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Design of Windshield Wiper with Integrated Nozzle Using 3D-Printing Technology

Jaykumar Gajera[1*], Uttam Khunt[2], Parthkumar Rudani[3]
[1,2,3]*Department of Automobile Engineering, Uka Tarsadia University, Surat, India*

***Abstract*: Having properly working windshield wipers is one of the most overlooked features of being safe while driving. Whether it's dealing with poor weather conditions or other obstructions, efficient windshield wipers are key to having the clearest view while driving. It features wiper blades with holes that produce a highly precise spray of washer fluid directly in front of the moving wipers. The system helps eliminate the brief, vision-blocking spray across the full windshield that happens with most vehicles. Washer and wiper are combined into the blade to replace conventional spray nozzles. A duct system will take washer fluid directly to the wiper blade, where the wiper fluid is sprayed out from many small holes. The fluid will be precisely ejected to the front of the wipers and onto the windshield and the wiper blade at the same time will sweep across the surface to in either direction. This aim of work is described in this research paper, design and manufacture windshield wiper using 3D-printing which can be installed in conventional vehicle to maintained clear view during the windshield cleaning process.**

***Keywords*: Arm, 3D-printing, Nozzle, Windshield wiper, Wiper blade.**

1. Introduction

A windscreen wiper or windshield wiper is a device used to remove rain, snow, ice and debris from a windscreen or windshield. Almost all motor vehicles, including cars, trucks, buses, train locomotives, watercraft with a cabin and some aircraft, are equipped with such wipers, which are usually a legal requirement.

A wiper generally consists of a metal arm, pivoting at one end and with a long rubber blade attached to the other. The arm is powered by a motor, often an electric motor, although pneumatic power is also used in some vehicles. The blade is swung back and forth over the glass, pushing water or other precipitation from its surface. The speed is normally adjustable, with several continuous speeds and often one or more "intermittent" settings. Most automobiles use two synchronized radial type arms, while many commercial vehicles use one or more pantograph arms.

A windshield washer system is also used. This system sprays water or an antifreeze window washer fluid at the windshield using several nozzles. The windshield washer system helps to remove dirt or dust from the windshield when it is used in concert with the wiper blades.

Fig. 1. A common windscreen wiper arm and blade

The wipers combine two mechanical technologies to perform their task:

- A combination electric motor and worm gear reduction provides power to the wipers.
- A neat linkage converts the rotational output of the motor into the back-and-forth motion of the wipers.

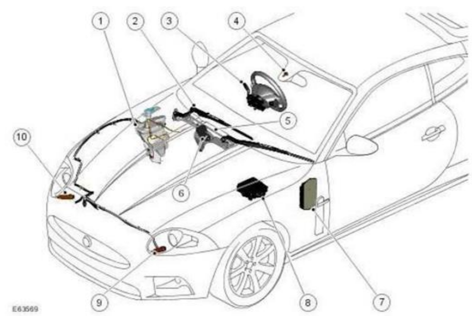

Fig. 2. System diagram

Table 1
Name of component of Wiper system

Item No.	Description
1	Washer reservoir bottle and filler neck
2	Wiper arms/blades (2 off)
3	Wiper/Washer control switch
4	Rain sensor
5	Mounting arm and pivot shaft
6	Wiper motor
7	Central junction Box (CJB)
8	Power distribution box
9	RH headlamp power wash jet
10	LH headlight Power wash jet

*Corresponding author: gajerajk1998@gmail.com

A. Geometry

Most wipers are of the pivot (or radial) type: they are attached to a single arm, which in turn is attached to the motor. These are commonly found on many cars, trucks, trains, boats, airplanes, etc.

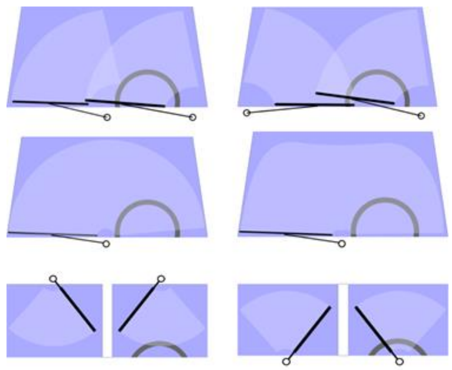

Fig. 3. Different geometry

B. Rain-Sensing Wiper

Some vehicle are now available with drive programmable intelligent (automatic) windscreen wipers that detect the presence and amount of rain using a rain sensor. The sensor automatically adjusts the speed and frequency of the blades according to the amount of rain detected. These controls usually have a manual override.

Rain-sensing windscreen wipers appeared on various models in the late 20th century, one of the first being the Citroen SM. As of early 2006, rain-sensing wipers are optional or standard on all Cadillac and most Volkswagens, and are available on many other mainstream manufacturers.

Fig. 4. Rain sensor on the windshield of a car

C. Magic Vision Control

A few years ago, the German brand developed a sophisticated new windshield wiper that promised all-season capability, less waste of washer fluid and longer-lasting blade performance. The MAGIC VISION CONTROL system was first introduced on the 2012 Mercedes-Benz SL, and is now trickling down to lower-priced models such as the 2018 Mercedes-Benz E-Class Coupe we recently drove in Spain.

Each wiper arm is equipped with two washer fluid channels that benefit from laser-cut pores. Washer fluid is distributed along the entire length of the wiper blade, a little more at the end of the blade that sweeps a greater surface of the windscreen.

Mercedes-Benz claims this system is safer than a conventional wiper system that shoots washer fluid on the windshield, blurring the driver's vision for a second before the wipers activate themselves.

The system is programmed to squirt less fluid in the summertime, and more in winter to be more effective against slush and calcium that has accumulated on the windscreen. It regulates washer fluid output based on, among other things, outside temperature and vehicle speed. According to the automaker, this reduces the quantity of washer fluid used and vehicles following behind in traffic don't get sprayed, either. In the case of convertibles such as the SL roadster, the Mercedes-Benz S-Class Cabriolet and the newly introduced 2018 Mercedes-Benz E-Class Cabriolet, MAGIC VISION CONTROL reduces the amount of washer fluid used when the vehicle's top is down so occupants don't get sprayed. In addition, the wiper and the fluid hose system both incorporate heating elements. Snow and ice cannot build up on these wipers, which mean they remain flexible and effective at all times, even in a bad snowstorm. Combined with the fact that the wipers will never scrub a dry windshield, the blades are said to last longer. A great system for our harsh Canadian winters.

The only downside to these innovative windshield wipers is price. If they break, or once the blades will eventually need to be replaced, the car's owner will have to change the whole wiper assembly. A pair of MAGIC VISION CONTROL wipers costs about 95 Euros, or CAD$137 with the current exchange rate, installation not included. In all fairness, that's only $43 more than a set of Mercedes-Benz's regular windshield wipers. It features wiper blades with laser-cut holes that produce a highly precise spray of washer fluid directly in front of the

moving wipers. The system helps eliminate the brief, vision-blocking spray across the full windshield that happens with most vehicles. This technique also helps minimize overspray and runoff. In addition, since the washer fluid reservoir, lines and even the wiper blade are heated, it is very effective in cold weather.

Fig. 5. The magic vision control

Each wiper arm is equipped with two washer fluid channels that benefit from laser-cut pores. Washer fluid is distributed along the entire length of the wiper blade, a little more at the end of the blade that sweeps a greater surface of the windscreen. This system is safer than a conventional wiper system that shoots washer fluid on the windshield, blurring the driver's vision for a second before the wipers activate themselves.

2. Design

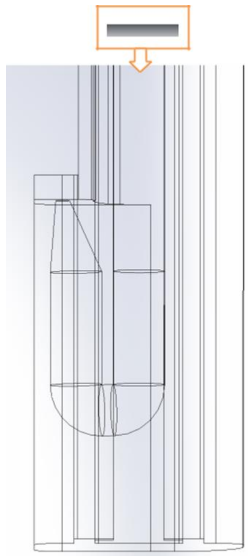

Fig. 6. Top view of windshield wiper

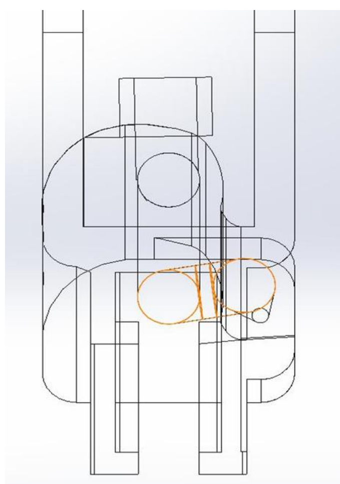

Fig. 7. Side view of windshield wiper

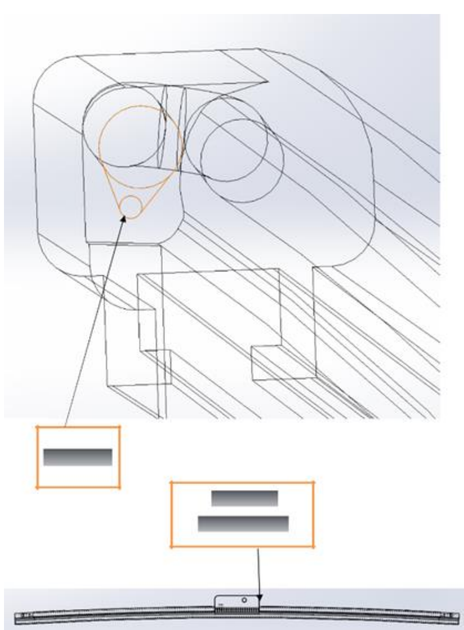

Fig. 8. Isometric view of windshield wiper

3. Implementation

After completing design of the modified wiper, proper method needs to convert the design of modified wiper in to actual model which easy in manufacture, cost effective and weight of product is less.

In current time, Industry 4.0 is a name given to the current trend of automation and data exchange in manufacturing technologies. There are several methods of manufacturing but cost effective and less weighted product is manufacture using only 3D-printing technology. Additive manufacturing is a transformative approach to industrial production that enables the creation of lighter, stronger parts and systems. Additive manufacturing uses data computer-aided-design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes. As its name implies, additive manufacturing adds material to create an object. By contrast, when you create an object by traditional means, it is often necessary to remove material through milling, machining, carving, shaping or other means. Although the terms "3D printing" and "rapid prototyping" are casually used to discuss additive manufacturing, each process is actually a subset of additive manufacturing.

The term 3D printing covers a variety of processes in which material is joined or solidified under computer control to create a three-dimensional object, with material being added together (such as liquid molecules or powder grains being fused together), typically layer by layer.

Today, the precision, repeatability and material range have increased to the point that some 3D printing processes are considered viable as an industrial production technology, whereby the term additive manufacturing can be used synonymously with 3D printing. One of the key advantages of 3D printing is the ability to produce very complex shapes or geometries, and a prerequisite for producing any 3D printed part is a digital 3D model or a CAD file.

There are many different 3D printing processes, that can be grouped into seven categories:

- Vat photo polymerization
- Material jetting
- Binder jetting
- Powder bed fusion
- Material extrusion
- Directed energy deposition
- Sheet lamination

For our project, we are using the “Material extrusion” process.

A. *Material Extrusion*

The most commonly used technology in this process is Fused Deposition Modelling (FDM). Fused deposition modelling (FDM), a method of rapid prototyping: 1 – nozzle ejecting molten material (plastic), 2 – deposited material (modelled part), 3 – controlled movable table.

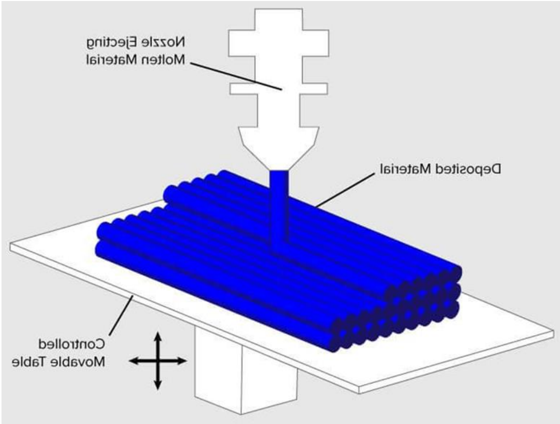

Fig. 9. Fused deposition modelling

The FDM technology works using a plastic filament or metal wire which is unwound from a coil and supplying material to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism, directly controlled by a computer-aided manufacturing (CAM) software package. The object is produced by extruding melted material to form layers as the material hardens immediately after extrusion from the nozzle. This technology is most widely used with two plastic 3D printer filament types: ABS (Acrylonitrile Butadiene Styrene) and PLA (Polylactic acid). Though many other materials are available ranging in properties from wood fill to flexible and even conductive materials.

B. Process of 3D Printing

1) 3D model creation

First a 3D model of the object is created using CAD software or a 3D object scanner. Here we are using the “SOLIDWORKS”.

2) Slicing the 3D model

3D model is slice in order to make it 3D printable. Slicing is dividing a 3D model into hundreds or thousands of horizontal layers and is done with slicing software. Here we are using the “CURA”. CURA is open source slicing software. Slicing of 3D model is depend on the value of initial layer height, layer thickness and fill density, support material.

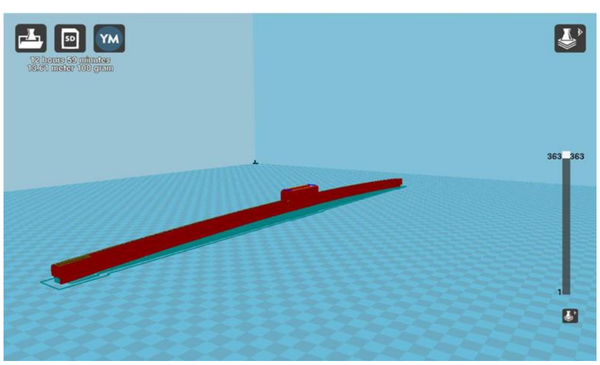

Fig. 10. Slicing of 3D model

Above figure represent the slicing of 3D model with support material. In figure red lines are shows the layer and blur colour shows the support material. For 0.1 mm layer height and 80% fill density there are total 363 layer are built for completing this object.

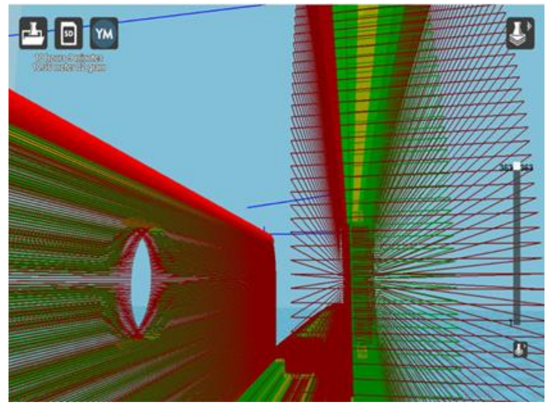

Fig. 11. Slice(layer) of 3D model

3) Generate G-code file

After applying all condition and value, click on SD button which generate G-Code file. G-code file is the numerical control file which read by the 3D printer and start to printing according to the code.

4) Printer set-up

Power on the printer. First most important step is “Bed levelling”. In bed levelling, 9 points are set on bed for perfect level of bed. If bed is not in level than extruder nozzle is strike on the surface of bed and may be chance of breaking of nozzle or misalignment of nozzle.

5) Material Selection

Fused Deposition Modelling mostly used PLA (Polylactic acid), ABS (Acrylonitrile Butadiene Styrene), Photo curable resin, carbon fiber. In our project, we are used PLA (Polylactic acid) because its filament is easily available and cost effective. PLA has also lower melting temperature.

Table 2
Property of PLA (polylactic acid)

Property	Value
Technical Name	Polylactic Acid (PLA)
Chemical Formula	$(C3H4O2)n$
Melt Temperature	157 - 170 °C
Typical Injection Molding Temperature	178 - 240 °C
Density	1.210–1.430 g·cm³
Tensile Strength	61 - 66 MPa (8840 - 9500 PSI)
Flexural Strength	48 - 110 MPa (6,950 - 16,000 PSI)
Specific Gravity	1.24
Shrink Rate	0.37 - 0.41% (0.0037 - 0.0041 in/in)
Glass Transition	60-65 °C

6) Printing

Now select the G-code file from the storage of the printer with the help of control panel.

7) Post-Processing

When product is completely printed than in this step removal of the support material, finishing of surface and painting included.

4. Actual Model

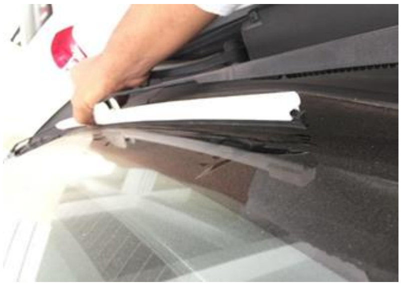

Fig. 12. Actual model

Fig. 13. Direction of spray of water from nozzle

5. Calculation

1) Motor calculation

Low speed	High speed
P=I*V	P=I*V
=3*12	=5*12
= 36 watts	= 60 watts

2) Washer motor calculation

P=I*V
=0.5*12
= 6 watts

3) Water flow discharge of the washer

$D = (V_0-V_1)/t$ $\quad$ $D = (v_0-v_1)/t$

D = Water flow discharge $\quad$ = (0.001-0.0005)/300

V_0 = The initial volume of the tank $\quad$ = 0.0017 lit/s

V_1 = The end volume of the tank

T = 5 min. = 300 sec.

V_0 = 1 lit.

V_1 = 0.5 lit.

4) Area of the front windshield glass

The total area of the front windshield is

A=A1+A2+A3

A1=P*L	A2=1/2a*t	A3=1/2a*t
= 8750 cm^2	= 444.375 cm^2	= 444.375 cm^2

A = 9638.75 cm^2

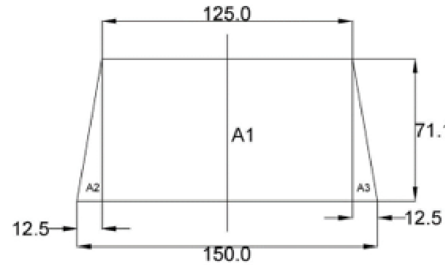

Fig. 14. Schematic view of front windshield wiper

5) The Area of wiper blades wipe on the windshield glass

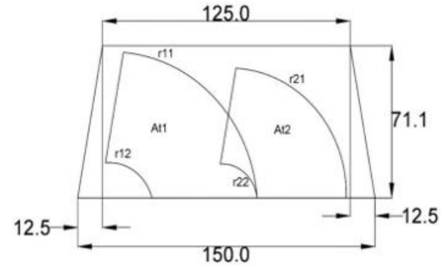

Fig. 15. Schematic view of front windshield wiper

The area of the first circle:

A = A1-A2

$A1 = \pi * r^2$ $\quad$ $A2 = \pi * r_2^2$

= 14519 1 cm^2 $\quad$ = 452.16 cm^2

A = 14066 cm^2

The area of the second circle:

A = A1-A2

$A1 = \pi * r^2$ $\quad$ $A2 = \pi * r_2^2$

= 13677 cm^2 $\quad$ = 452 cm^2

A = 13225 cm^2

6. Conclusion

It was a wonderful and learning experience while working on this project. This project took through the various phases of project development and gave the real insight into the world of CAD Design and 3D printing. The joy of working and the thrill involve while tackling the various problems and challenges gave a feel of developer's industry. It was due to this project came to know how professional software's are used to designed and which factor to be considered for developing new system.

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