

Yoreh Mitwa - An Electrochemical Rain Sensing Wiper*

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Abstract ----In this paper, we have investigated an electrochemical switch which is rain sensitive and independent of the electronics of the vehicle. Also, a lot of electrical components are involved in electrically operated rain sensing wiper, hence, there is always a chance of short circuit since the system deals specifically with water as medium. As a result regular inspection and preventive maintenance prove to be crucial for it as compared to our wiper which is eco-friendly and offers high reliability. In this paper, we have compared our electrochemical based wiper system with other existing methods in literature.

Keywords—*electrochemical, rain sensitive, wiper, low cost*

1. INTRODUCTION

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 Cadillacs and most Volkswagens, and are available on many other mainstream manufacturers. Some vehicles are now available with driver-programmable intelligent (automatic) windscreen wipers that detect the presence and amount of rain using a rain sensor. The sensor automatically



Figure 1 – Mumbai Flooding

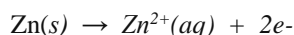
adjusts the speed and frequency of the blades according to the amount of rain detected. These controls usually have a manual override.

2.MAIN WORK

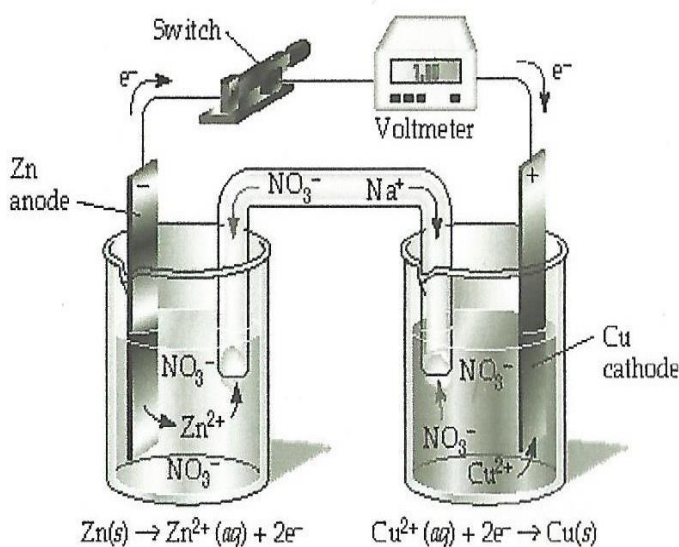
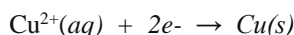
2.1 PRINCIPLE OF OPERATION : ELECTROCHEMISTRY

Electrochemistry is the study of chemical processes that cause electrons to move. This movement of electrons is called electricity, which can be generated by movements of electrons from one element to another in a reaction known as an oxidation-reduction ("redox") reaction (See Figure 2.)

Chemical reactions involving the transfer of electrons from one reactant to another are called *oxidation-reduction reactions or redox reactions*. In a redox reaction, two half-reactions occur; one reactant gives up electrons (undergoes oxidation) and another reactant gains electrons (undergoes reduction). A piece of zinc going into a solution as zinc ions, with each Zn atom giving up 2 electrons.^{1*}



In a reduction there is a decrease (or reduction) in oxidation number. Chemical equation representing half-reactions must be both mass and charge balanced. In the half-reactions above, there is one zinc on both sides of the equation. The charge is balanced because the 2+ charge on the zinc ion is balanced by two electrons, 2e-, giving zero net charge on both sides.



Proper choice of electrodes and electrolytes will enable us to create an electrochemical rain sensitive cell

%% Calculation of voltage generated by Copper cathode and Magnesium anode using Nernst equation

$$V_0 = 0.34 - (-0.76) = 1.1;$$

$$R_{\text{const}} = 8.314;$$

$$F = 96485;$$

$$\text{Temp}_{\text{Cu}} = 25 + 273;$$

$$\text{Temp}_{\text{Al}} = 25 + 273;$$

$$\text{Zn} = 0.001;$$

$$\text{Cu} = 5;$$

$$V_{\text{cell}} = V_0 - (R_{\text{const}} * \text{Temp}_{\text{Zn}} / (2 * F)) * \log(\text{Zn}) + (R_{\text{const}} * \text{Temp}_{\text{Cu}} / (2 * F)) * \log(\text{Cu})$$

^{1*} *Yoreh Mitwa means "a dear friend of the early spring rains"*

The electrochemical rain sensitive cell produces a voltage of around 1.1 V

2.2 ADVANTAGES AND LIMITATIONS

A. Advantages

- 1) In developing countries, there is heavy neck to neck traffic allowing very less reflection time on the part of the driver. Also, situations are common where the vehicles have to follow huge trucks without tail-lights. Such situations can cause the driver to panic resulting in him pressing some wrong button in-order to start the wiper. A low cost rain sensing wiper will be very useful in such a scenario.
- 2) Also, during the Mumbai 26/7 rains, lot of vehicles lost their electronic capability due to water logging in the vehicles. This resulted in loss of life of individuals as they were incapable of leaving the vehicle as all the power driven windows and doors were sealed. A rain sensing wiper system that works on other principle than electronics would be a boon in such a situation. The voltage can be made to open the power locking windows allowing passengers to escape from the vehicles.
- 3) In developed nations, when the vehicle is left in the open and a snowfall occurs such a system would turn on the wipers and scrub the snow. When the ignition is turned off the wiper still keeps on running allowing for better visibility for the driver. The shut off ignition should close the opening for the water thereby stopping the wiper.
- 4) During normal driving in cities with heavy traffic, the car heats up very fast and the bonnet also tends to have a very high temperature. The collected water can be used to cool the bonnet in such a situation when there is no rainfall.
- 5) Lot of electrical components are involved in electrically operated rain sensing wiper there is always a chance of short circuit since the system deals specifically with water as medium. As a result regular inspection and preventive maintenance prove to be crucial for it.
- 6) The initial cost of traditional rain sensing wiper is considerably high as compared to the proposed one ; so in regions where rainfall is as scarce as one to two months annually it is not economical to invest such a high amount in it.

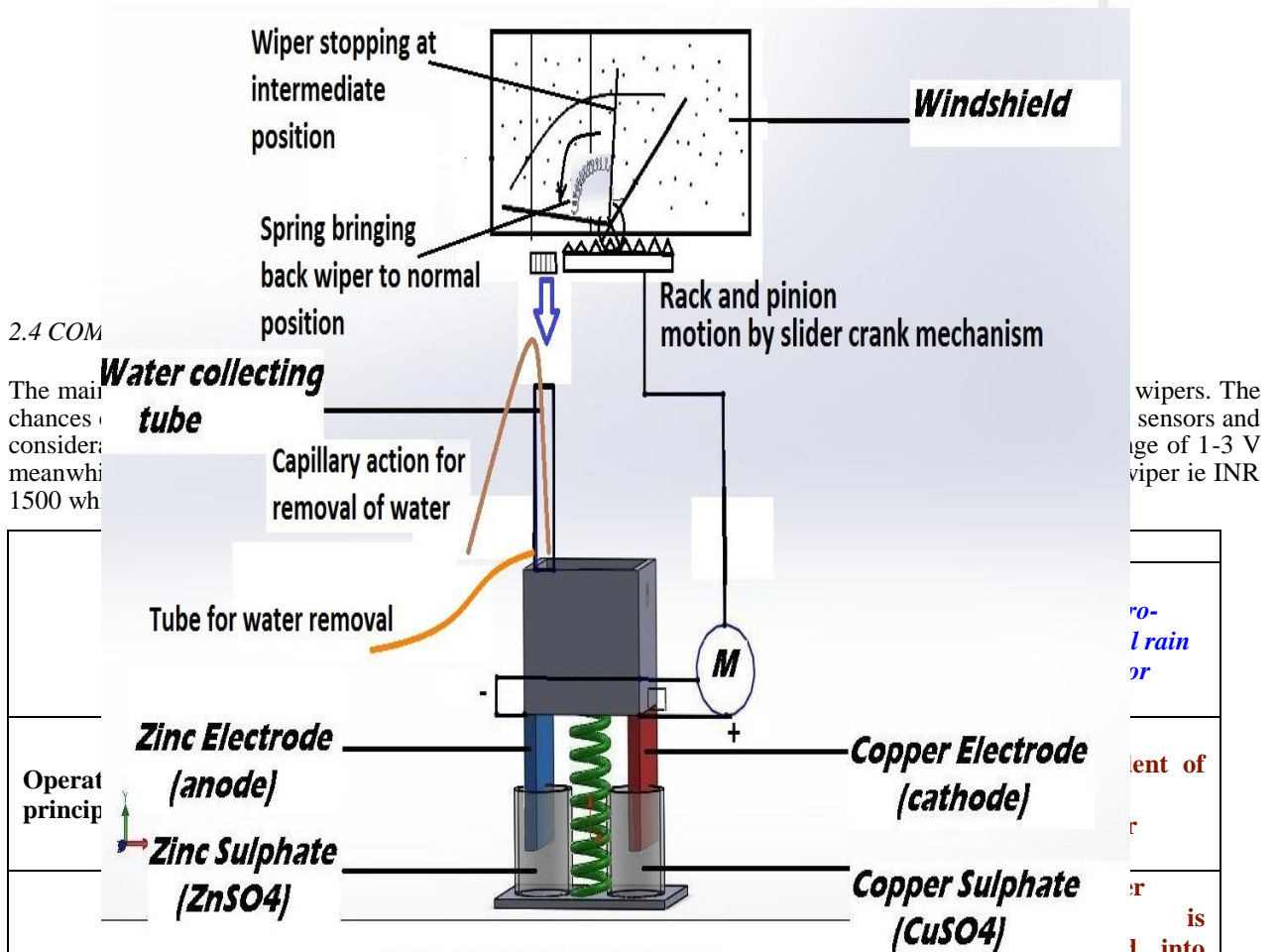
B. Limitations

1. Even though the redox (reduction-oxidation) reaction is spontaneous, response time for this electrochemical rain sensing wiper may be more as compared to traditional method since some amount of rainwater needs to get collected for the wiper to operate. This needs to be tested and checked in laboratory. Also in case of smog or fog may not be wiped from windshield which is done by certain rain sensing wiper.
2. For this rain sensing wiper to work continuously for years it depends of life of electrolyte and electrodes. Often after a very long drive when galvanic cell(battery) reaches polarization the it is recharged by generator and after prolonged usage the electrolytes are changed or distilled water is added as substitute. It takes about 6 to 7 years of driving to make certain galvanic cell inoperable.
3. Temperature makes some issue with galvanic cell (battery). When the temperature is very low the density of electrolyte increases and in certain cases freezing of electrolyte occurs which obstructs the flow

2.3 Working of Electrochemical Rain Sensitive Cell

The galvanic cell used consists of two electrodes ie Zinc and Copper. These are attached to the water collecting container which is supported by a spring. The other end of spring is fixed to a base plate , further the two beakers containing respective electrolytes are placed on the plate exactly below those corresponding electrodes. When it is raining the water droplets tend to fall on the car's windshield and the water starts getting collected in the container through the water collecting tube which acts as a passage for the rain water. As a result the weight of the container increases due to the rainwater accumulation. Hence the container is displaced from its original position

downwards due to which the spring is compressed. The electrodes which are attached to the container simultaneously get dipped in their respective electrolytes which results in electrochemical reaction and therefore electricity is produced. This electricity is harnessed to run the motor. The rotary motion of the motor is converted to reciprocating motion by rack and pinion mechanism. This motion is fed to the wiper via connecting rod which is attached to the pinion. Thus the wiper moves thereby cleaning the rainwater off the windshield which serves the purpose.



Working	water change the resistance	plates decrease resistance	probe completes rain circuit	reflection due to rain water	displacement of electrochemical switch
False rain detection rate	Very high	Less than 5 %	Less than 2 %	Less than 2 %	Less than 2 %
Voltage required	12 – 5 V DC	12 – 5 V DC	2 – 6 V DC	12 – 5 V DC	1 – 3 V per single cell
System response time	Not mentioned	500 ms after rain contact	On collection of 10 cu.cm	Very low	110 – 260 ms after rain contact
Sensor size surface	Very large	<= 4 cm x 4 cm	>=2.58 cm x 2.58 cm	Not applicable	1 cm x 1 cm
Placement of sensor	On the windshield	On the windshield	Inside the front hood	Inside the car cabin	Inside the front hood

Cost replacement of	Quite high	Quite high	Around 1000 Rs	Around 7000 Rs	Around 1500 Rs
Adaptation	Changes the aesthetics of the vehicle	Embedded on windshield	Volume of rain collected is high	Seamless integration with vehicles	Adaptable to all vehicles

2.5 EXPERIMENTAL RESULTS

We conducted the electrochemistry experiment in the lab manually. As specified earlier the electrodes of zinc and copper were used in the solutions of zinc sulphate and copper sulphate respectively. The reaction was instantaneous with time response of less than one second. The voltage obtained from the reaction was 1.027 Volts. Salt bridge which was used (U tube glass apparatus) was manually drafted with both the ends of it installed by porous cotton plugs. The reading of 1.027 Voltage may or may not be able to suffice for effective running of the automatic wiper as planned. Thus further we have to cross check all the possibilities of increasing the voltage by changing various parameters used in the experiment.

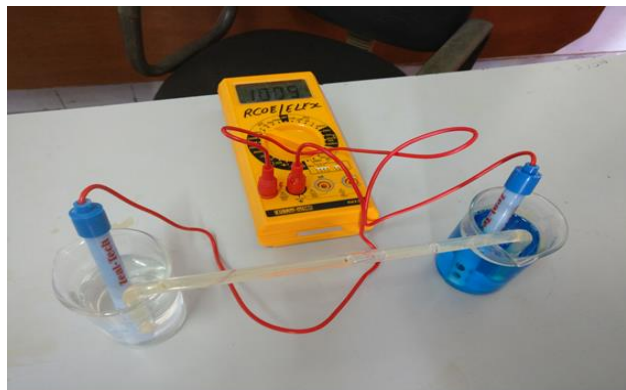


FIG. 3 READINGS OBTAINED

2.6 FUTURE WORK

Based on the initial experimental results, a suitable ARAI standard compatible product will be designed. The sensitivity of the product will be compared with the existing products in the market.

Pilot project on an actual existing compact car will be carried out to prove the effectiveness of the technology. Also, suitable maintenance procedures and manuals will be designed so that the technology transfer to existing car companies or OEMs or Car Service Centers can be easily carried out.

Furthermore, following enhancements will be done in due course of time which will lead to value addition of the above rain sensing wiper :

- a) Selection of material for rack and pinion mechanism based on finite element analysis.
- b) Automatic speed control of wiper based on rate of rainfall
- c) Automatic mist and fog removal
- d) Enhanced cooling effect during hot summer and during long drives
- e) Automatic rolling down of windows during electronic circuit breakdown or malfunctioning allowing for easy escape of passengers from the vehicle.
- f) Testing of response time after rain contact
- g) The introduction of this new type of system in current cars needs to also be checked in terms of its effect on the fuel economy and the gains/losses that it has as compared to existing rain wiper system.

3. CONCLUSION

As this proposed mechanism does not involve a micro-controller thus it proves to be highly reliable in places where there is heavy rainfall and vehicles lose their electronic capability. Since this wiper mechanism is economical it can be used in regions even where there is sparse rainfall and buying a high end automatic rain sensing wiper is not practical.

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REFERENCES

- [1] Dr A.M. Khatkhate, Rizvi College of Engineering, Mumbai, amol.khatkhate@gmail.com
- [2] International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 4, Issue 2, April 2014 (An ISO 9001: 2008 Certified International Journal)
- [3] An Efficient Low Cost Wiper System for Autonomous Vehicle N. Prabhakaran, Purushothaman Surendran Research Associate, School of Electronics Engineering VIT University, Vellore, Tamil Nadu, India.
- [4] American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-03, Issue-04, pp-24-34
- [5] International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, Volume 2, Issue 7, July 2012) Semi-Automatic Rain Wiper System Dept of Automobile Engg, B V Bhoomaraddi College of Engg & Tech Hubli