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Evaluation Of The Performance Of Front Winshield Wipers On Land Transport Safety

(The Study Was Conducted Usinga Simulator Design of the Electric System of Windshield Wipers and Washer of Toyota Kijang KF80)

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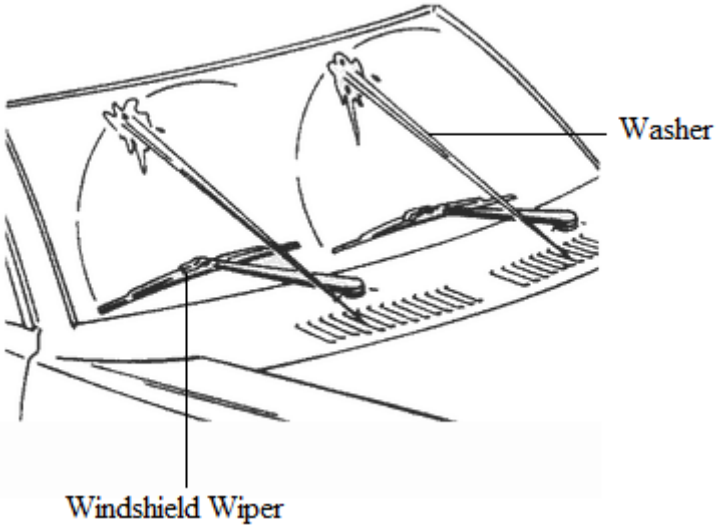
ABSTRACT : *Rainwater, dust and exhaust gas chemicals from vehicles that stick to the surface of an automobilewindshield are probably not an issue as long as the driver has an unobstructed view of the road. However, if the sticking substances are left unchecked, they will become a threat for travel safety.*
Relying on the Front Windshield Wipers and Washer in order to clean the front windshield glass is not the final solution. Proper care is needed in order to ensure the cleanliness of the windshield glass. The area of the windshield glass of Toyota Kijang KF80 is 0.964 m^2.With the area covered by the wipe of the wiper blades as much as 0.6162 m^2, then the effectiveness of the wipe of the wiper blade is 63.92%. The comparison between worm gear and gear reduction is 8:1, with the reduction objective to lower the rotation of wiper motor and increase the moment of the wipe.
Key words: *performance, front windshield wipers*

I. INTRODUCTION

The front windshield wiper systemis one of the safety systems in a vehicle, which is categorized as a passive safety system because it only works when needed. The front windshield wipersfunction to ensure that the driver's view remainsunobstructed when rain and or other natural disturbances occur.

As a supporting component of an automotive vehicle, a windshield wiperis one of the prerequisites of vehicle roadworthiness; therefore, the front windshield wipers on four-wheeled or more vehicles become an inseparable part. The number of wipers designed by the industry is 2 units on the front, with one vehicle being required to at least have one unit. The windshield wiper is not merely made to fulfill the requirements, but more ultimately it is built in order to abide by Law Number 22 of 2009, article 48, paragraph 2 on Traffic and Road Transport as part of the technical requirements for motor vehicles, and also function-wise the wipers can clean the windshield glass optimally.



Picture 1:WindshieldGlass and Wipers on a Car

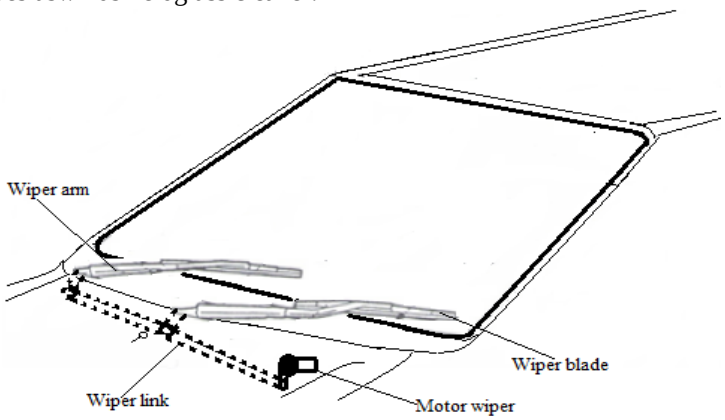
The front windshield wiperswork by wiping the windshield glass. The wipers have to work according to the needs: When drizzle occurs, the front windshield wipershave to move slowly so that the driver's view will not be obstructed by the movement of the wiper blades;while when it rains heavily, the windshield wipersmust move quickly in order for the wiper bladesto be able to clean water from the windshieldglass maximally.

Nevertheless, based on Toyota Step 2 book, there are a few problems that sometimes occur in the front windshield wiper system, such as:wiper motoris unable to work at all positions (low speedand high speed);wiper motoris unable to work at low speed;wiper motoris unable to work at high speed;wiper motorstops at every position;when the switch is off, wiper motor works intermittently; wiper motoris unable to work together with washer;washer motoris unable to work;and the fuse system of the windshield wipersgets disconnectedbecause of a short circuit.

II. THEORETICAL REVIEW

1. Front Windshield Wiper System

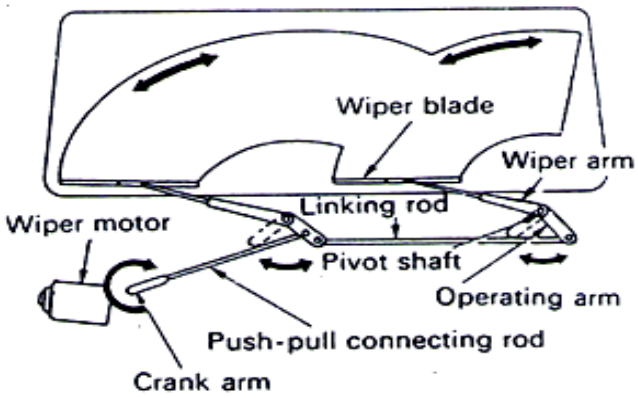
The front windshield wipersystem comprises several components,namely: wiper motor, which functions as the prime mover in windshield wiper system; wiper link, which functions to translate the rotationalmotion of wiper motorinto a translationalone; wiper armthat functions as wiper blade holder; and wiper blade, which serves aswindshieldglass cleaner.



Picture 2: Windshield Wiper Construction

2. Howthe Front Windshield Wiper System Works

The prime mover of wipers is a magnetic motor with reduction gear. Generally, the working principle of the wipers can be described below:



Picture 3:The Working Principle of Wipers

When motor is switched on, worm gear will rotate, causing the contact point to move and rotate the crank arm, which will then translate the rotational motion of the contact point into a translational motion on the push-pull connecting rod. Operating arm that is connected to the push-pull connecting rod will move the wiper arm on the pivot shaft,which will result inthe wiper blade making a half circle wipe on the windshield. The right and left sides of operating arm are connected by a linking rod, so that the motion of the left wiper blade and right wiper blade will be simultaneous.

3. General Review on the Basics of Electricity

a. Basics of Electricity

Electricity is one of the forms of energy that cannot be seen with the naked eye, but its effects and benefits can be perceived. The word comes from *electron*, which is a part of an atom. It is of two types, namely: static and dynamic electricity (Toyota, 1995:2-3).

b. Electric Power

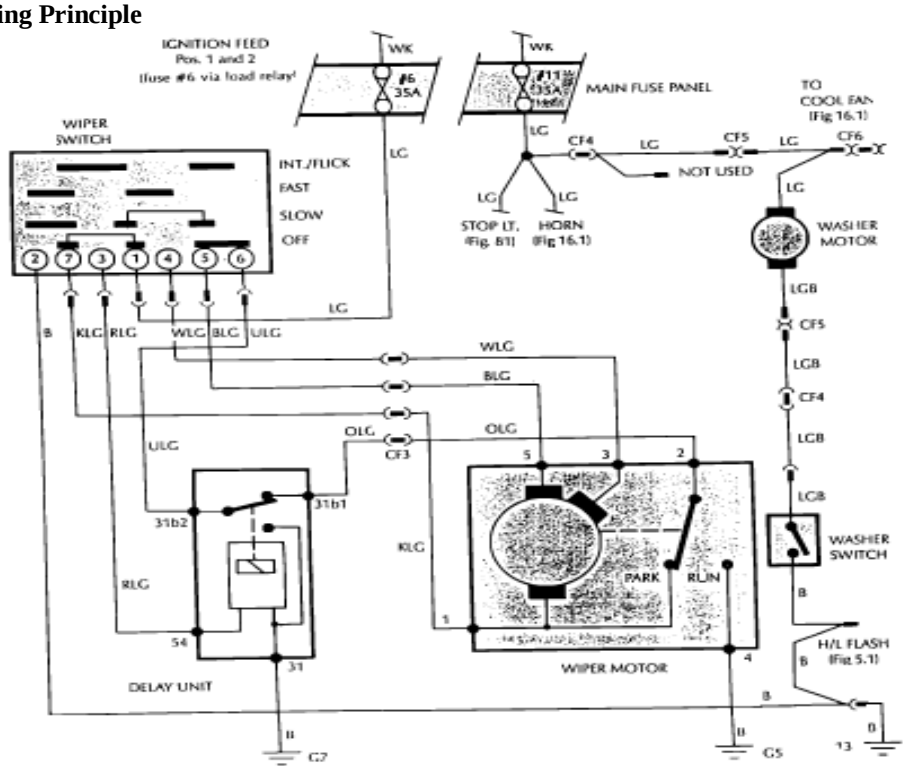
The amount of work done per unit of time is called power (P), thus, the equation for power can be formulatedbelow:

$$P = \frac{W}{t} = V \cdot I \qquad \text{(Toyota 1995: 8-3)}$$

Notes:

P = Electric Power (*Watt*)
W = Electric Energy (*Joule*)
V = Voltage (*Volt*)
I = Electric Current (*Ampere*)
t = Time (second)

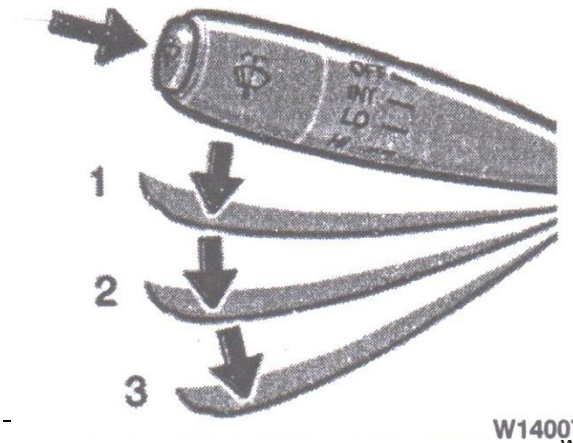
c. The Working Principle



Picture 4: Windshield Wiper System Electrical Circuit

The working principle of wipers can be explained by the circuit above.
Terminals +1, +2, and (+) and (-) are located on wiper motor, and terminalsLR1, LB1, LW and L on wiper switch, with terminal LR as a low speed terminal, LB = high speed terminal, and LW = auto stop negative terminal. At low speed, the current flows from L battery → LB_1 → +2 → B_2 → B_3 → (-) →body mass, and wiper motor will rotate quickly.

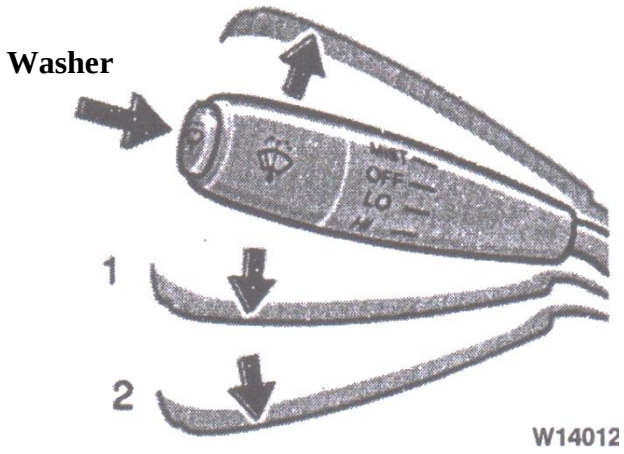
To turn on the front windshield wipers, move the lever to the desired setting.



Fire switchmust be in the "ON" position
Type A-

Lever Position	Speed Setting
Position 1	Intermittent
Position 2	Slow
Position 3	Fast

Picture 5:Type A Wiper Switch



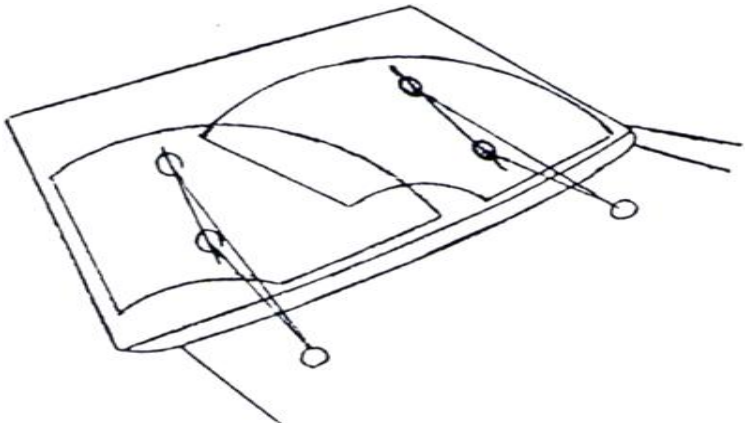
Type B-

Lever Position	Speed Setting
Position 1	Slow
Position 2	Fast

Picture 6:Type B Wiper Switch

4. WasherSystem

Washer systemis used to complete the work of wiper bladesin cleaning the windshieldglass and reducing the burden of the motor while moving the wiper blades. Generally, the working principle of the washer is as follow: If washer motor is activated, the impeller will rotate and transfer fluid out of the pump housing through the hose and to the nozzle.



Picture 7:The Working Principle of the Washer

a. Washer Tank

The shape of a washer tankis varied depending on the available placement position.

b. Washer motor(Pump)

Washer motorfunctions to move the pump, which will then eject cleaning fluid from the tank. There are two types of washer motor, namely wound rotor and ferrite magnet. The ferrite magnet type is more commonly used in vehicles today.

c. Nozzle

Nozzle is made of copper, aluminum, or resin pipe with one or two holes. Currently, the widely used nozzle is resin nozzle with adjustable orifice.

III. RESULTAND DISCUSSION

1. Discussion of Motor Calculation

a. Motor Power (P)

1) Low speed

$P = I_1 \times V$

$= 3 \times 12$

$= 36$ *Watts*

2) High speed

$P = I_2 \times V$

= 5 x 12
= 60 *Watts*

b. Worm Gear andGear Reduction Calculation

Based on the measurements, the following data on worm gear and gear reduction are obtained:

Diameter of worm gear (d_1) = 7,30 mm
Diameter of gear reduction (d_2) = 61,30 mm

a) Comparisonof Rotation (u)

$$u = \frac{d_1}{d_2} = \frac{7,30}{61,30} = 0,114$$

Based on the results of the calculation above, it is found that u < 1, so the comparison between d_1 and$d_2$serves to reduce the rotation.

b) Comparison of Rotation between Worm Gear and Gear Reduction (u)

$$u = \frac{n_2}{n_1}$$
$$= \frac{1}{0,114}$$
$$= 8,77 \approx 8 \text{ Rotations}$$

So, the comparison of rotation between worm gear and gear reduction is 8 :1 (8 worm gear rotations = 1 gear reduction rotation).

1. Washer MotorCalculation

a. Discussion on Washer MotorCalculation

Motor Power (P)

$P = I \; x \; V$
= 0,5 *x* 12
= 6 *Watts*

b. Calculation of Water Flow Discharge of the Washer

The water flow discharge of the washer can be calculated by subtracting the volume of the washer tank by the end volume and then divided it by time.

$D = \frac{V_0 - V_1}{t}$ (http://rangkuman-pelajaran.blogspot.com)

Where
D = Water Flow Discharge (liter/second)
V_0 = the initial volume of the tank (m^3)
V_1 = the end volume of the tank (m^3)
t = Time (second)

The initial volume of the washer tank is one liter and the end volume is 0.5 liter. The time needed to transfer 0.5 liter water is 5 minutes; therefore, the water flow discharge of the washer is:

V_0 = 1 liter
V_1 = 0.5 liter
t = 5 minutes ≈ 300 seconds
Then

$$D = \frac{V_0 - V_1}{t}$$
$$= \frac{1x10^{-3} - 5x10^{-4}}{300}$$

= 0,0017 liter/second

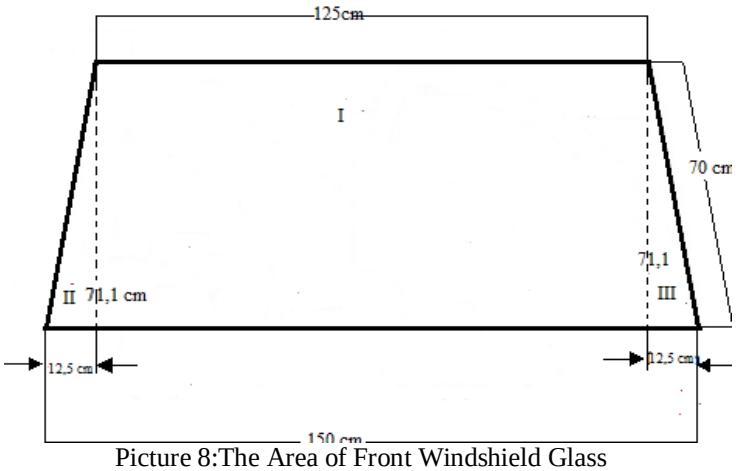
So, the water flow discharge of the washeris 0.0017 liter/second.

The water flowper one second in the washer consumes 0.0017 liter of cleaning waterin the washer tank.

2. The Effectiveness of Vehicle Front View

The percentage of the wipeof wiper blades on the windshieldglass can be found by dividing the area of the wiper blades' wipe on the windshieldglass by the total area of the front windshield glass.

a. The Area of the Front Windshield Glass



Picture 8:The Area of Front Windshield Glass

The total area of the front windshield glass can be counted by:

$L_k = L_I + L_{II} + L_{III}$

with,

$L_I = P \times L$

$= 125 \times 70$

$= 8750\ cm^2$

$L_{II} = \frac{1}{2} a \times t$

$= \frac{1}{2} . 12,5 \times 71,1$

$= 444,375\ cm^2$

$L_{III} = \frac{1}{2} a \times t$

$= \frac{1}{2} . 12,5 \times 71,1$

$= 444,375\ cm^2$

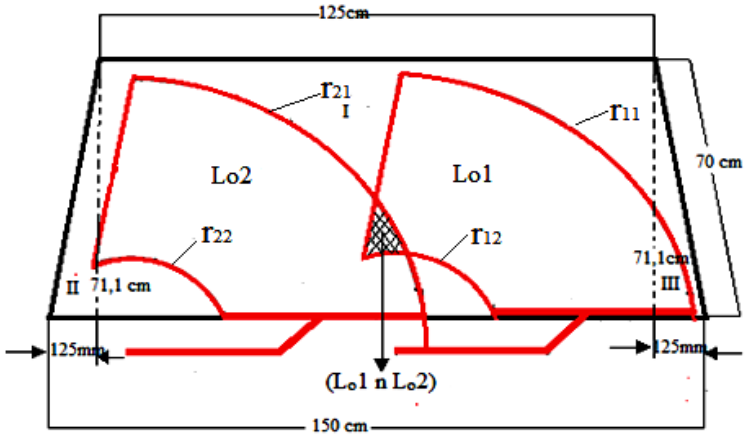
Then, the area of the front windshield glass is

$L_k = L_I + L_{II} + L_{III}$

$= 8750 + 444,375 + 444,375$

$= 9638,75\ cm^2 \approx 0,964\ m^2$

b. The Area of Wiper Blades' Wipe on the Windshield Glass



Picture 9:The Areaof the Wipeof Wiper Blades on the Windshield Glass

1) The area of the first circle (L_o1)

$Lo1 = L_{11} - L_{12}$

$L_{11} = (\pi \cdot r_{11}^2)$

$= 3,14 . 68^2$

$= 14519\ cm^2$

$L_{12} = (\pi \cdot r_{12}^2)$

$= 3,14 . 24^2$

$= 1808\ cm^2$

$Lo1 = L_{11} - L_{12}$
$= 14519 - 1808$
$= 12711\ cm^2$
$L_s = \frac{\beta}{360^\circ} x\ L_o 1$
$= \frac{93,48}{360^\circ} x\ 12711$
$= 3300,623\ cm^2 \approx 0,3300\ m^2$

2) The area of the second circle (L_o2)
$Lo2 = L_{21} - L_{22}$
$L_{21} = (\pi \cdot r_{21}{}^2)$
$= 3,14 . 67^2$
$= 14095\ cm^2$
$L_{22} = (\pi \cdot r_{22}{}^2)$
$= 3,14 . 23^2$
$= 1661\ cm^2$
$Lo2 = L_{21} - L_{22}$
$= 14095 - 1661$
$= 12434\ cm^2$
$L_s = \frac{\beta}{360^\circ} x\ L_o 2$
$= \frac{84,8}{360^\circ} x\ 12434$
$= 2928,89 cm^2 \approx 0,2928\ m^2$

Meanwhile, there is a slice on the result of the wipe of the wiper blades, so that:
$L_s = L_s1 + L_s2 - (L_o1\ n\ L_o2)$
$= 0,3300 + 0,2928 - (0,006624)$
$= 0,6162\ m^2$
The effectiveness of the wipe of the wiper bladeson the windshield glass can be found by:

$Effectiveness = \frac{L_s}{L_k}\ x\ 100\%$
$= \frac{0,6162}{0,964}\ x\ 100\%$
$= 63.92\%$

IV. CONCLUSION

1. The current needed by wiper motor and washer
   a. For low speed, the required current for the wiper motoris 3A.
   b. For high speed, the required current for the wiper motoris 5A.
   c. Intermittentwiperswork by using wiper motorat low speed, so that the current required for intermittent wipersis the same as the current required for wiper motorat low speed, which is 3A.
   d. The required current for washer motor is0.5A.
2. Wiper motorand washer motorpower
   a. For low speed, wiper motorgenerates power as much as 36 Watts.
   b. For high speed, wiper motorgenerates power as much as 60 Watts.
   c. Washer motorgenerates power as much as 6 Watts.
3. Fuse Size
   The current that flows in the windshield wipersystem is 9A, so that based on the results of the calculation, the fuse used is 15A.
4. The size ofthe conducting wirein the windshield wipersystem is 0.3 mm^2.
   The size of the conducting wirein the washer system is 0.3 mm^2.
5. Based on the results of the calculation, the comparison of worm gearand reduction gear is 8:1;the ratio serves to reduce the rotation of the motor in order to increase moment.
6. The area of thewipe of thewiper blades
   a. Based on the results of the calculation, the area of the front windshield glass of Toyota Kijang KF80 is 0.964 m^2.
   b. Based on the results of the calculation, the area of the wipeof both wiper bladeson the front windshield glass of Toyota Kijang KF80 is 0.6162 m^2.
   c. Based on the results of the calculation, the effectiveness of the wipe of both wiper blades on thefront windshield glass of Toyota Kijang KF80 is 63.92%.

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