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Design and Analysis of Multi- Link Structure for Rear Independent *Suspension of Heavy Vehicle*

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ABSTRACT

In this thesis, a multi link structure for rear independent structure of heavy vehicle is designed and modelled in 3D modelling software Creo 2.0. Two models are done by varying the pitch value of spring 12.6mm and 18.5mm. Finite element analysis is performed on the structure by varying materials Chromoly 4130, Alloy Steel 1018, Aluminium alloy 6061. Static, Modal and Random Vibration analysis are done to determine displacements, stresses and frequencies. Analysis is done in Ansys.

INTRODUCTION TO SUSPENSION SYSTEM

Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems must support both road holding/handling and ride quality, which are at odds with each other. The tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

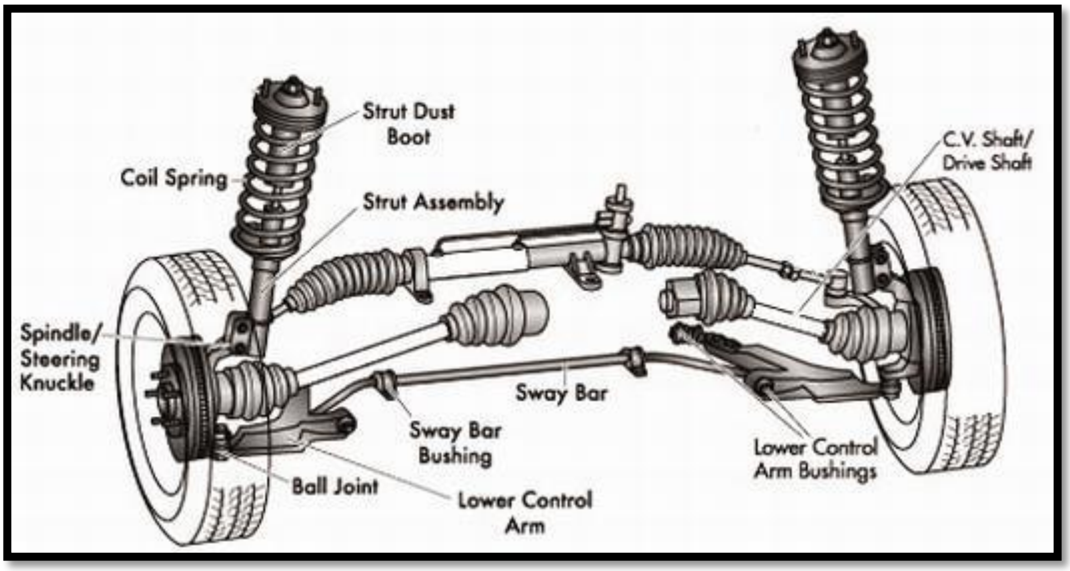

Fig:-Suspension system

Types of suspension systems in a vehicle
Well, the type of suspension to be used depends on the type of vehicle. Broadly, there are 2 types of suspension systems:-

a) Rigid Axle Suspension
b) Independent Suspension
c) Wishbone arm system
d) Trailing link system
e) Sliding pillar Type

MULTI-LINK SUSPENSION

A **multi-link suspension** is a type of vehicle suspension design typically used in independent suspensions, using three or more lateral arms, and one or more longitudinal arms A wider definition considers any independent suspensions having three control links or more multi-link suspensions. These arms do not have to be of equal length, and may be angled away from their "obvious" direction. It was first introduced in the late 1960s on the Mercedes-Benz C111 and later on their W201 and W124series.

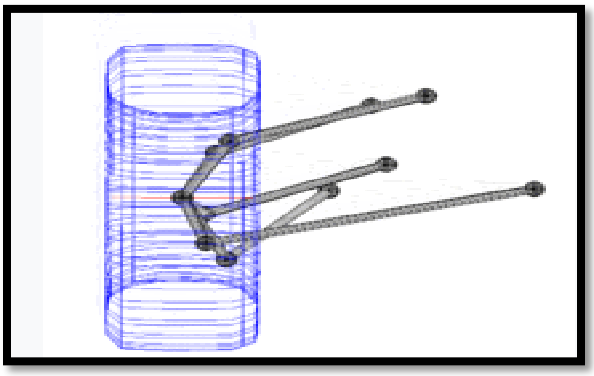

Fig:-Rear view

Weight of the car (W)	Total load=4905+981=5886N
Reaction due to gyroscopic couple	ωw = V/rW = 88.88 rad/sec
Angular velocity of precession	ωp = V/R=0.2222rad/sec
Reaction due to four wheels:	CW = 4IW × ×ωP = 0.2396m
Reaction of ground on each outer wheel and inner wheel	P/2=CW/2x = 0.0739N
Reaction due to rotating parts of the engine	CE=IE,ωE×ωP = =575.94N-m
Reaction of ground on each front and rear wheel	F/2=CE/2b = 106.48N
Reaction due to centrifugal couple	Mc = [M×V2÷R] ×h = 1925.5N-m

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Reaction on ground on each outer wheel and inner wheel	Q/2=C0/2x =594N
Wheel rate: Front Wheel& Rear Wheel:	R1=W1/2+P/2-F/2+Q/2 =2253.44N R2=W1/2-P/2-F/2-Q/2 =1064.49N
Design calculation for spring	Wahl stress factor: KS = 4C-1/4C-4 + 0.615/C =1.2525
	Shear stress: τmax=16×T×K/πd3 τ=480 N/mm2 τ= KS (8PC/πd2) d=74.86mm C = D/d D=54mm Wire diameter = 9mm
	Deflection of spring :(y) Y = 8pc3n/Gd =36.05mm
	Solid length: LS=dn+2d = 90 mm
	Free length of the spring (Lf)= Lf = LS + Y =126.05mm
	Pitch of the coil: (p) P = Lf - LS÷nt + d Nt = n+2=10 P = 12.60mm
	Helix angle :(α)
	α=tan-1[pitch/π×D]=4.24degree

LITERATURE REVIEW

D.S.Balaji, [1],The car model is generated in a virtual representation with the suspension system and the analysis was done by ANSYS. Using modelling software, 3-D models were generated, and the simulation was performed using ANSYS to estimate the value. The analytical values are calculated using vehicle dynamic values and they are entered in the ADAMS software. The construction of track ride analysis is done by road builder. The results of the theoretical values are validated with the values from the finite element analysis.

Dhamodharan.P, [2], In particular, an optimal dimensional synthesis of a five link suspension mechanism in terms of length of the five links and positions of the ten spherical joints, which are installed on the vehicle chassis and wheel carrier, is presented. In this paper, the influence of the complaint joints on the dynamic behaviour of the suspension system is approached, considering the axle guiding linkage used for an off-road vehicle. This optimisation has been carried out by using mat lab optimisation tool box with the aim to obtain a body motion of the wheel carrier with respect to the vehicle chassis as close as possible to a vertical translation. The simulation of the multi-link suspension is performed by using the MBS environment ADAMS of MSC software.

Ernesto ROCCA, [3],A multilink suspension analysis aimed to improve the performances in terms of car handling or comfort, by acting on the components of the suspension itself. In particular the analysis focuses on the effects produced on the suspension characteristic curves by some modifications in rods length. The technique can be adopted in the design phase of a multilink suspension to obtain a desired characteristic, in terms of camber or steering, by optimizing the proper length of each single rod.

MODELING OF MULTI-LINK STRUCTURE

For modelling of multi-link structure for rear independent suspension of heavy vehicle in reference is taken from "Design and Analysis of A Suspension Coil Spring For Automotive Vehicle" By N.Lavanya.

Spring pitch – 12.60mm

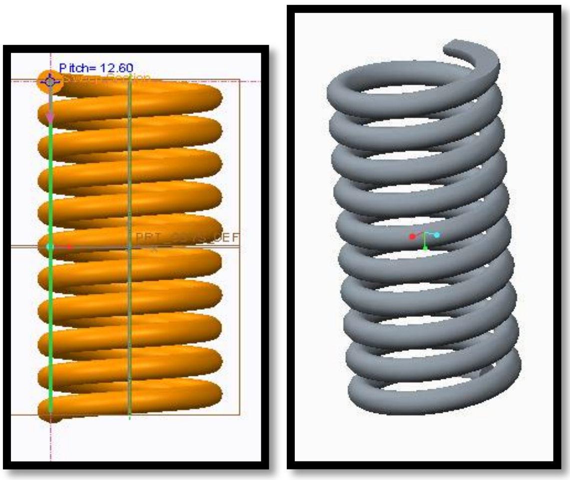

Fig: - Spring

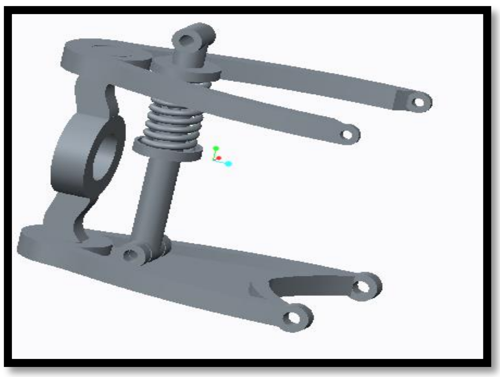

Fig: Final model of multi link structure with spring of pitch 12.6mm

ANALYSIS OF MULTI-LINK STRUCTURE

STATIC STRUCTURAL, MODAL AND RANDOM VIBRATION ANALYSIS

PITCH – 12.60mm

MATERIAL – Chromoly 4130

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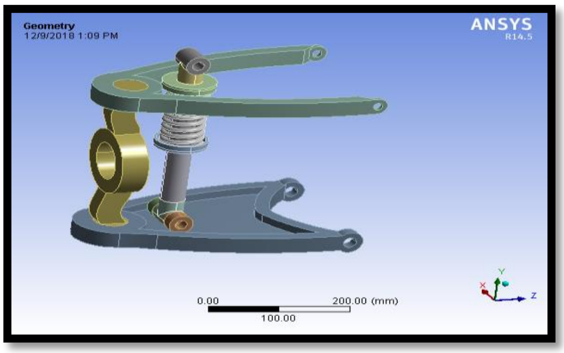

Fig: -Imported Model of multi link structure with 12.6mm pitch

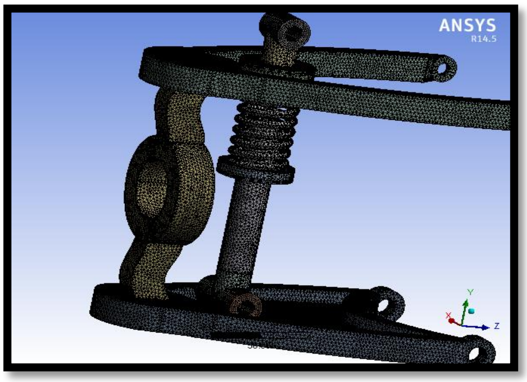

Fig: -Meshed Model of multi link structure with 12.6mm pitch

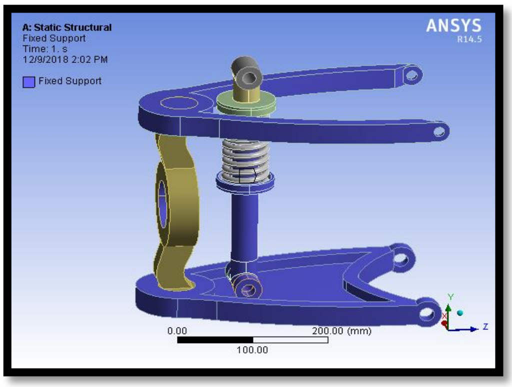

Fig: - Fixed Supports are applied on the base and top supports

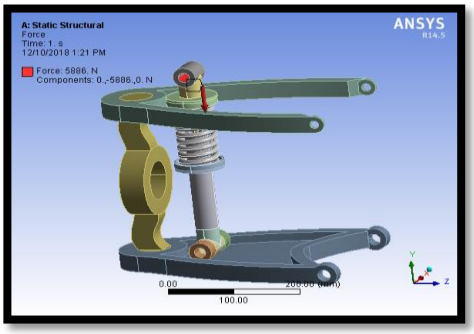

Fig: -Force is applied on the spring piston

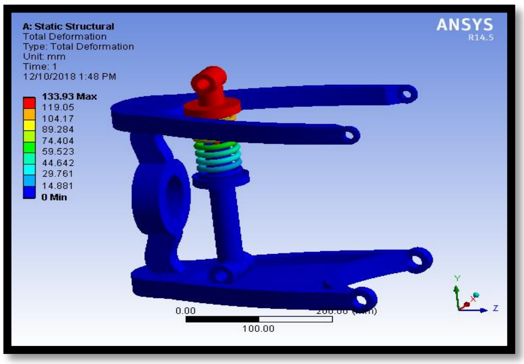

Fig: - Total Deformation in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

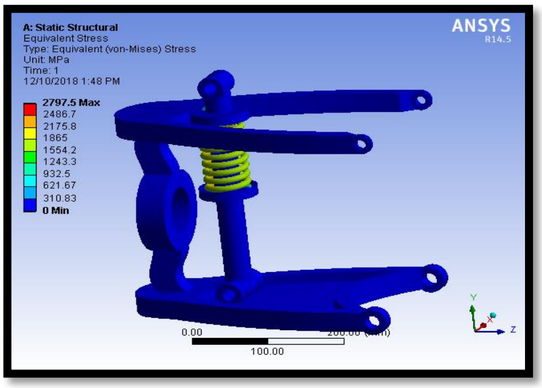

Fig: - Stress in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

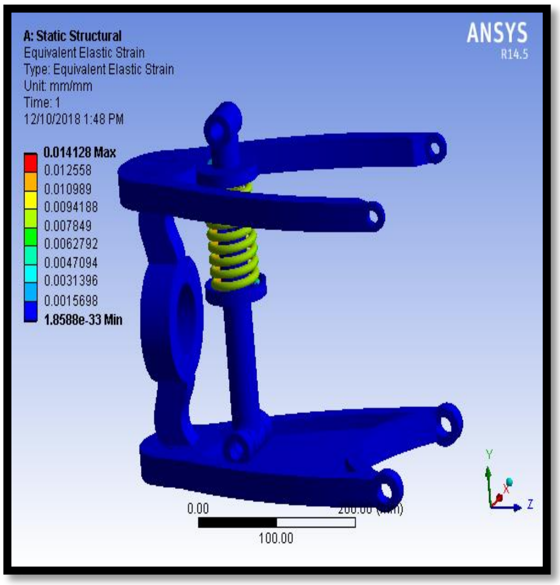

Fig: - Strain in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

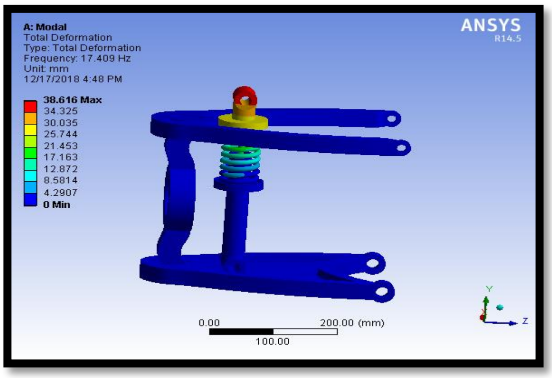

Fig: - Total Deformation 1 in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

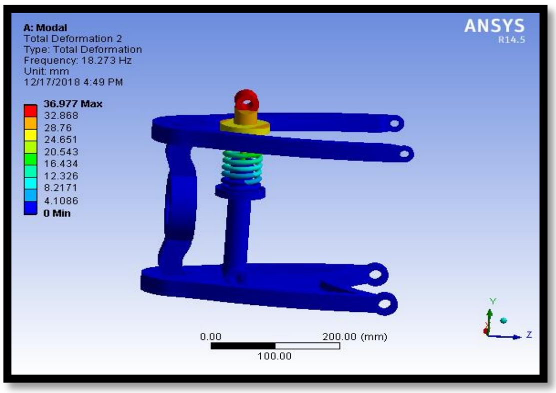

Fig: - Total Deformation 2 in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

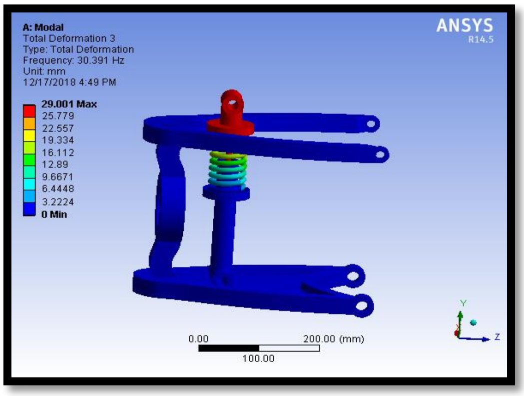

Fig: - Total Deformation 3 in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

Right Click on Random Vibration > Insert >PSD Displacement > Give Requried data.

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Details of "PSD Displacement"

Scope	
Boundary Condition	Fixed Support
Definition	
Load Data	Tabular Data
Direction	Y Axis
Suppressed	No

Tabular Data

	Frequency [Hz]	Displacement [(mm²)/Hz]
1	17.409	1491.2
2	18.273	1367.3
3	30.391	841.06
*		

Fig: - Tabular Data

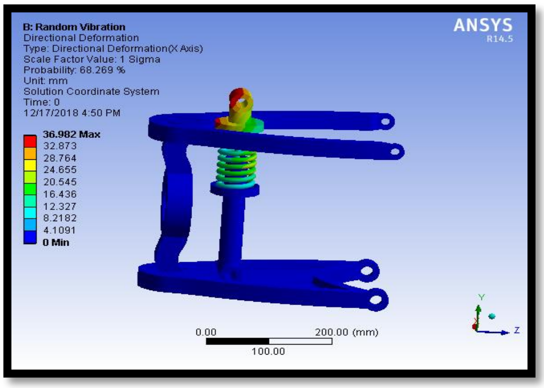

Fig: - Directional Deformation in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

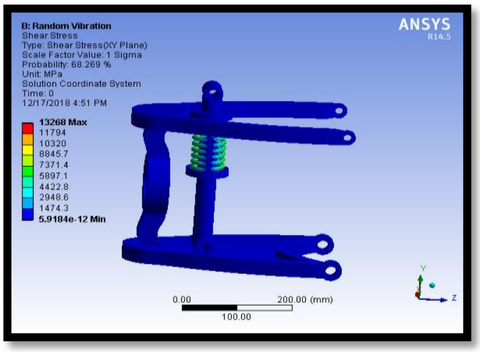

Fig: - Shear Stress in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

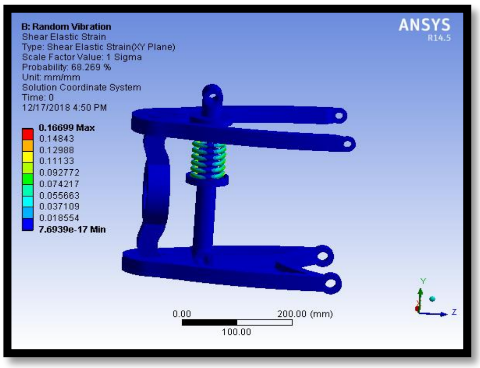

Fig: - Shear Strain in Multi-Link Structure with Pitch of 12.60 mm for Chromoly 4130.

RESULTS& DISCUSSIONS

STATIC STRUCTURAL ANALYSIS

Pitch - 12.60mm

Materials	Deformation (mm)	Stress (MPa)	Strain
Chromoly 4130	14.881	310.83	0.014125
1018 steel	15.253	310.83	0.14481
6061 aluminium	45.621	312.49	0.042142

Pitch – 18.5mm

Materials	Deformation (mm)	Stress (MPa)	Strain
Chromoly 4130	10.336	305.85	0.013808
1018 steel	10.594	305.85	0.014153
6061 aluminium	31.671	305.98	0.041052

By observing the static structural analysis results, the deformation, stress and strain are reducing by increasing the pitch value. The deformation value is less for Chromoly 4130. The stress values for all materials are less than their respective yield stress values. The stress values are reducing by increasing the pitch value. The stress value is reducing by about 0.5% for both Chromoly 4130 and 1008 Steel when compared with Aluminium 6061 with pitch value of 12.6mm. The stress value is reducing by about 0.042% for both Chromoly 4130 and 1008 Steel when compared with Aluminium 6061 with pitch value of 18.5mm. By using Aluminium 6061 material is better due to its less weight.

MODAL ANALYSIS

Pitch - 12.60mm

Material	Total Deformation 1 (mm)	Frequency 1 (Hz)	Total Deformation 2 (mm)	Frequency 2 (Hz)	Total Deformation 3 (mm)	Frequency 3 (Hz)
Chromoly 4130	38.016	17.409	36.977	18.273	29.001	30.391

1018 Steel	38.527	17.241	36.881	18.094	28.99	30.009
6061 Aluminium	40.355	11.379	38.719	11.924	31.854	19.007

Pitch – 18.5mm

Material	Total Deformation 1 (mm)	Frequency 1 (Hz)	Total Deformation 2 (mm)	Frequency 2 (Hz)	Total Deformation 3 (mm)	Frequency 3 (Hz)
Chromoly 4130	71.992	94.074	69.087	128.43	98.201	204.9
1018 Steel	33.718	0	39.415	9.0745	77.774	53.158
6061 Aluminium	95.941	105.45	249.61	133.98	185.42	243.29

By observing the modal analysis results, the deformation values are increasing by increasing the pitch value. The deformation value is more for Aluminium 6061. The frequency values are increasing by increasing the pitch value. The frequencies are less when 1018Steel is used.

RANDOM VIBRATION ANALYSIS

Pitch – 12.6mm

Materials	Directional Deformation (mm)	Shear Stress (MPa)	Shear Strain (mm/mm)
Chromoly 4130	36.982	$5.9184e^{-12}$	0.16699
1018 steel	36.796	$5.9184e^{-12}$	0.16588
6061 aluminium	21.899	$3.3554e^{-12}$	0.12973

Pitch – 18.5mm

Materials	Directional Deformation (mm)	Shear Stress (MPa)	Shear Strain (mm/mm)
Chromoly 4130	65.625	$2.2139e^{-13}$	0.26965
1018 steel	64.965	$2.2139e^{-13}$	0.2681
6061 aluminium	60.583	$1.6169e^{-13}$	0.20833

By observing the random vibration analysis results, the directional deformation is increasing and shear stress value is decreasing by increasing the pitch value. The directional deformation value is less for Aluminium 6061. The shear stress value is reducing by about 43% for Aluminium 6061 when compared with other two materials with pitch value of 12.6mm. . The shear stress value is reducing by about 27% for Aluminium 6061 when compared with other two materials with pitch value of 18.5mm.

CONCLUSION

By observing the static structural analysis results, the deformation, stress and strain are reducing by increasing the pitch value. The deformation value is less for Chromoly 4130. The stress values for all materials are less than their respective yield stress values. By using Aluminium 6061 material is better due to its less weight.

By observing the modal analysis results, the deformation values are increasing by increasing the pitch value. The deformation value is more for Aluminium 6061. The frequency values are increasing by increasing the pitch value. The frequencies are less when 1018Steel is used.

By observing the random vibration analysis results, the directional deformation is increasing and shear stress value is decreasing by increasing the pitch value. The directional deformation value is less for Aluminium 6061. The shear stress value is reducing by about 43% for Aluminium 6061 when compared with other two materials with pitch value of 12.6mm. . The shear stress value is reducing by about 27% for Aluminium 6061 when compared with other two materials with pitch value of 18.5mm.

So it can be concluded that using Aluminium 6061 is better at pitch value 18.5mm.

REFERENCES

[1] D.S.Balaji, S Prabhakaran, K.Umanath,Design and analysis of the double wishbone suspension system,

[2]Dhamodharan.P,Mohamed Raafiq.N,b,Madhu.S,MULTI LINK SUSPENSION MECHANISM WITH COMPLIANT JOINTS,International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.33 (2015).

[3]Ernesto ROCCA, Francesco TIMPONE, Analysis of Multilink SuspensionCharacteristics due to the Rods Length Variations, Proceedings of the World Congress on Engineering 2016 Vol II.

[4] Bhagwat Vishal , Deokar Monika , Ghatkar Omkar , Tunge Vaishnavi , Prof. Londhe B. Design and Development of Multi-Linkage Suspension System in Heavy Vehicles,International Research Journal of Engineering and Technology (IRJET) , Volume: 05 Issue: 09 | Sep 2018.

[5] Kikuo Fujita,Noriyasu Hirokawa,Shinsuke Akagi,Takanori Hirat,Design optimization of multi-link suspension systemfor total vehicle handling and stability,American Institute of Aeronautics and Astronautics.

[6] Vijay Rathor , P.Srinivasa Kumar , P. H. V. Sesha Talapa Sai,Four Link Suspension For Heavy Vehicles,IJARIIE, Vol-1 Issue-3 2015.

[7] Duygu GULER,DYNAMIC ANALYSIS OF DOUBLE WISHBONE SUSPENSION,

Graduate School of Engineering and Sciences of Izmir Institute of Technology,July 2006.

[8] Wable Abhay S. , Prof Londhe B.C. , Prof Wable A.D,Multi-link structure for rear independent suspension of heavy vehicle,International journal of mechanical engineering and technology (ijmet),Volume 6, Issue 5, May (2015).

[9] Dishant, Er.Parminder Singh, Er.Mohit Sharma,Suspension Systems: A Review,

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 04 | Apr -2017.

[10]Amol Lokhande, Abhishek Nair, Mayur Muthal, Shubham Nehe, Omkar Patwardhan, Design & analysis of double wishbone suspension system,International Journal of Advance Engineering and Research Development Volume 5, Issue 05, May -2018