INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD
ISSN(O): 2455-0620 [Impact Factor: 9.47]
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value : 86.87
Volume - 10, Issue - 12, December - 2024

DOIs:10.2015/IJIRMF/202412021 --:-- Research Paper / Article / Review

Design, Modify and analyse of ATV Gear Shifter to optimise material and shape for reduction in weight and increase in strength

Shalender Singh Bhandari[1] , Prof. D.S. Chaudhari[2]
[1]P.G Scholar Mechanical Engineering, and [2]Professor of Mechanical Engineering,
Gokhale Education Society's R. H. Sapat College of Engineering, Management Studies and Research, Nashik, Maharashtra-422005 (India)
Email - bhandari.me01@gmail.com

Abstract: *The fork's primary purpose is to allow the gears to be engaged or disengaged in accordance with the specified gear ratio. The gearbox's primary job is to move the fork into the proper engagement between the synchronizer ring and the required gears. Since the fork is subjected to loads when shifting gears, it is vital to monitor the loads on it to guarantee a long service life. The stress analysis and gear shift fork optimisation are the main topics of study in this review. The gear shift fork's primary purpose is to facilitate the appropriate engagement and disengagement of the necessary gear in order to attain a particular transmission ratio. The purpose of this study is to conduct a review of analysis and develop a new, optimised fork design. In this review study we got to know the use of FEA method used for analysis under some stresses and constraints. Generally, Ansys software is utilized for analysis in various papers.*

Keywords: *stress analysis, gear shifter fork, optimization, Ansys.*

1. INTRODUCTION:

The driver's experience during gear changing has been crucial in the design stage of the shifting systems because to the market's more stringent quality criteria for the vehicle comfort in recent years. In order to explain the application and practice of ergonomics in the creative design of the vehicle shifting device, this study integrates ergonomic theory with the vehicle shifting device. First, the GSA analysis system is used to pre-evaluate the vehicle's overall static and dynamic shifting performance. Ultimately, post-test analysis is done to confirm the efficiency in improving the Driving experience of the whole vehicle, and ultimately enhance the competitiveness of the studied shifting device in the vehicle industry. [1]

One of the essential components of the vehicle's speed-shifting mechanism, the fork plays a crucial function in adjusting the vehicle's direction and speed. The synchroniser's ring gear may be moved by the fork to split and reunite, allowing for the achievement of speed shifting. [2]

1.1 Sequential Gear Shifter for All Terrain Vehicles:

An all-terrain vehicle (ATV), also known as a quad, three-wheeler, four-track, four- wheeler, or quadricycle, as defined by the American National Standards Institute (ANSI) is a vehicle that travels on low-pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. As the name implies, it is designed to handle a wider variety of terrain than most other vehicles. In India, All terrain vehicles stands for the three wheelers which comprises of Auto Rickshaws, the Passenger seats Three Wheeler. Some of the Common Manufacturers of this kind of Vehicles are Bajaj, Mahindra and Mahindra, Piaggo Vehicles, Force Auto, TVS, Scooters India Forces Acting on Sequential gear.[4]

Fig. 1. The gear shifting mechanism and gear shifting fork[2]

Figure 2. Sequential Gear Shifter [2]

2. Problem Statement:

A Sequential Gear Shifter is designed considering all the stress and loads. The Modification of the shifter is done to meet the new requirements of the vehicle engine power transmission. Due to the modification, there will be increase in weight of the shifter, hence so as to maintain the Strength and reduce the weight, material optimization of the mechanism is necessary, hence for the same material optimization will be done.

3. Objectives of Study:

- 'To design, modify and analyse the Sequential gear shifter to material and shape optimization for reduction in weight and increase in strength"
- To analyse the different Loads acting on the shifter mechanism during static and dynamic conditions.
- To modify the size of the shifter mechanism, so as to meet the current power transmission requirement.
- To analyse the effect of Stress and Loads acting on the Mechanism by Finite Element Analysis.
- To Find Best possible alternative material, so as to maintain/increase the strength thereby reducing the weight.

4. Parameters

For Design of experiments we have 3 Designs, 3 Loading conditions and 3 Materials as follows:

Design			**Force**			**Material**		
D1	D2	D3	F1	F2	F3	M1	M2	M3
			Moment	Twist	Pull	BEL 220H	AL A360	AL7075
			3.9 N-m	3.9 N-m	150 N			

Table.1 Parameters

5. Designs

A. Design 1:

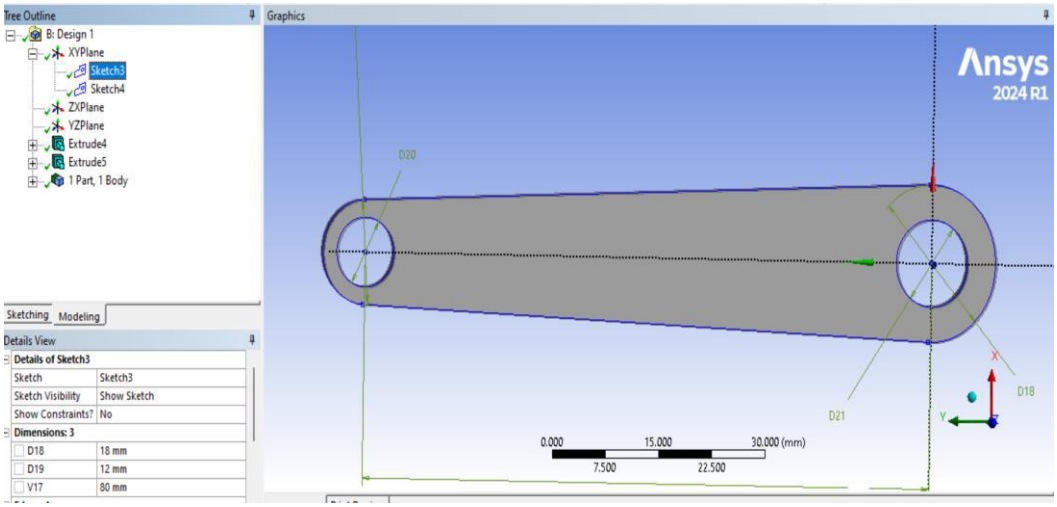

Fig.3 Design 1

B. Design 2:

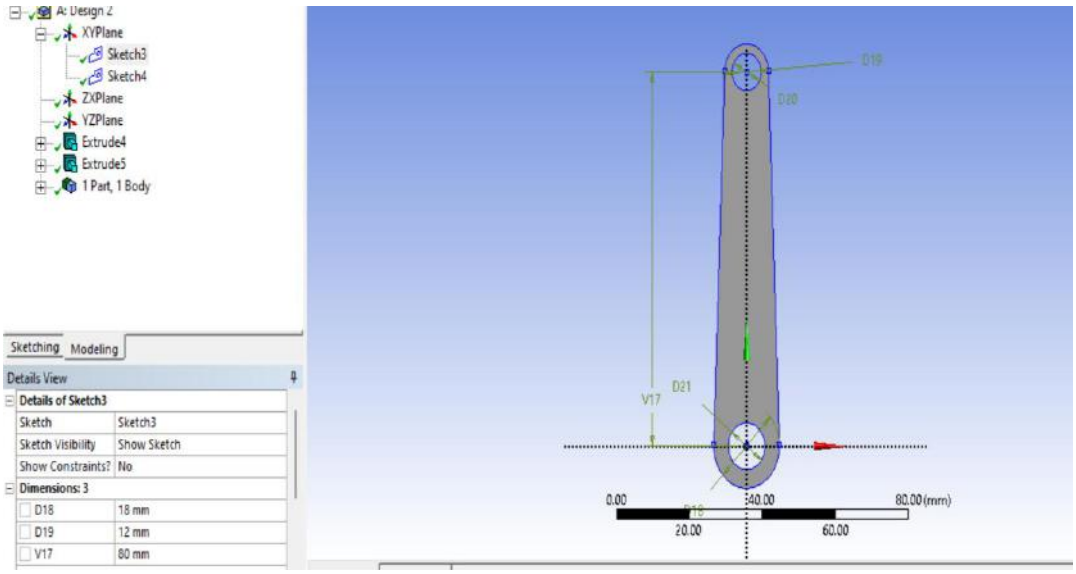

Fig.4 Design 2

C. Design 3:

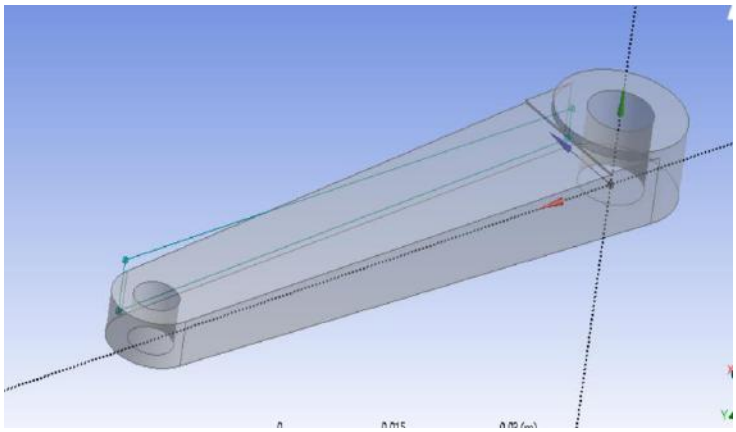

Fig. 5 Design 3

6. Finite Element Analysis

6.1 Sample FEA Plot:

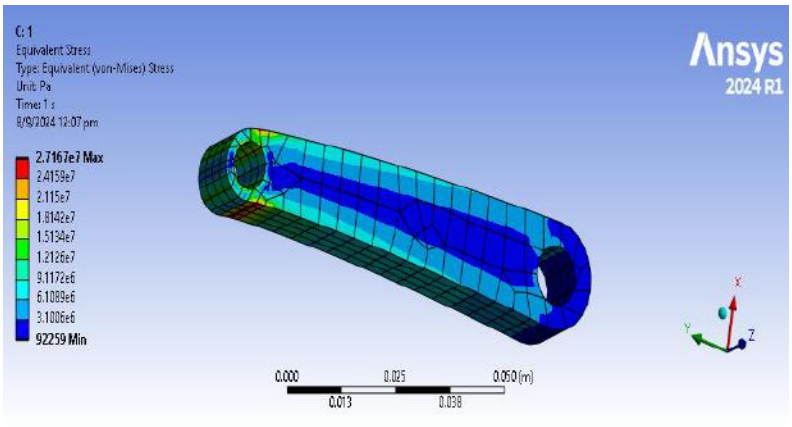

Fig.6 Stress Analysis Experiment no.1

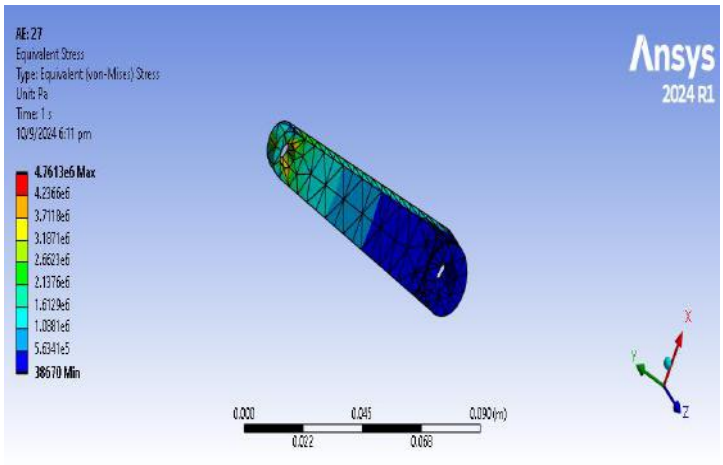

Fig.7 Stress Analysis Experiment no.27

6.2 Finite Element Analysis Results- Equivalent von misses stress

Sr.No	Parameters			Maximum stress (MPa)	Safe/Not Safe
1	D1	M1	F1	27.16	Safe
2	D1	M2	F1	26.93	Safe
3	D1	M3	F1	25.92	Safe
4	D1	M1	F2	114.32	Safe
5	D1	M2	F2	36.31	Safe
6	D1	M3	F2	28.16	Safe
7	D1	M1	F3	3.65	Safe
8	D1	M2	F3	4.32	Safe
9	D1	M3	F3	3.48	Safe
10	D2	M1	F1	38.02	Safe
11	D2	M2	F1	36.44	Safe
12	D2	M3	F1	37.86	Safe
13	D2	M1	F2	42.68	Safe
14	D2	M2	F2	57.89	Safe
15	D2	M3	F2	43.65	Safe

16	D2	M1	F3	5.12	Safe
17	D2	M2	F3	6.09	Safe
18	D2	M3	F3	4.94	Safe
19	D3	M1	F1	26.31	Safe
20	D3	M2	F1	28.42	Safe
21	D3	M3	F1	27.32	Safe
22	D3	M1	F2	59.97	Safe
23	D3	M2	F2	56.37	Safe
24	D3	M3	F2	57.19	Safe
25	D3	M1	F3	4.93	Safe
26	D3	M2	F3	5.64	Safe
27	D3	M3	F3	4.76	Safe

Table. No.2 Finite Element Analysis results

To determine the safe results of FEA we compared the FEA von misses stress with the ultimate tensile and ultimate strength. With reference to the FEA results we see that all generated stresses are within the safe limit for all conditions. From above table we see that Design number 3 which has less mass is also safe. Maximum stress is generated at AL360, and minimum stress at AL 7075.

We can consider DESIGN 3 and MATERIAL 3 (AL 7075) as optimize level.

7. Experimental Validation:

Validation involves performing laboratory tests to verify that a particular experiment, software program, or measurement technique is working properly. As our Design no 3 is safe in FEA results, we will consider the same design for validation under all three force conditions.

For each Experiment we will take 4 tests. So total tests will be 36 nos.

The experiments are conducted on UTM, for loading conditions like moment, twist and pull.

The experimental results of the selected Design no.3 are as follows:

7.1 Comparison of Simulation:

In this chapter the results of simulation and experimentation are presented in form of data and hence findings or investigations. It provides the explanation and interpretation of results or findings by comparing with the findings in prior studies. The Work output is done in three different stages of simulation, optimization and experimental investigation.

				FEA RESULT	**Experimental Result Maximum Stress MPa**					
Sr.No	**Parameters**			**Maximum Stress Mpa**	**1**	**2**	**3**	**4**	**Average**	**Percentage difference**
1	D3	M1	F1	26.31	25.22	29.33	28.78	29.91	28.31	7.32
2	D3	M2	F1	28.42	29.46	30.49	31.73	29.34	30.26	6.25
3	D3	M3	F1	27.32	28.95	29.73	28.45	29.72	29.21	6.70
4	D3	M1	F2	59.97	62.82	61.92	62.67	62.44	62.46	4.07
5	D3	M2	F2	56.37	59.73	58.56	59.81	58.16	59.07	4.67
6	D3	M3	F2	57.19	60.16	59.62	58.64	58.82	59.31	3.64
7	D3	M1	F3	4.93	5.11	5.63	5.23	5.36	5.33	7.84
8	D3	M2	F3	5.64	6.43	6.69	5.98	5.51	6.15	8.69
9	D3	M3	F3	4.76	5.85	4.94	5.37	4.62	5.20	8.74

Table 3. Comparison of FEA and Experimental Results

The Study of optimization is carried out in two stages, design analysis and optimization analysis. The boundary constraints are first explained determined in the Simulation of Component using different materials. The nature of simulation is discussed in form of Equivalent Stress, Strain and Deformation.

7.2 Discussion on comparison FEA and Experimental results

For the said Design number 3 which is our optimized level from FEA results, when the same conditions applied in actual testing we find the similar results as that of the FEA results. Design 3 is safe for all materials considered.

However there is some difference in FEA test values of maximum stress and average stress values of experimental tests. We see that maximum difference is 8.74% whereas minimum difference is 4.07% which is in an acceptable range.

For F1, F2 and F3 loading conditions applied, maximum stress generated at Al360 and minimum at BEL 220H alloy and optimum at AL 7075. So we have to select finalize the material from BEL 220H and AL 7075 alloy.

8. CONCLUSIONS:

- The Load and Stress analysis have been studied and mathematical algorithm has been prepared to define the area and section of loading. Finite Element Modelling is performed in Ansys 2024 software to determine the simulation in stress, strain and deformation.
- The design constraints for strength of material is been defined in reference of BEL 220H, AL A360, Al7075. Hence, in this case we can say that the optimized material of Al7075 satisfies the criteria for Strength.
- The Principal Stresses produced under different loading conditions for BEL 220H, AL A360, and Al7075 are studied. The stress for Al7075 is finding out to be less than BEL 220H, AL A360.
- The deformation is less for Al7075 than BEL 220H, AL A360, so The stress for Al7075 is finding out to be less than BEL 220H, AL A360.Hence we can say that the Al7075 Satisfies the criteria for deformation.
- The sample specimens of BEL 220H, AL A360, and Al7075 are prepared for experimental testing. The testing is been done under the loading conditions applied. The Experimental results for Al7075 are better in case of bending deflection and stress produced.

REFERENCES :

1. Qiangwei, L. (2017). Finite Element Analysis and Vibration Control of Lorry's Shift Mechanism. In Proceedings IV International Conference on Advanced Materials, Mechanics and Structural Engineering (pp. 56-61). Tianjin, China.
2. Li, Y., Cheng, S., Chen, Z., Chen, Z., Guo, H., & Ye, A. (2022). Study on the improvement of gearshift performance in commercial vehicle based on ergonomics. *Results in Engineering*, *14*, 100418.
3. Dogan, S.N. (1999). Loose part vibration in vehicle transmissions Gear rattles. Transactions Journal of Engineering and Environmental Science, 23, 439-454.
4. Snežana Joksić, Mladen Radojkovi, Blaža Stojanović , Živče Šakorčević, Saša Milojević (2023),Stress analysis of gear shift fork with mass optimization ,XII International Conference On Social And Technological Development Trebinje., 15-18,
5. Bo, L., Wenqing, G., Yiqiang Z., & Shanshi C. (2015). Shift Force Loading Rules Research for Automated Mechanical Transmission. The Open Mechanical Engineering Journal, 9, 574578.
6. Patel, P., Patel, K., & Patel D. (2015). Designing a Fixture for Machining Gear Shifting Fork.International Journal of Engineering Development and Research, 3(3), 1-8.
7. Jianjun, H., Hongliang, R., & Zhang, Y. (2016). Parameter design and performance analysis of shift actuator for a two-speed automatic mechanical transmission for pure electric vehicles.
8. Abouel-Seoud, S.S.; Mohamed, E.S.; Abdel-Hamid, A.A.; and Abdallah, A.S. (2013). Analytical Technique for Predicting Passenger Car Gearbox Structure Noise Using Vibration Response Analysis. British Journal of Applied Science & Technology, 3(4), 860-883.
9. Vandi, G.; Cavina, N.; Corti, E.; Mancini, G.; Moro, D.; Ponti, F.; and Ravaglioli, V. (2014). Development of software in the loop environment for automotive powertrain systems. Energy Procedia, 45, 789 – 798.
10. Nacib, L.; Pekpe, K.M.; and Sakhara, S. (2013). Detecting gear tooth cracks using cepstral analysis in gearbox of helicopters. International Journal of Advances in Engineering & Technology, 5, 139-145.

11. Jaideep, S., Ankur, V., Rohit, K., Ajay, B., & Mangesh, D. (2013). Shifter Fork Stiffness Correlation to Gear Shift Quality, SAE Intternational Journal of Commercial Vehicles. 6(2), 498-509.
12. Gordon, T.J.; and Bareket, Z. (2007). Vibration Transmission from Road Surface Features– Vehicle Measurement and Detection. Technical Report for Nissan Technical Center North America, Inc. UMTRI-2007-4.
13. Li, Y., Cheng, S., Chen, Z., Chen, Z., Guo, H., & Ye, A. (2022). Study on the improvement of gearshift performance in commercial vehicle based on ergonomics. *Results in Engineering*, *14*, 100418.
14. Joshi, N. & Sharma, S. (2018). Experimental Analysis through Design Optimization for DFM and weight Reduction of Fork Diff-Lock Gear Shifter. International Journal of Science and Research, 60(1), 1172-1176.
15. Wang, J.; Zheng, J.; and Yang, A. (2012). An Analytical Study of Bifurcation and Chaos in a Spur Gear Pair with Sliding Friction. Procedia Engineering, 31, 563-570