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Reciprocating Motion Wiper System for Automobiles (RMWS)

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***Abstract*---Windshield wipers play a key role in assuring the driver's safety during precipitation of water and heavy rainfall. Most of the conventional wiper systems at present do not completely wipe off the rain droplets still leaving blind spots at the top right corner and at the edges of the windshield. Blind-spots are regions which act as a hindrance to the driver. These are caused by the unswept rain drops that fall on the windshield during rain .Thus a wiper system has been designed using the whit-worth mechanism to provide maximum view to the driver thereby eliminating the blind spots that occurs on the windshield glass of a bus. Moreover the long traditional sweeping motion of the wiper blades is replaced by a reciprocating sweeping motion in the radial direction of the windshield glass.**

Keywords*--- *Blind-spots, windshield, slider-crank mechanism, six bar mechanism.

I. INTRODUCTION

Windshield wipers are used to clean the windshield of a bus so that the driver has an unobstructed view of the road. Typical wipe angle for buses is about 67 degrees. The blades are 22-41 inches long with lengths increasing in 2-in increments. The main scope of this project is to reduce the blind spots that occur during heavy rainfall. If the blind spots are larger, then the driver of the vehicle would not acquire the maximum view of the road thereby leading to major road accidents. Here we have designed a Reciprocating Motion Wiper System to suit the windshield of dimension 1100x 500 mm with a unique approach that encompasses manual design backed by software aided analysis. We have designed the Reciprocating Motion Wiper System with aid of sophisticated software tools like ADAMS [1] to achieve a greater degree of accuracy and precision. This data has been corroborated with the manual design calculations to enable us achieve our purpose of designing a top notch Reciprocating Motion Wiper System.

II. PROBLEM STATEMENT

The conventional wiper system used in buses consists of a mono blade wiper, fixed at the top edge of the driver's end. These mono blade wipers have a sweep angle of about 120 degrees thereby covering only a minimum portion of the windshield paving way for major accidents. In order to overcome this drawback Twin blade wipers have been introduced where the sweep angle of each wiper is about 90-100 degrees thereby covering a larger area of the windshield as compared to the previous case. This twin blade system is of two types. One is Tandem system in which both the wipers move in the same direction with respect to time. The other is the opposed system in which both the wipers move in opposite direction with respect to time.

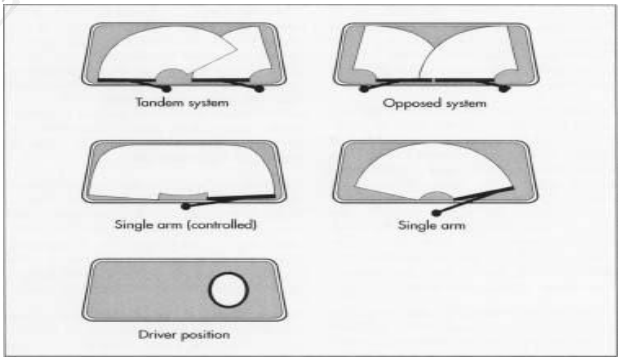

Figure 1. Types of wiping system.

But the twin blade wipers too does not completely wipe off the rain droplets still leaving blind spots at the top corner filleted portions and non-driver's visibility region of the windshield glass

A. Statistical Data on Road Accidents

TABLE 1. ACCIDENT STATISTICS

Rain	Weather Related Crash Statistics	
	Annual Rates (Approx.)	Percentages
Invisibility of Roads	707,000 crashes	47% of rain-related crashes.
	330,220 persons injured	52% of total road accident injuries.
	3,300 killed	***8%*** of total persons killed due to road accidents.

Source [3]:
http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm

III. METHODOLOGY

A. Mechanism of Reciprocating Motion Wiper System

The Reciprocating Motion Wiper system uses Six-Bar mechanism as well as Slider-Crank mechanism in order to move the wiper blade to and fro radially. This method is a modification of the present wiper system in which a slider slides along the windshield transforming radial motion to reciprocating radial motion. In this model only a single wiper blade is used for the entire length of the windshield. Hence the entire windshield could be wiped-off during heavy rainfall by the to and fro motion of wiper blade along the vertical direction. We have used Adams 2013 student edition to design the links [2].The primary design of the model is mentioned in Figure 2.

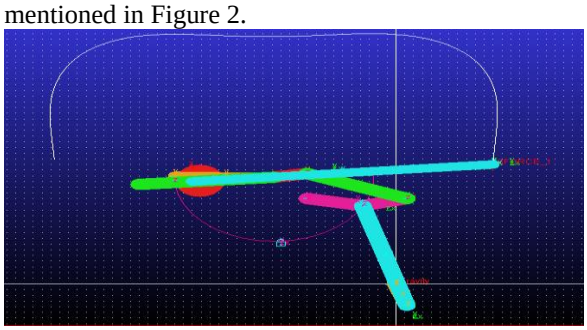

Figure 2. Reciprocating Motion Wiper System

IV. WIPER DESIGN METHODOLOGY

A. Material Selection

One of the key design decisions of our model that greatly increases the safety, reliability and performance in any automobile design is material selection. To ensure that the optimal material is chosen, extensive research was carried out and compared with materials from multiple categories. The key categories for comparison were strength, weight, and cost. Based on comparison results obtained, we have concluded the following results.The material used for each link is C60 steel. The material for wiper blade housing is Aluminium. The bearing to be used at each joint of the links is SKF2200 (100mm) [4]. The most important parts of any wiper system are its Blade. We have arrived at a conclusion to use a rubber material, with low polarity, a polymer of a butadiene derivative, e.g. Natural Rubber (NR), Butadiene Rubber (BR), Styrene-Butadiene Rubber (SBR), Isobutyl-Isoprene Rubber (IIR), or Isoprene Rubber (IR). This is advantageous if at least partially substituted by its functionalized derivative. The mechanical properties of the materials mentioned above are given in Annexure.

V. SPECIFICATIONS

A. Wiper Motor

The wiper motor is the crucial part of a wiper system and the power it consumes for its output determines the betterness of a wiper system. We have designed the wiper system for the following wiper motor specifications.

Rated power : 150W
Rated voltage : 12 V
No Load current : 2.0-2.5A
No Load speed : 20-40 rpm
Load speed : 20-35 rpm
Stall Torque : 98NM
Weight : 4.8 Kg

B. Link Dimensions

The entire system was developed keeping in mind that there would be no aero-dynamical problem in the buses by implementing this prototype. The setup remains encompassed within the breadth of the vehicle. The model consists of 6 links, a sun and a planet gear and a wiper link. The lengths of various links are:
1st link- 79mm; 2nd link-364mm; 3rd link-127mm; 4th link-108mm; 5th link-243mm; 6th link-381mm. The connecting rod attached to planet gear is 225mm. The bearing at each joint is of type SKF2200 with the diameter of 10mm. The length of wiper blade is 685mm. The radius of planet gear is 56.4mm and that of sun gear is 225.5mm which is about 4 times that of planet gear.

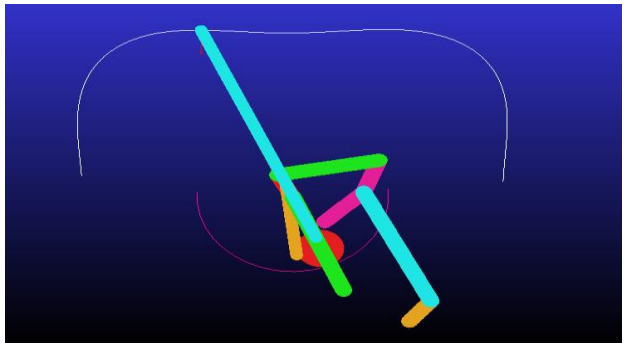

Figure 4. Unfolded view of Reciprocating Motion Wiper System

VI. RESULTS

A. *Force analysis*

The force at each joint is done using Adams, dynamic analysis software.

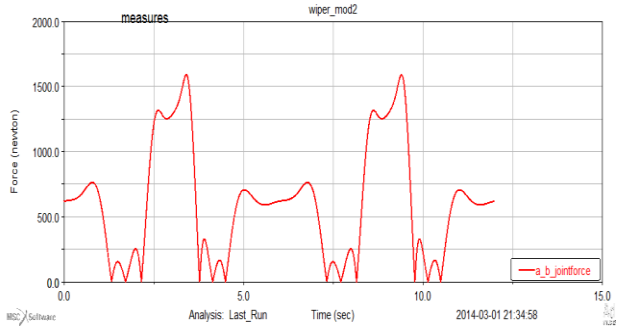

Figure 5. Joint force between 'a' and 'b'.

The graph shown in figure 5 illustrates the variation in the magnitude of force on the revolute joint of the links 'a' and 'b'. The Maximum force inferred is 1650N.

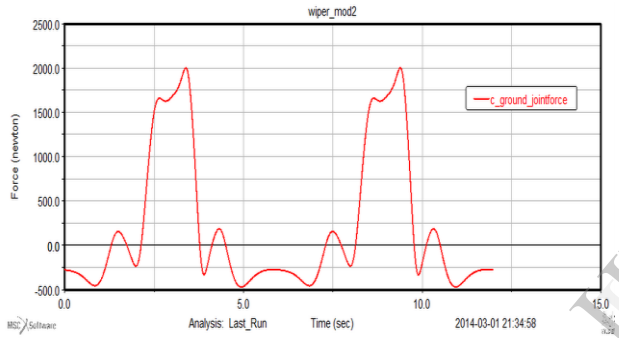

Figure 6. Joint force between 'c' and ground

The graph shown in figure 6 illustrates the variation in force on the revolute joint that connects the link 'a' and ground. The maximum force is inferred to be 2020N.

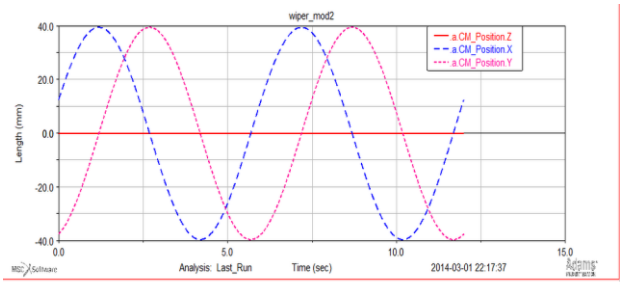

Figure 7. Link 'a' position velocity

The graph shown in figure 7 describes the position of link 'a' with respect to time. The maximum displacement of link 'a' is found to be 80mm.

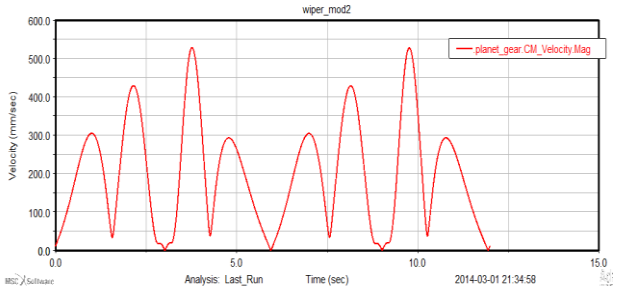

Figure 8. Velocity of planet gear

The graph shown in figure 8 illustrates the velocity of planet gear with respect to time. The maximum velocity is found to be 530mm/second.

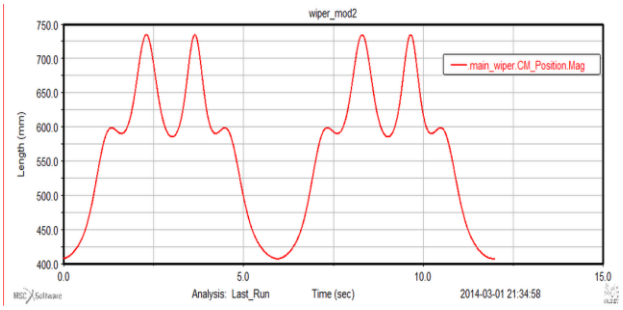

Figure 9. Position of main wiper w.r.t time

The Figure 9 illustrates the changes in position of the main wiper with respect to time. The maximum displacement is inferred to be 340mm.

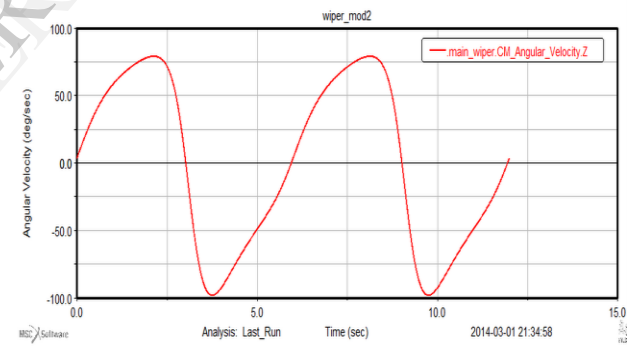

Figure 10. Angular velocity of the wiper

The figure 10 shows the angular velocity of the wiper with respect to time. It is inferred that the velocity of the wiper is maximum at negative coordinates. This is due to the acceleration due to gravity component.

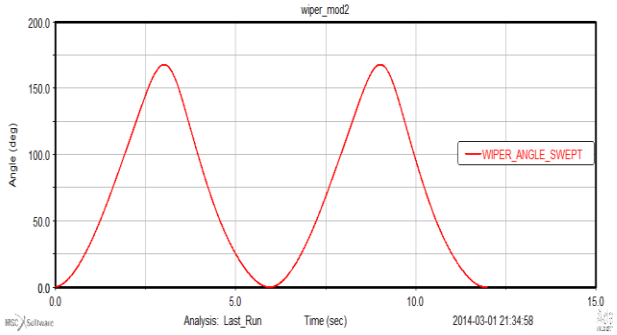

Figure 11. Angle of sweep

The graph shown in figure 11 illustrates the angle swept by the wiper radially while it is reciprocating up and down. Th angle of sweep is 170 degrees.

B. Numerical Analysis

Angular Velocity Fixed: 60rpm

(60x 360 degrees)/60

=360 degrees/sec.

Time for one rotation:

Angular velocity = Degrees of rotation / Time taken

=>Time taken=Deg. of rot./ Angular velocity

= 360 degrees / 360 = 1 second.

(i.e.) for 1 second the link 'a' rotates an angle of 360 degrees

C. Power calculations

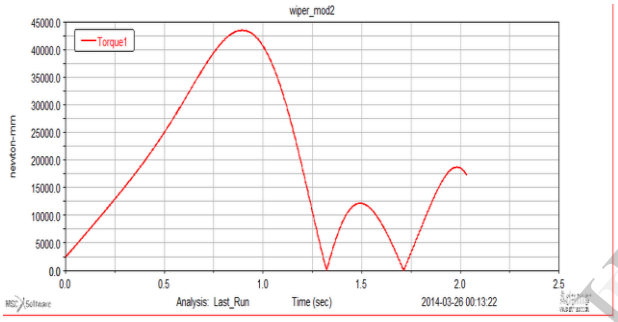

Figure 12. Torque produced by the wiper blades.

Power = Torque / Time

(i.e.) *Torque =Force × radius*

Thus Torque on each joint is calculated and power calculations are made.

Given Torque= 43Nm (from graph)

For a Torque of 43 Nm,

Power = Torque / Time

= 43/1

=43 watts

This is the power required for the wiper motor. This is much less than the rated power of the wiper motor considered and hence the beneficed of the system is maintained as that of in Twin blade wipers. Since the motor power is 150 watts, there would not be any reduction in the efficiency of the system.

VII. CONCLUSION

Thus the simulation of Reciprocating Motion Wiper System is done with the help of Adams and various dynamic results are obtained. The Reciprocating Motion Wiper System provides a better view of the road for the drivers and thus helped in decreasing the rate of accidents occurring due to heavy rainfall. The efficiency of the system is also maintained.

VIII. REFERENCES

[1] A. Mazzei, "Integrating simulation software into an undergraduate dynamics course: a web-based approach," *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition, Nashville - TN*, 2003.

[2] A. Mazzei, "On the use of CAE software in mechanical engineering design courses II," *Proceedings of the International Conference on Engineering and Computer Education – ICECE 2007, Santos, Brazil*, 2007.

[3] Road accidents data collected from "*www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm"*

[4] Shigley and Mischke, *Mechanical engineering design*, 6th ed: McGraw Hill, 2001.

IX. ANNEXURE

A. Mechanical Properties

The mechanical properties of materials used include:

C 60 steel:

Specific weight: 0.0783 N/cc; Young's Modulus: 2.04e5; Modulus of rigidity: 0.894e5; coefficient of linear expansion: 11.1 micrometer/m.degree Celsius; Poisson ratio: 0.3; Tensile Strength: 75kgf/mm^2; Yield stress: 42kgf/mm^2.

Aluminium:

Specific weight: 0.027 N/cc; Young's Modulus: 0.675e5; Modulus of rigidity: 0.26e5; coefficient of linear expansion: 23.8 micrometer/m.degree Celsius; Poisson ratio: 0.34.