Design, Analysis and Performance Evaluation of Adaptive Headlight System

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Abstract- *In today's fast moving vehicle scenario, road safety is of most importance. Many people have lost their lives while travelling, due to a road accident. Major road accidents are occurs during night time. In most cases, the late recognition of objects in the traffic zone plays a key role. These facts point to the importance of the role of automobile forward-lighting systems. The existing Conventional headlight systems incorporate fixed direction lamps, with higher or lower beam configuration which is not suitable to night driving as they do not properly illuminate the road during turning or gradient travel of vehicle. Hence to provide enhanced night time safety measures there is a need of such system which will give global positioning of head lamp in minimum time. The adaptive headlight system with spiral path positioned enables to position the headlight in any global position in minimum path travel using a single motor and low cost automation. Project aims at design, development test and analysis of this spiral path generation mechanism.*

Keywords- Forward-lighting systems, Direction lamps, Higher or Lower beam, Spiral path, Global positioning.

I. INTRODUCTION

Preventive and active safety of road vehicles is one of the top priorities in automobile design and development nowadays. Passive and active safety systems have been developed in R&D activities to produce vehicles that will perform at the highest level of safety and ensure comfortable driving under various conditions. In the present scenario, a headlight of an automobile has a fixed path for the emanation of beam of light in front direction only. So when the vehicle takes a turn, the beam of light follows the tangential path as a result some part of the roads remains dark, thereby creating a dead angle of illumination and such lack of visibility poses danger in driving at night or on steep turn. This causes a lot of accidents. It is therefore imperative to study new technology. Adaptive front light system (AFS) is an innovative technology and is being studied by researchers across the globe. Lighting in modern vehicles has been steadily improving in the last decades. Modern technology provides new light sources and more powerful optical systems. With current sensors and control equipment, advanced dynamic lighting systems are possible. The Adaptive Headlight System (AHS) is the outcome of engineering efforts in developing the next generation lighting systems not only for drivers but also for all other road users. AHS is introduced in order to prevent a possible accident from happening by increasing the visibility at night. AHS automatically adjusts the light to match the direction of travel. That enables the driver to react more quickly because he/she will see the road ahead more clearly. AHS significantly enhances driving safety in the dark by dynamically adjusting the headlights according to the vehicle current direction of travel to ensure optimum illumination of the road ahead and to give the driver much better visibility. [1] Mentioned that driving is a visual task and if light is not there, it can get risky. The driver has to drive by his own personal experience by using clutch and brake more often than on the straight path. Additional to this, [2] classified vehicle lighting as active safety. So this creates a need for simple solutions that help us cater this problem and increase road safety by improving the visual conditions provided by vehicle headlights. Thus this mechanism of turnable headlight is devised to enhance the safety of drivers and pedestrian especially on curvy roads in hilly areas. This mechanism also enables us to save some fuel, expended in hilly driving due to frequent clutch and brake operations. Although the effects of "high beam" or "low beam" can be achieved by switching the different filament of the bulb. This moves the beam of light in up and down direction which helps to cut off the significant amount of light from being cast into the eyes of drivers of preceding or oncoming cars. But the direction of emanation of beam of light still not adjustable with spiral motion. Therefore, it is highly desirable to create a mechanism of high utility to solve the above problem that to at an economical cost. In this project the headlights of an automobile, moves with spiral path, which position the headlight in any global position in minimum path travel using a single motor and low cost automation.

Problem Definition

Design and Development of adaptive headlight system to provide a multi-plane orientation to the headlight such that it will provide adequate illumination.

II. OBJECTIVES

- Design of kinematic linkage components of spiral path positioned by use of 2-d cad, determination of gear pair configuration and cam profile to achieve the given motion.
- Mechanical design and development of the set up with mechanical drawing preparation, 3d modelling of critical parts and analysis of critical parts.
- Manufacturing, assembly and testing of set up to derive the scanned domain using modified system.

III. METHODOLOGY

- Literature review regarding concerned topic.
- Study of high speed spiral path generator mechanism.
- CAD modelling of spiral path mechanism.
- Finite element analysis of critical component of mechanism in ANSYS WORKBENCH R15.
- Validation through Experimental testing of spiral path mechanism.

IV. DESIGN AND DEVELOPMENT OF ADAPTIVE HEADLIGHT SYSTEM

The proposed system comprises mainly of two sub-systems:

a) High speed spiral path generator mechanism with headlight mount plate.
b) Headlight mechanism with reflector and lights powered by 12 volt DC.

Description of High speed spiral path generator mechanism:

In this case, the spiral path generator consists of a headlight mounting plate held in adapter actuated by a power operated mechanism. The mirror is tilted at a constantly changing angle with respect to an axis passing vertically through its centre. At the same time, the direction of tilt continuously changes through a complete circle of 360 degree .Thus , the motion of mirror is such that it can “see” any object within the angle of its cone of motion.

1. Construction and working

Carrier as shown in fig.1 is integral with main shaft and is balanced. Spur gear having twenty four teeth rotates on a pivot integral with the carrier, and meshes with the internal worm thread in housing. Cam is fixed to the gear and revolves with it. The scanner shaft is attached to scanner disc and Global bearing is used for providing support to the scanner shaft so it can easily be given the continuous tilting or conic motion required. There is a slider bracket which is positioned between the gear and the carrier. Slider bracket is carried on the scanner shaft and is free to rotate around it. Spring is also provided in the slider to maintain the continuous contact between scanner shaft and cam. In operation, the spur gear and cam move as a unit with the carrier, rotating at high speed with the main shaft so that the scanner shaft performs the required conic motion. At the same time, the worm thread causes the gear to revolve around its own axis while centrifugal force presses the slider against the cam. Since the gear and cam are also revolving around the gear axis, the opening angle of the cone varies continuously as dictated by the shape of the cam, thus producing the required spiral scanning motion. When the slider reaches the centre, flat spring thrusts it against the cam, replacing the centrifugal force, and a new scanning cycle begins.

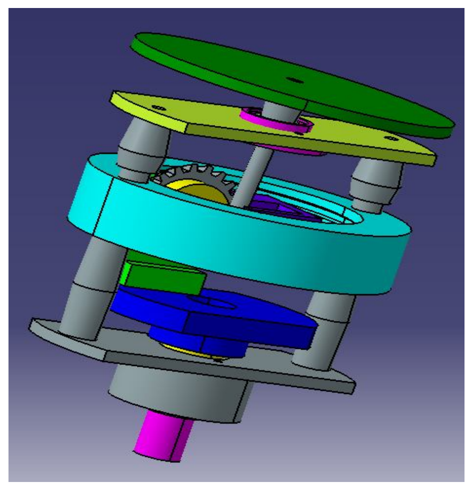

Fig.1: Cad model of mechanism

V. DESIGN OF CRITICAL COMPONENT

A. Selection of drive motor

Electric motor of following specification is used as the source of power in drive; 12 volt, 5 Amp, Power =5watt, Speed= 0 to 10 rpm.

I. Input Torque at motor = (60 x 5)/2Π x 10 =4.77 N-m,

1. Material Selection.

Table 1 Material Specification

Designation	Ultimate tensile strength N/mm^2	Yield strength N/mm^2
EN24	800	680

2. *ASME code for design of shaft.*

As the loads on most shafts which are connected in the machinery are not constant, it's necessary to make proper allowance for the harmful effects of load fluctuations. According to ASME code permissible values of shear stress may be calculated from various relations.

fs_{max} = 0.18 fyt = 0.18 x 800 = 144 N/mm2

or

fs_{max} = 0.3 fyt = 0.3 x 680 = 204N/mm2

Considering minimum of the above values;

fs_{max} = 144 N/mm2

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

3. Check for tensional shear failure of shaft.

Assuming minimum section diameter on input shaft = 6mm

$$T_d = \Pi/16 \times fs_{act} \times d^3$$

$$fs_{act} = \frac{(16 \times T_d)}{(\Pi \times d^3)}$$

$$fs_{act} = 112.46\ N/mm^2$$

As $fs_{act} < fs_{all}$

Scanner shaft is safe under tensional load.

4. Structural Analysis of Scanner Shaft.

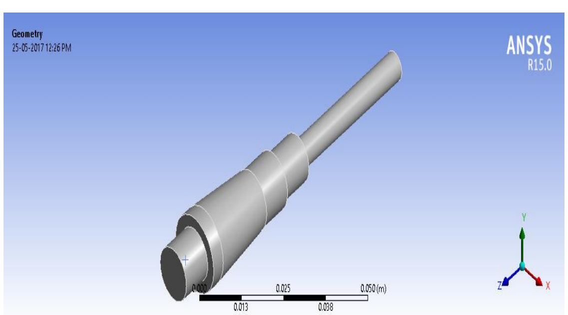

Fig.2: Importing of Scanner shaft into ANSYS WORKBENCH.

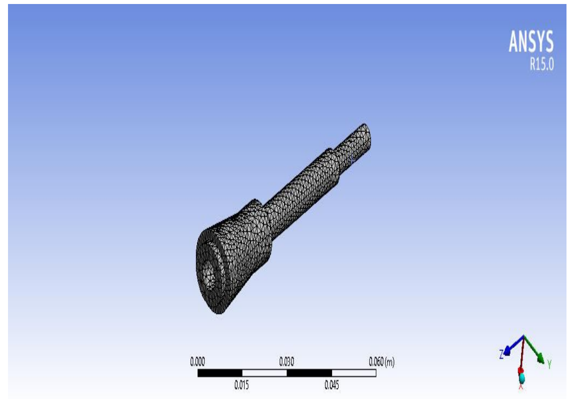

Fig.3: Meshing of Scanner shaft.

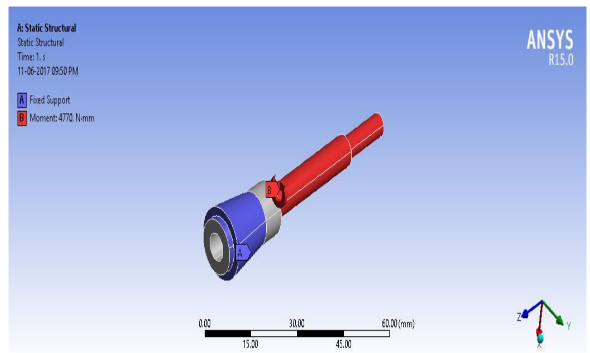

Fig.4: Boundary conditions.

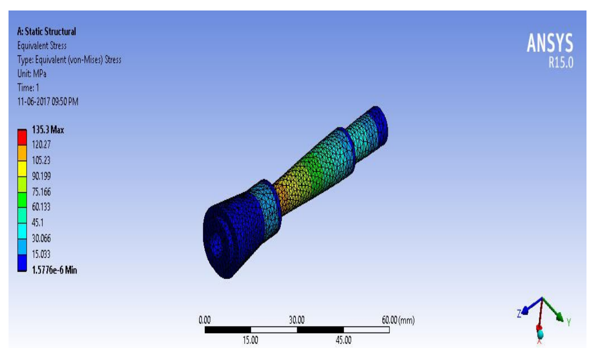

Fig.5: Von-Mises Stress.

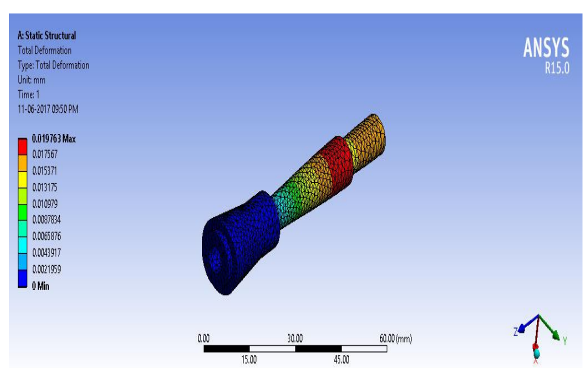

Fig.6: Total Deformation of Scanner shaft.

5. Design of scanner gear.

5.1 Material Selection.

Table 2 Material Specification

Designation	Ultimate tensile strength N/mm^2	Yield strength N/mm^2
EN24	800	680

Maximum torque = 4.77 N-m
No of teeth on gear =20
Module = 2 mm
Radius of gear by geometry = 20 x2 /2 = 20 mm
W=Maximum load = T/r = $4.77 \times 10^3 / 20$ =238.5N
b = 10 m
Material of spur gear and pinion = EN24
S_{ult} pinion = S_{ult} gear = $800 N/mm^2$
Service factor (Cs) = 1.5
$\Rightarrow$Pt = (W x Cs) = 357.75 N.
P_{eff} = 357.75 N (as C_v=1 due to low speed of operation)
P_{eff} = 357.75 N -------- (A)
Lewis Strength equation
W_T = Sbym
Where;

$$y_p = 0.484 - \frac{2.86}{Z}$$

$$y_p = 0.484 - \frac{2.86}{20} = 0.341$$

$\Rightarrow S_{yp}$ =272.8

As $\Rightarrow$ pinion is weaker
$W_T = (S_{yp}) \times b \times m$
=272.8x 10m x m

W_T= $2728m^2$---------- (B)
Equation (A) & (B)
$2728m^2$ = 357.75
$\Rightarrow$m=0.371 mm

Selecting standard module = 2 mm for ease of construction so that there is proper mesh between the internal threads of the ring and the spur gear.

6. Structural Analysis of Scanner Gear.

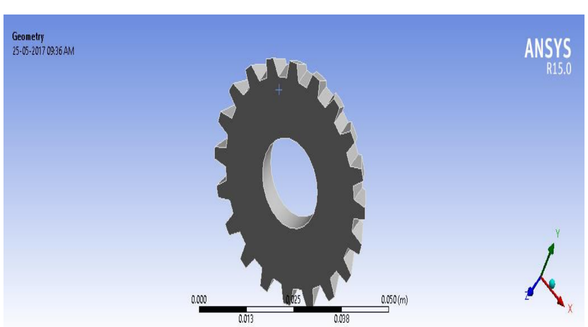

Fig.7: Importing of Scanner gear into ANSYS WORKBENCH.

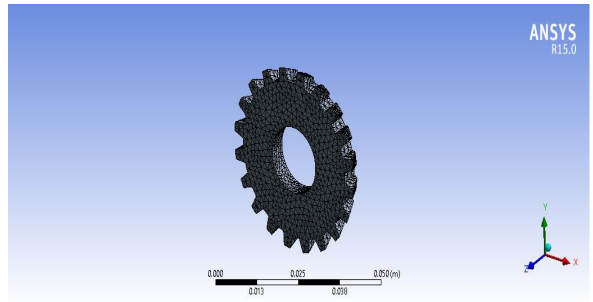

Fig.8: Meshing of Scanner shaft.

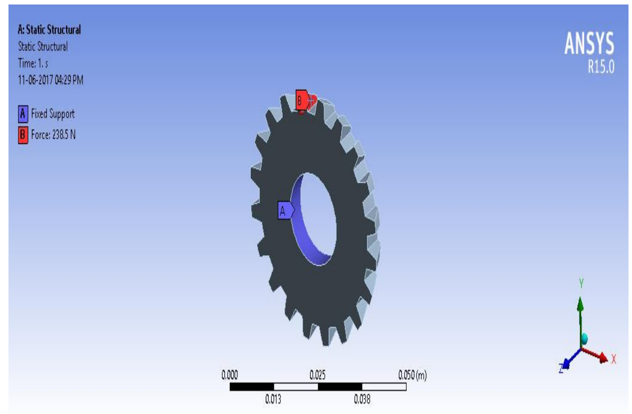

Fig.9: Boundary conditions.

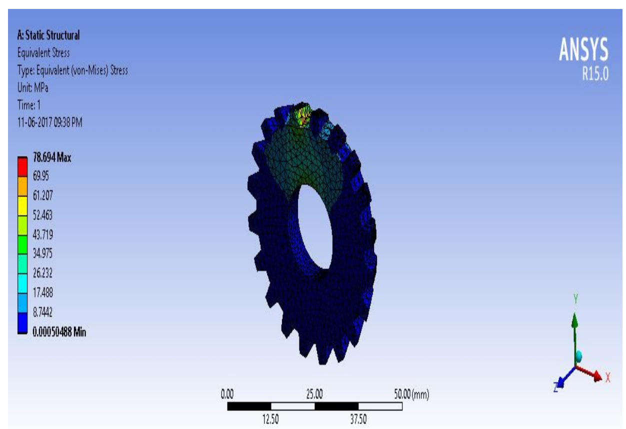

Fig.10: Von-Mises Stress.

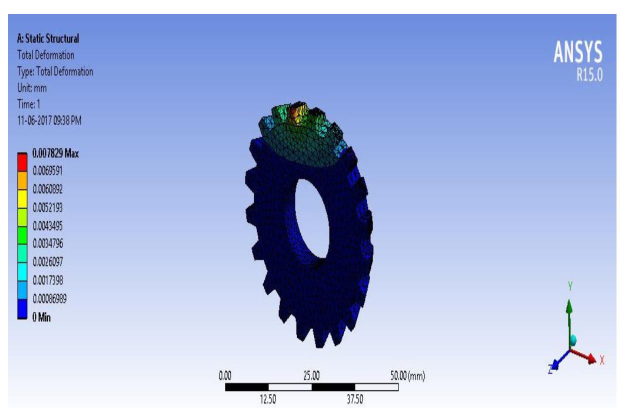

Fig.11: Total Deformation of Scanner gear.

In the above work we have modelled a scanner shaft and scanner gear from theoretical calculation and the 3D modelling is done through CATIA V5R21. The both gear and shaft are analyzed through ANSYS WORKBENCH R15. It is found that maximum stress by theoretical and analytical methods are well below the allowable limit. Also deformation is small or negligible. Hence the gear and shaft are safe under the rated torque.

VI. EXPERIMENTAL SETUP

Fig.12: Experimental setup.

As discussed in construction and working the fig shows the actual working setup for experimentation of headlight system. In experimentation angle finder is used to find the degree of inclination of headlight. A 12V battery is used for power supply, switch and push button is connected to the 12V battery, and these switches are also connected to the motor. When push button is press the motor starts to rotate hence the main shaft started rotating, because of rotation of main shaft the assembly of gear, cam and scanner shaft starts to rotate and then the inclination of scanner disc is measure with the help on angle finder.

VII. EXPREIMENTAL RESULTS AND DISCUSSION

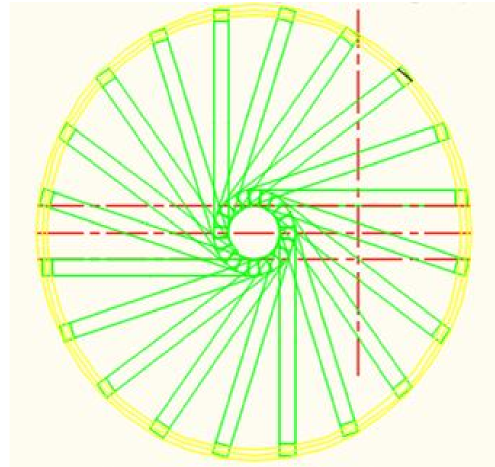

Fig.13: Array of position of spur gear carrying cam For every 20 degree about vertical axis.

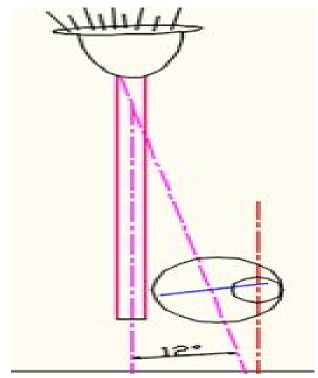

Fig.14: Position of system at maximum rise of cam

Theoretical inclination of headlight is 0 degree and actual inclination of headlight found in experimentation is 0.5 degree so the percentage of accuracy is found to be

Percentage accuracy = (12-0.5)/12 x 100 = 95.8%

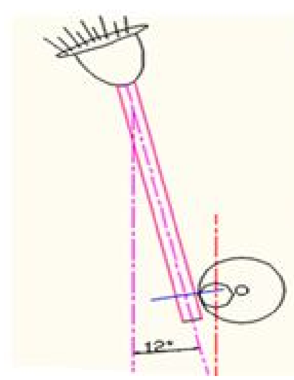

Fig.15: Position of system at maximum rise of cam

Theoretical inclination of headlight is 12 degree and actual inclination of headlight found in experimentation is 11 degree so the percentage of accuracy is found to be

Percentage accuracy = (11-0)/12 x 100 = 91.67%

VIII. CONCLUSION

1. Headlight travels a spiral path thereby cover a domain of conic angle of 12 degree.
2. Maximum accuracy of the system is 95.8% for maximum rise of cam position
3. Maximum accuracy of the system is 91.8 % for zero rise of cam
4. Thus the probability of positioning the headlight in position in less than 2 seconds is close to 90 %.

IX. ACKNOWLEDGMENT

I gratefully acknowledge Mechanical Engineering Department of DYPCOE, Akurdi, Pune for their technical support. I would also like to thank to Prof. Swati K. Dhamale (Project guide), Dr. Pachngade (HOD, Mech Dept.), and Dr. Tapobrata Dey (PG co-ordinator) for their help and dedication toward my work. Also, I thanks to my friends for their direct & indirect help, support and co-operation.

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