Int. J. Chem. Sci.: 14(S2), 2016, 675-680
ISSN 0972-768X
www.sadgurupublications.com

DESIGN AND FABRICATION OF MECHANICAL ADAPTIVE HEADLIGHT SYSTEM PROTOTYPE

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ABSTRACT

Drivers in India are highly dependent on headlights to provide illumination in low light conditions especially on highways. Static headlights are insufficient for this purpose on curved roads as the headlights point tangentially along every point of the curve instead of pointing in the direction of the vehicle. Adaptive headlight systems (AHS) attempt to make the headlights steerable so that they illuminate the actual path of the road. This project utilizes a rack and pinion mechanism and a four bar linkage to connect the headlights to the steering wheel. The model prototype was successfully designed and fabricated. Its dimensions were inspected and found to be of intended specifications and functioning was verified to be as per theoretical predictions and requirements. This mechanism has the potential to be a viable alternative to expensive electromechanical AHS systems with strategic improvements and further research on mode of implementation in the real world.

Key words: Adaptive headlight system, Rack and pinion, Four bar mechanism, Swiveling headlights.

INTRODUCTION

The core concept behind the Adaptive headlight System (AHS) is facilitating the change of direction of the headlights to correspond with the angle of the steering wheel[1]. This causes the headlights to illuminate the actual path of the vehicle on curved roads as opposed to being directed tangentially ahead at all points of the curve and reduces reaction time and increases comfort of the driver[2,3,4]. Headlamp performance has steadily improved throughout the automobile age, spurred by the great disparity between daytime and nighttime traffic fatalities. The U.S. National Highway Traffic Safety Administration states that nearly half of all traffic-related fatalities occur in the dark, despite only 25% of traffic travelling during darkness[5]. In India 22.9% of road crashes in 2012 occurred between 6 pm and 3 am[6]. Of the total number of accidents in India, 54.7% occurs on national or state

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highways[6]. These statistics highlight the importance of improving visibility in low light conditions as a crucial factor in ensuring better road safety on highways[7,8]. While conventional static headlights provide sufficient lighting on straight roads, they are not capable of illuminating the more commonly encountered curved roads of India's dynamic terrain. As India's economy picks up momentum, there is a great increase in the demand for low end, affordable cars. Therefore incorporating crucial active safety features must not be restricted to high end cars. This can only be achieved if cheap, reliable alternatives are available for expensive technology used in safety features, such as the complex electromechanical Adaptive Headlight systems, which are currently in development by luxury car manufacturers such as Audi and BMW[9]. Therefore we place focus on purely mechanical systems to achieve steerable headlights[10].

Design of mechanical AHS

A kinematic diagram was drawn representing all the forces in the scaled down model. The Force required to turn the model steering wheel was calculated based on the diagram[11]. Based on this Force the power required to turn the steering wheel at the maximum expected velocity was calculated. This power was used in the calculation of basic dimensions of the rack and pinion[12]. The expected load that the rack and pinion can handle was calculated[13]. The permissible force was then calculated and found to be greater than the force experienced by the system[13]. The horizontal distance the rack needs to move to achieve 45 degree deflection of the headlight was calculated[14,15]. The angle the steering wheel needs to be turned for achieving 45 degree deflection in headlight was then calculated. Typical forces in the system and final dimensions of the model are given in the Fig. 1.

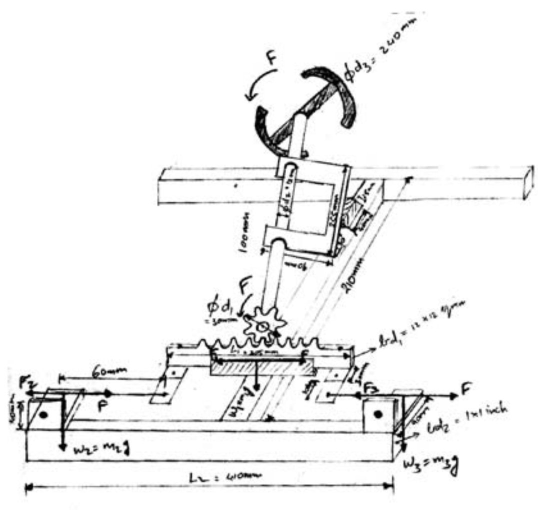

Fig. 1: Forces in the system and dimensions of the model

Manufacture and assembly

A mild steel shaft of diameter 12.7 mm is machined on a lathe to 12 mm. A pinion is turned on a lathe to specifications and teeth are machined by gear hobbing method. It is then screwed tightly onto one end of the shaft. A U-bar is created by gas welding two short bars to either ends of one long bar, all made of mild steel. A rack of specified dimensions is also machined by gear hobbing method.

The shaft is then placed into two parallel holes drilled into the shorter sides of the U-bar. An H-bar is made by gas welding the centres of two equally long bars placed parallel onto either side of another bar placed perpendicularly between these two. The U-bar is then placed at a 30 degree angle onto the centre arm of the H-bar with the support of another short block and this set up is also welded together firmly. An aluminium support structure for the rack is created near the lower end of the shaft right below where the pinion is placed using screws and fasteners.

The rack is then placed on this support such that the pinion meshes with it at the centre. A steering wheel is welded onto the free end of the shaft. On either end of the rack, two small aluminium links are screwed tightly. On either ends of the H-bar two long aluminium links are screwed such that they may rotate freely around that point. The corresponding long and small aluminium links are then aligned appropriately and coupled by a metal wire.

Working principle

When the steering wheel is rotated from centre to either direction, the pinion that is connected to it by a shaft also rotates correspondingly. This is used to drive a rack with which the pinion meshes. Therefore when the steering wheel is turned clockwise, the rack moves to the left, and vice versa. The rotatory motion of the steering wheel is thus converted to corresponding linear motion. The rack is a part of a four bar mechanism. It is connected to two short links on either side which are in turn connected to a common fixed link. The linear motion of the rack to either side therefore causes the aluminium links to swivel proportionally and vary its angle with respect to the fixed link[16,17]. The LEDs representing the headlights are mounted on these two links[18]. Therefore when the steering wheel is rotated, the direction of the headlights rotates correspondingly[19,20]. A steering ratio of 5:1 is selected for the purposes of this project[16]. This means for every 5 degrees of change in the angle of the steering wheel, the headlights will swivel one degree in that corresponding direction.

RESULTS AND DISCUSSION

A "Mechanical Adaptive Headlight System" has been designed and fabricated. The various components were inspected and found to be of desired specifications. The functioning of the system has been verified by checking for various angles of the steering wheel and the corresponding angle of deflection of headlights manually using a protractor and comparing these with their respective expected theoretical results. Tabulated values are shown below in Table 1. The actual values measured are satisfactorily close to the expected theoretical values for a steering ratio of 5:1.

Table 1: Comparing Actual angles of LEDs with theoretical values for the corresponding steering angles

	S. No.	Steering angle Θ (degrees)	Left LED angle (degrees)	Right LED angle (degrees)	Theoretical angle value Θ/5 (degrees)
Turning right:	1	30	5	4	6
	2	60	10	8	10
	3	90	16	15	18
	4	215	45	44	45
Turning left:	5	30	4	6	6
	6	60	8	11	10
	7	90	14	16	18
	8	215	43	44	45

Fig. 3: Final assembled model

CONCLUSION

The project has been a unique experience, successful in utilizing the theoretical knowledge into practical application right from the conception of the idea, through the design and calculations till the various manufacturing and assembly processes. There is scope for further improvement in this project, such as the implementation of the Ackermann criterion in determining angle of deflection of headlights and a system for vertical direction control of headlights depending on various conditions.

REFERENCES

1. M. Hamm, Adaptive Lighting Functions History and Future-Performance Investigations and Field Test for User's Acceptance, SAE Technical Paper #2002-01-0526. (E) (2002)
2. Gunnar D. Jenssen, Cato A. Bjørkli, Kristian Sakshaug and Terje Moen, Behavioural Adaptation to Adaptive Front Lighting Systems (AFS): A Six Day Driving Simulator Study, 01155244, Proceedings Of The 14th World Congress On Intelligent Transport Systems, Beijing, October (2007).
3. T. Hara, T. Kuramochi, M. Ayama, S. Kojima and T. Sato, Evaluation of AFS from Driver's Point of View, Proceedings of PAL 2001 - Progress in Automobile Lighting, Held Laboratory of Lighting Technology, Publisher: Herbert utz verlag gmbh, 3-89675-971-x, **8**, 397-402 (2001).
4. M. Grimm, Improved Night Time Visibility for Drivers Through Dynamic Bend Lighting, Proceedings of Pal 2001 - Progress in Automobile Lighting, Held Laboratory of Lighting Technology, **8**, 3-89675-971-x (2001).
5. Varghese, Cherian, Shankar and Umesh, Passenger Vehicle Occupant Fatalities by Day and Night – A Contrast, Traffic Safety Facts, Research Note (DOT HS 810 637) (NHTSA's National Center for Statistics and Analysis, May (2007)
6. Manisha Ruikar, National Statistics of Road Traffic Accidents in India, J. Orthopaedics, Traumatol. Rehabilitation, **6**, 1-6 (2013).
7. D. Decker, Adaptive Headlights Aim to Ease Night Time Driving Hazards, Photonics Spectra, **40(12)**, 54-56 (2006), Department of Research and Development, Optics Lighting Div, Hella KGAA Hueck and Co., Lippstadt, Germany; (Copyright © 2006, Laurin Publishing).

8. C. Xue-mei, W. Zhong-hua and G. Li, Study on Drivers' Behaviour Under Emergency Situations, (School of Mechanical and Vehicular Engineering, Beijing Institute of Technology, Beijing 100081, China; Traffic Engineering Key Lab of Beijing, Beijing University of Technology, Beijing 100022, China), [J], J. Beijing Uni. Technol., 05 (2007).

9. Adaptive Headlights, BMW Technologies: http://www.bmw.com/com/en/insights/technology/technology_guide/articles/mm_adaptive_headlights.html.

10. M. Hamm, System Strategies for Adaptive Lighting Systems, Proceedings of PAL Progress in Automobile Lighting, Held Laboratory of Lighting Technol. Sept. 8 (2001).

11. N. Laxmi, B. Anil Kumar and D. Kiran Varma, Design and Fabrication of A Steering Controlled Headlights in Automobile, Int. J. Magazine Engg. Technol. Manage. Res., **2(7)** (2015).

12. A. Thirugnanam, Praphul dDs and Lenin Rakesh, Design and Fabrication of Rack and Pinion Lift, Middle-East J. Sci. Res., **20(6)**, 744-748 (2014).

13. ATLANTA, Rack and Pinion Drive – Calculation and Selection http://www.atlantadrives.com/pdf/ads_racksel.pdf

14. M. Ikegaya and M. Ohkawa, Study of Distribution Control Methods for AFSPAL, (J), **10**, 426-439 (2003).

15. S. McLaughlin, J. Hankey, C. Green and M. Larsen, Discomfort Glare Ratings of Swiveling HID Headlamps, USG No. 3774, General Motors North America (NA) (2003).

16. K. Wada, K. Miyazawa, S. Yagi, K. Takahashi and H. Shibata, Steerable Forward Lighting System, SAE Technical Paper #980682 (J) (1989).

17. S. Kobayashi, K. Takahashi and S. Yagi, Development of New Forward Lighting Systems with Controllable Beams, SAE Technical Paper #970646 (J) (1997).

18. J. Roslak, Lighting Systems for the Adaptive Illumination of the Traffic Space, PAL, **10**, 883-894 (E) (2003).

19. S. Kobayashi and M. Hayakawa, Beam Controllable Head Lighting Systems, SAE Technical Paper #910829 (J) (1991).

20. K. Ishiguro and Y. Yamada, Control Technology for Bending Mode AFS, SAE Technical Paper #2004-01-0441 (J) (2004).

Accepted : 01.07.2016