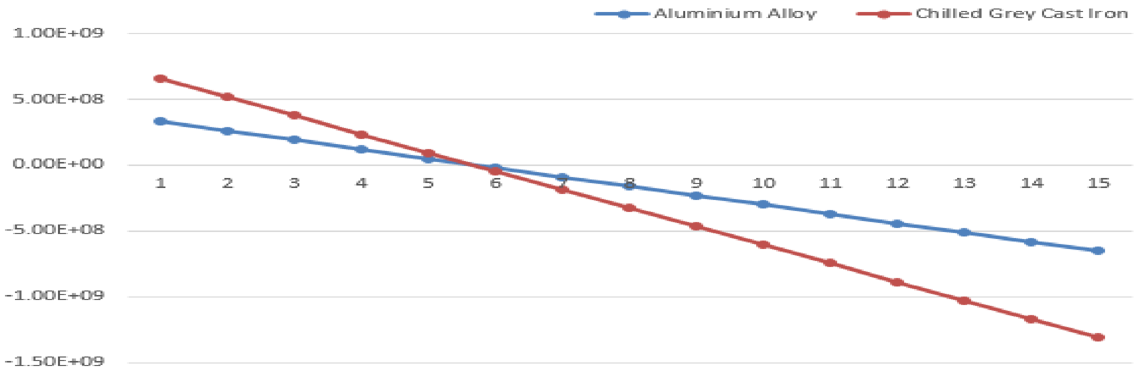
Compare Between Aluminium Alloy and Chilled Grey Cast Iron Equivalent Stress of Cam



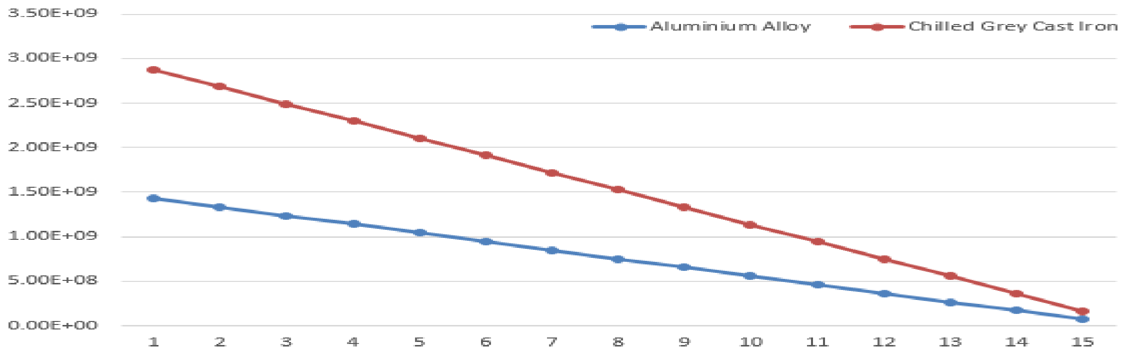
Compare Between Aluminium Alloy and Chilled Grey Cast Iron Maximum Shear Stress of Cam



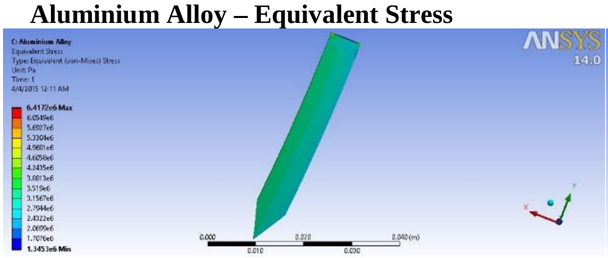
Compare Between Aluminium Alloy and Chilled Grey Cast Iron Shear Stress of Cam



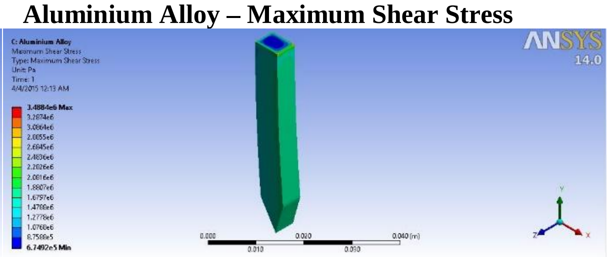
Compare Between Aluminium Alloy and Chilled Grey Cast Iron Stress Intensity of Cam



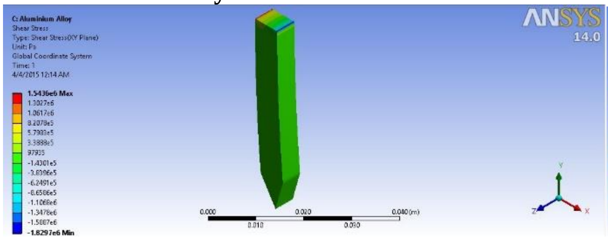
Aluminium Alloy – Equivalent Stress



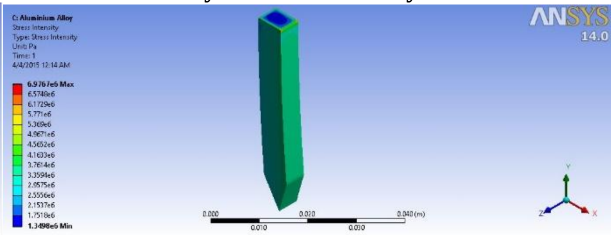
Aluminium Alloy – Maximum Shear Stress



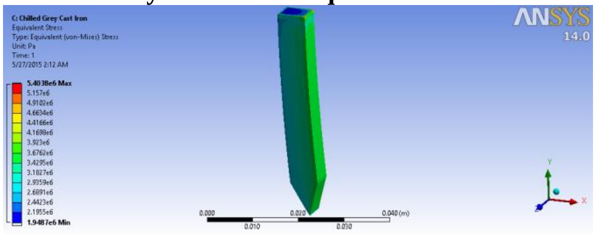
Aluminium Alloy – Shear Stress



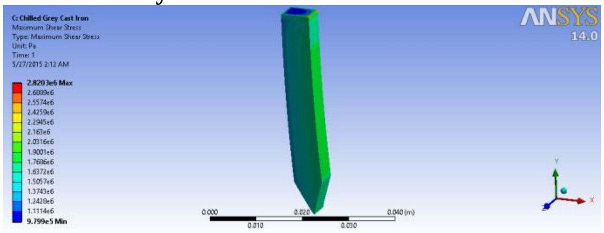
Aluminium Alloy – Stress Intensity



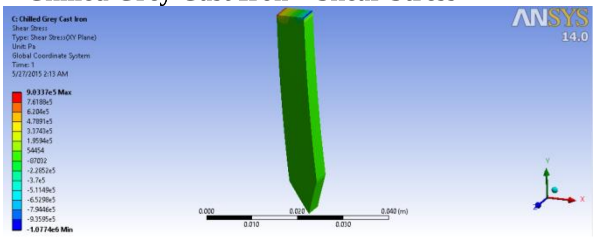
Chilled Grey Cast Iron – Equivalent Stress



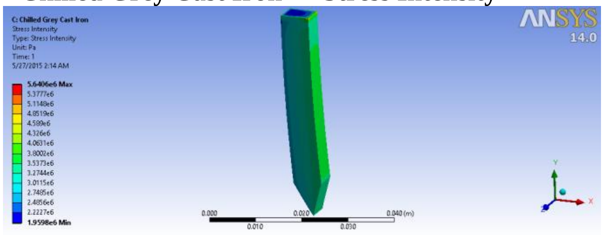
Chilled Grey Cast Iron – Maximum Shear stress



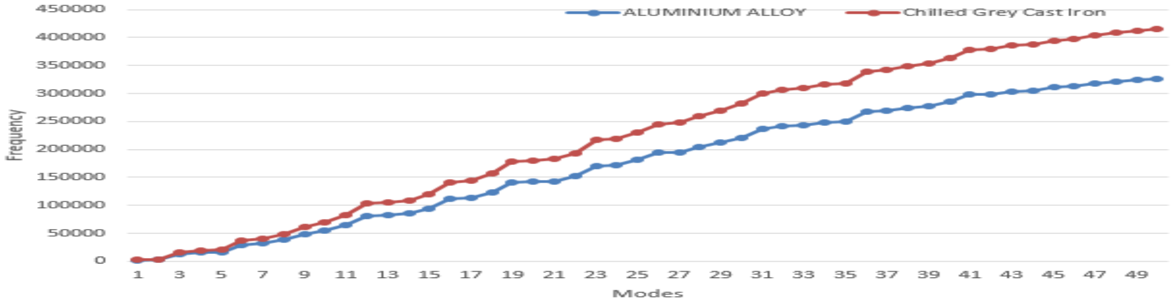
Chilled Grey Cast Iron – Shear Stress



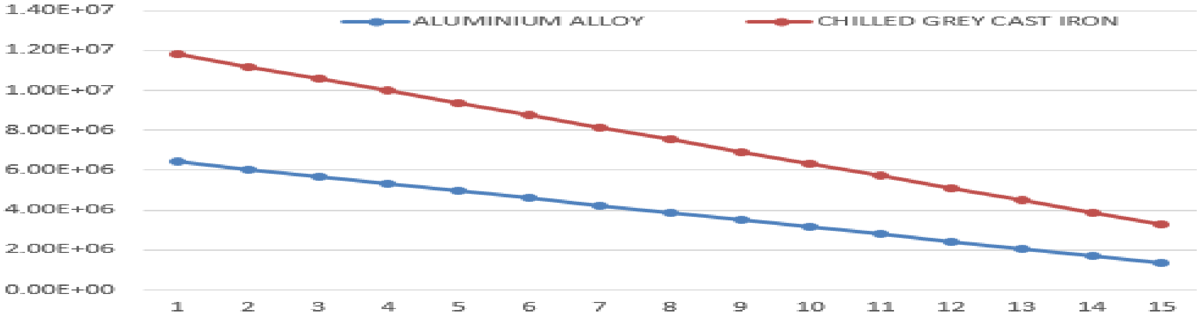
Chilled Grey Cast Iron – Stress Intensity



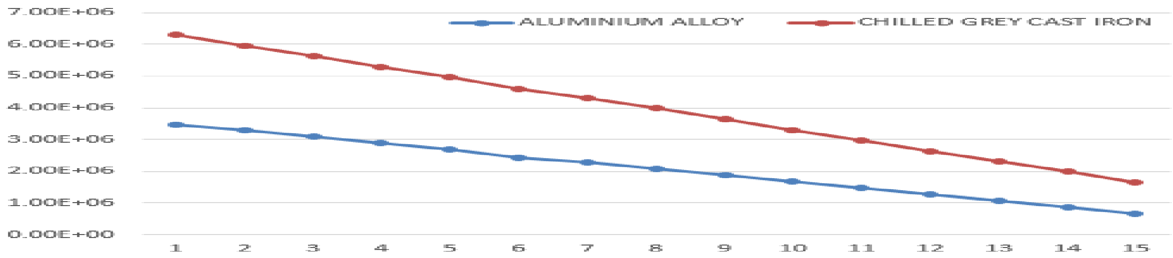
Natural Frequency Vs Mode Shape of Aluminium Alloy and Chilled Grey Cast Iron Follower



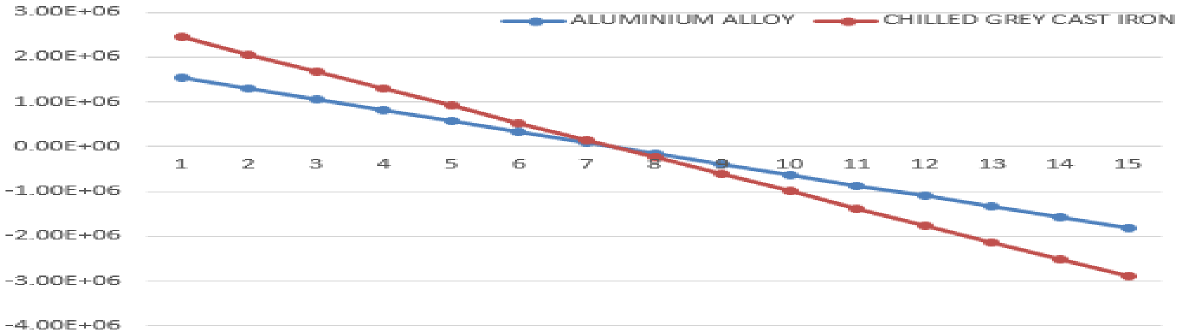
Compare Between Aluminium Alloy and Chilled Grey Cast Iron Equivalent Stress of Follower



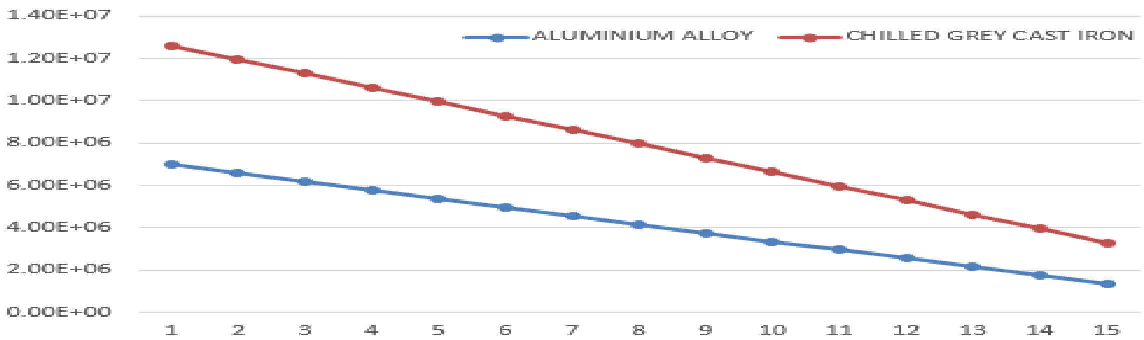
Compare Between Aluminium Alloy and Chilled Grey Cast Iron Maximum Shear Stress of Follower



Compare Between Aluminium Alloy and Chilled Grey Cast Iron Shear Stress of Follower



Compare Between Aluminium Alloy and Chilled Grey Cast Iron Stress Intensity of Follower



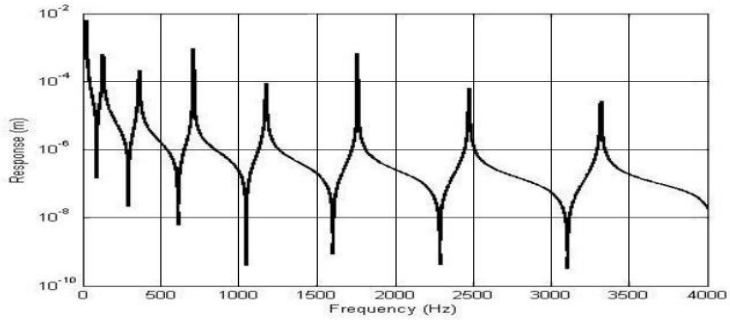
Artificial Neural Network (ANN)

Artificial neural systems are that physical cellular systems which acquire, store and utilize experimental information. Powerful learning algorithm and self-organizing rule allow ANN to self-adapt as per the requirements in continually varying environment (adaptability property). The ANN architecture is a multilayer, feed forward back propagation architecture. Multilayer perception (MLP) has an input layer, output layer and hidden layer. Input vector is incident on input layer and then to hidden layer and subsequently to final layer/output layer via. Weighted connections. Each neuron operates by taking the sum of its weighted inputs and passing the results through a non-linear activation function.

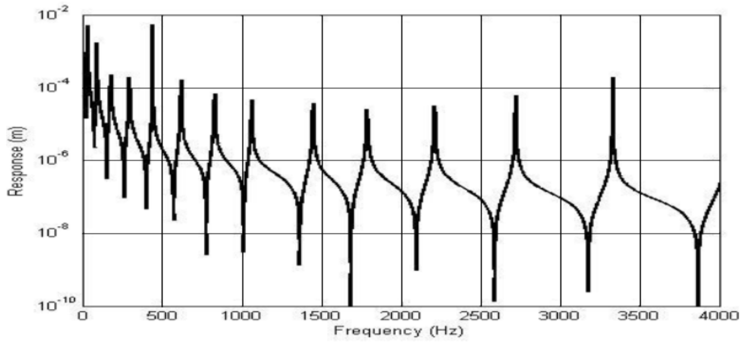
For the prediction of life of cam and follower of both the material an ANN network is developed.

Output of ANN

Aluminium Alloy



Chilled Grey Cast Iron



IV. CONCLUSION

Static Analysis

Aluminium Alloy CAM

From the graph the equivalent stress in cam is continuously increased and its maximum value is $1.2646x10^9$ Pa and its minimum value is $7.2646x10^7$ Pa. The stress intensity in cam is continuously increased and its maximum value is $1.4312x10^9$ Pa and its minimum value is $7.3299x10^7$ Pa. The shear stress in cam is continuously increased and its maximum value is $3.3172x10^8$ Pa and its minimum value is $-6.5228x10^8$ Pa. The maximum shear stress in cam is continuously increased and its maximum value is $7.1558x10^8$ Pa and its minimum value is $3.665x10^7$ Pa.

Chilled Grey Cast Iron CAM

From the graph the equivalent stress in cam is continuously increased and its maximum value is $1.3789x10^9$ Pa and its minimum value is $9.3013x10^7$ Pa. The stress intensity in cam is continuously increased and its maximum value is $1.4578x10^9$ Pa and its minimum value is $9.3844x10^7$ Pa. The shear stress in cam is continuously increased and its maximum value is $3.2376x10^8$ Pa and its minimum value i-$6.5426x10^8$ Pa. The maximum shear stress in cam is continuously increased and its maximum value is $7.2891x10^8$ Pa and its minimum value is $4.6922x10^7$ Pa.

From the analysis of aluminum alloy and chilled grey cast iron cam, chilled grey cast iron cam is better than the aluminum alloy cam.

Aluminium Alloy FOLLOWER

From the graph the equivalent stress in follower is continuously increased and its maximum value is $6.4172x10^6$ Pa and its minimum value is $1.3453x10^6$ Pa. The stress intensity in follower is continuously increased and its maximum value is $6.9767x10^6$ Pa and its minimum value is $1.3498x10^6$ Pa. The shear stress in follower is continuously increased and its maximum value is $1.5436x10^6$ Pa and its minimum value is -$1.8297x10^6$ Pa. The maximum shear stress in follower is continuously increased and its maximum value is $3.4884x10^6$ Pa and its minimum value is $6.7492x10^5$ Pa.

Chilled Grey Cast Iron FOLLOWER

From the graph the equivalent stress in follower is continuously increased and its maximum value is $5.4038x10^6$ Pa and its minimum value is $1.9487x10^6$ Pa. The stress intensity in follower is continuously increased and its maximum value is $5.6406x10^6$ Pa and its minimum value is $1.9598x10^6$ Pa. The shear stress in follower is continuously increased and its maximum value is $9.0337x10^5$ Pa and its minimum value is $-1.0774x10^6$ Pa. The maximum shear stress in follower is continuously increased and its maximum value is $2.8203x10^6$ Pa and its minimum value is $9.799x10^5$ Pa.

From the analysis of aluminum alloy and chilled grey cast iron follower, chilled grey cast iron follower is better than aluminum alloy follower.

Dynamic Analysis

From the analysis, the natural frequency obtained through the graph shows that the frequency of chilled grey cast iron cam and follower is higher than aluminum alloy cam and follower.

Life Prediction

From the analysis through artificial neural network, the output graph of ANN shows that the life of chilled grey cast iron cam and follower is greater as compared to the life of aluminum alloy cam and follower on the basis of static analysis and the dynamic analysis.

REFERENCES

[1]. Advanced Engine Technology, 2009 "Valve Train Design and Calculation for High-Performance Engines".
[2]. Ananthasuresh G. K, "Design of Fully,Rotatable, Roller-Crank-Driven Cam Mechanism for Arbitrary Motion Specifications" Mechanism and Machine Theory, 36: 445-467, 2001.
[3]. Cardona, D., Lens, E., and Nigro, N., 2002, “Optimal Design of Cams”. Multibody System Dynamics, **7**, pp. 285-305.
[4]. Carra, S, Garziera, R., and Pellegrini, M., 2004, “Synthesis of cams with negative radius follower and evaluation of the pressure angle”. Mechanism and Machine Theory, 39, pp. 1017-1032.
[5]. Demeulenaere, B., and De Schutter, J., 2003, “Synthesis of Inertially Compensated Variable-Speed Cams”. Journal of Mechanical Design, 125, pp. 593-601.
[6]. H. Heisler “Advanced Engine Technology,” 2nd Edition, Butterworth-Heinmann, Oxford, 2002.
[7]. Jevzy Zajaczkowski "Application of Mathematical Methods to Designing a Cam-Driven Loom Batten " Fibres and Textiles in Eastern Europe, Vol. 13, No. 3, Page 70, 2005.
[8]. Jesen P. W, "Cam Design andManufacture" 1987, Marcel Dekker, New York and Basel.
[9]. Khalil Sherafatnia "Vibration in Cam- Follower Systems" July 2007.
[10]. Lee M. K, "Design for Manufacturability of Speed-Reduction Cam Mechanisms"M. Eng. Thesis, Department ofMechanical Engineering, McGill University, Monterpal, 2001.
[11]. Mandal, M., and Naskar, T.K., 2009, “Introduction of control points in splines for synthesis of optimized cam motion program”.Mechanism and Machine Theory, 44, pp. 255-271.
[12]. Vasian Paradorn "An Impact Model for the Industrial Cam-Follower System: Simulation and Experiment" Thesis of Master Degree in Mech. Eng. Worcester Polytechnic Institute, October 11th , 2007.
[13]. Yao Y A, Yan H S, Zhang C. Integrated design of cam mechanisms and servo-control systems. Science in China: Series E 2000; 43(5): 511-518.
[14]. Zhang, Y., and Shin, J-H., 2004, “A computational approach to profile generation of planar cam mechanisms”. Journal of Mechanical Design, 126, pp. 183-188.
[15]. Zhang Youhu, Xia Qiuhua. Conical Cam Mechanism Parametric Design and Movement Simulation based on Pro/E, Journal of Mechanical Transmission, 2011, 35(1):31-33.