International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 03, March-2015

Effective Self-Healing System for Automobile Tyres

[1]Sagar Bhardwaj
Department of Electrical Engineering
Aligarh Muslim University
Aligarh, India

[2]Piyush Varshney
Department of Electronics Engineering
Aligarh Muslim University
Aligarh, India

***Abstract*— The most common problem encountered in vehicles which leads to thousands of accidents and tragic human life loss is punctures of automobile tyres. To overcome the problem there have been many innovations like Tubeless Tires, Tuff less Tires which had their own limitations due to which they could not be carried for long as a remedy to the problem. The main idea behind Effective Self-Healing System ESHS is to protect the tire, by not allowing any material to penetrate to the tube of the tire, which are capable enough to damage the tube ESHS has been introduced in order to overcome the limitations of previous technologies. ESHS is based on the same theory on which existing technologies have been conceptualized, but it comes with some extra features which are extremely significant and would enhance the performance of the self. ESHS is also enhanced by a MEMS pressure sensor system, which will indicate the driver about abnormal pressure changes in the tire, so that the driver could be notified about any malfunctioning in the tire system.**

***Index Terms*—ESHS, MEMS, puncture, penetrate.**

I. INTRODUCTION

Puncturing of the tube-tire system is the most common problem encountered in the automobiles. The problem is instantaneous in nature and is irresistible. There is no indication for the occurrence of the problem to the driver. The remedies employed are not feasible and the problem still persists among the masses. A survey was conducted in Aligarh City to determine the severity of the problem statement by calculating the occurrence of Punctures on three busiest roads of the city. The number of punctures among the population of 7 lakhs (approx.) [1] people was surprisingly high.

Considering the main city Aligarh a case study was carried out from 10/12/2013- 16/12/2013 which determined the severity of the problem as total number of punctures were found between 760- 980 punctures in a day. Figure 1 shows the variation of the total number of punctures on different days. The survey was carried out on three different roads, the Grand trunk road, the Ramghat Road and Agra Aligarh Road

Place-*Aligarh*
Location- *G.T. Road linking Aligarh to Delhi*
No of tire puncture shops in a 10Km length = 17
Average no of punctures they fix in a day = 30-40
Total Average no of punctures fixed in a day = 510-680
Place-*Aligarh*
Location-*Ramghat Road to Bareilly*
No of tire puncture shops in a 8Km length = 14
Average no of punctures they fix in a day = 20-30
Total Average no of punctures fixed in a day = 280-480

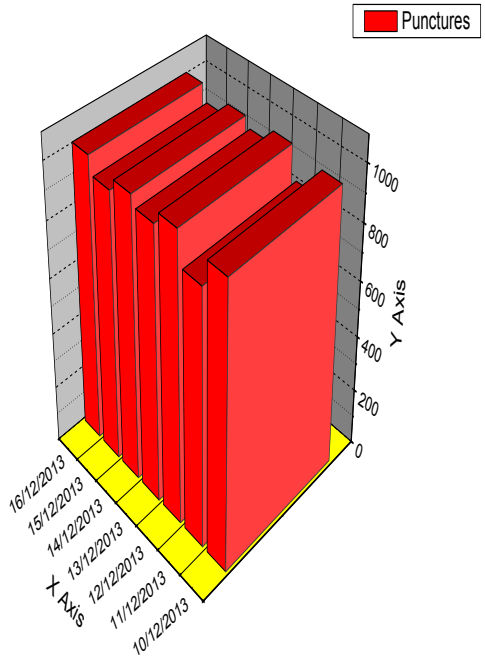

Figure 1: Number of Punctures/day in Aligarh City

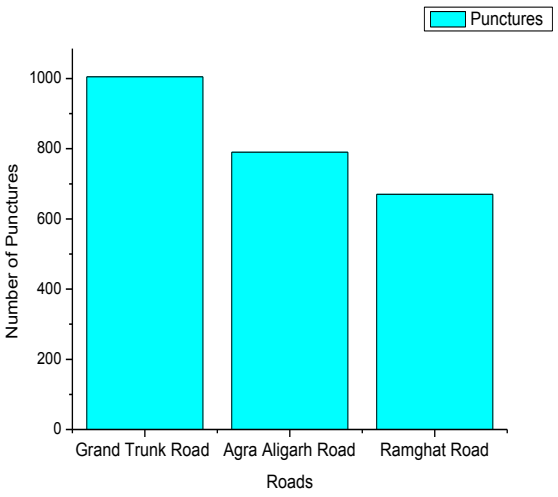

Figure2: Number of Punctures on different Roads in Aligarh City

There was a study carried out for the different roads of the city and as a result it concluded following points:

i. Emerged as the most severe and basic problem in Automobiles.
ii. Puncturing of tyres is a common problem to all the vehicles, irrespective of the size.

As a result, various attempts are made to solve the severe problem statement. The conventional fixing of punctures evolved to smart adhesive printed punctures Band-Aids aimed to improve the stability and hold the puncture for longer duration.

The Ban-Aids were soon replaced by the Tube Less- Tires which made an advent by removing tube itself from the tyre. But soon due to its high maintenance cost and applicability shortcomings, it was a failure to meet the larger audience. More Innovations in high end automobiles aim to use hard polymer substances, the resins high in cost are employed which can't be easily repaired. One such example was tuffless tube which comprises of a layer of fluid on the tube which opposes any change to the Tyre- Tube system by repelling at first and then diluting the puncturing substance by reacting with the polymeric fluid. But this also faced various drawbacks as it leaked all of the fluid in case of large punctures, needed complete substitution of the tube after 2-3 punctures which is costly.

This all led us to our innovative and robust concept, combatting all the drawbacks of the previous ones named ESHS- Effective Self Healing Sytem for automobile tyres.

ESHS is the only technology of its kind which gives indication about any malfunctioning in the tyre and also aims to remove the drawbacks of previous Innovations.

II. Introduction to ESHS

This system regulates and heals the puncture within fraction of seconds safeguarding the tube and preventing inflation. It comprises of three units which help to heal the Puncture:

- Controlling Unit

Present in front of driver similar to Petrol, battery and service indicators and informs about the defect/ puncture detected in the tire. Connected to the MEMS wireless pressure sensors present inside tyre. Regulates the Speed of the vehicle when the healing process is taking place.

Comprises of a Microcontroller Unit with wireless receiving unit and adhered to the speed control of the Vehicle.

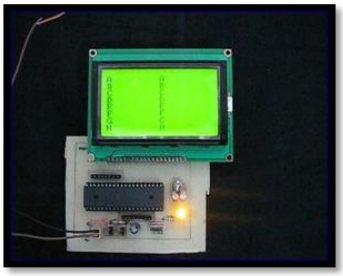

Figure3: Controlling Unit of ESHS

- MEMS(Micro Electromechanical System)

Wireless Pressure Sensors cum actuators are of 0.5 cm Radius. Present inside the tire at the two ends but not on the touching tire surface. Placed at regular Interval to sense the change in pressure.

MEMS detect the change in pressure by taking average of the two ends and transmit the information wirelessly to the controlling unit.

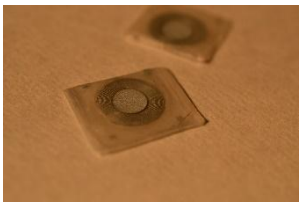

Fig4: Wireless Micro-Electro Mechanical Sensors

- Solid Sealant Layer of Polymer

Solid rubber latex polymer with biodegradable properties. We experimented to find the best solid sealant which neither flows away and forms a repulsive layer once reacted with air and prevents further entering of the puncture cause. The Sealant is being prepared with mica flakes, hydrated bentonite clay, and a water-miscible carrying agent such as propylene glycol. We are continuously trying with other epoxy resins to combat the temperature and pressure conditions to wider range.

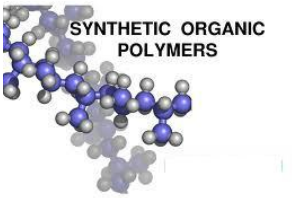

Fig5: Synthetic organic polymers

III. ARCHITECTURE OF ESHS

ESHS comprises of three most important basic units:

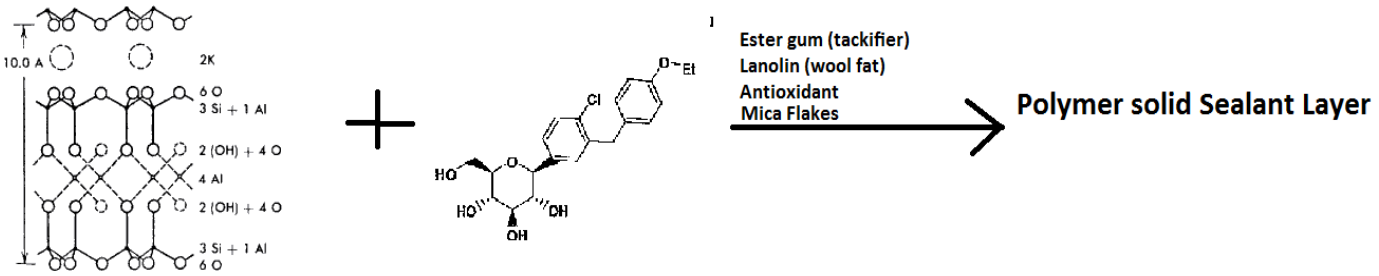

Fig 6: Polymer composition

1.) Controlling Unit

Microcontroller- Preferably, AT Mega16L control board powered by a battery source. Wireless Module - Receives signals from MEMS and transmit signals from MEMS. Ride Controller - Regulates the speed with the help of pressure speed comparator. Display Unit - Indicates the malfunctioning in the tyre in context to pressure change in the tyre.

2.) MEMS (Micro Electro Mechanical System) Wireless Pressure Sensors

Are very small in size, almost less than half a centimetre. Doesn't need a power supply as they are made of piezo-electric materials. Present on the sealant layer between tube and tyre. Detects the change in pressure and sends signals to the controlling unit.

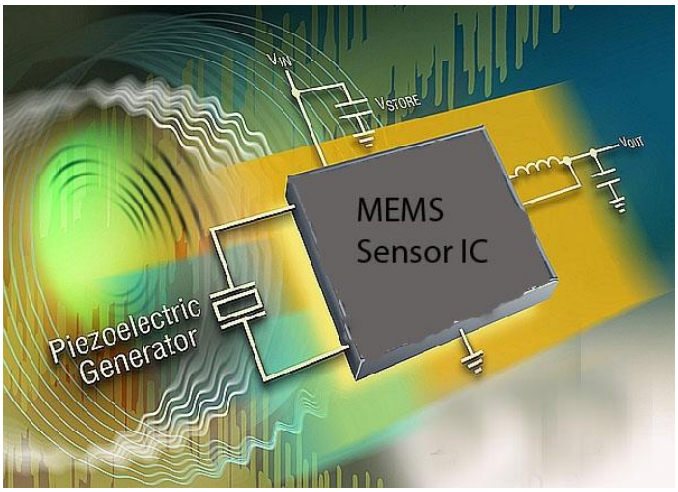

Fig 7: MEMS Function Circuit

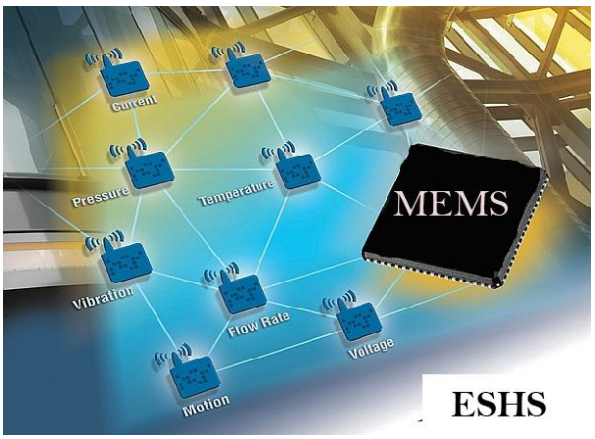

Fig8: MEMS Energy Tracking Model

Figure 6 shows the polymer composition of the Solid Adhesive Sealant of the ESHS.

3.) Polymeric Solid Adhesive Sealant

- Properties of a latex rubber which is a biodegradable polymer.
- A highly viscous adhesive which is in 'pseudo solid' state and doesn't drain away.
- It repels the inserting object by forming a very hard layer which prevents further insertion into the tyre.

Figure 7 and 8 shows the Inner structure of the MEMS working and its energy cycle employed in the system.

The Flowchart below shows the process cycle of the ESHS System, where step by step process is explained as it happnes:

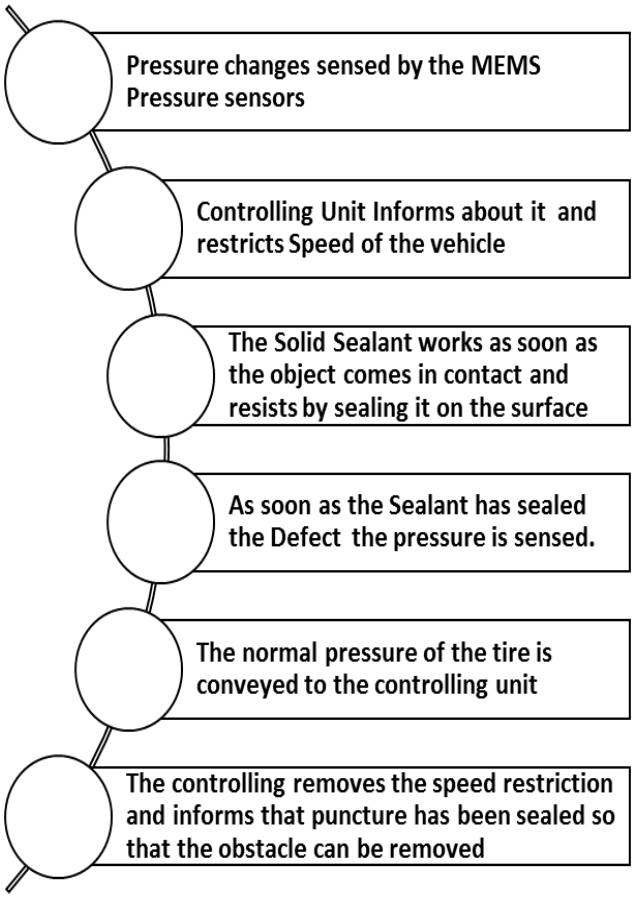

Fig9: Flowchart depicting the process of ESHS

IV. Cost Estimation and Market Analysis

Cost of whole ESHS which involves one time installation.

- Controlling Unit: 150/-

It includes 7-Segment 1 letter LCD display, a microcontroller, a signal receiver, automated ride control switch.

MEMS: Meant to be cheapest and reliable pressure sensors which cost around 10/- per sensor on bulk purchase.

- Polymeric Solid Adhesive Sealant: 50/- for whole ESHS sealant layer.

Cost Estimation for replaceable single ESHS strip: 50/- which you have to pay after undergoing 15-20 fatal punctures.

Market Analysis

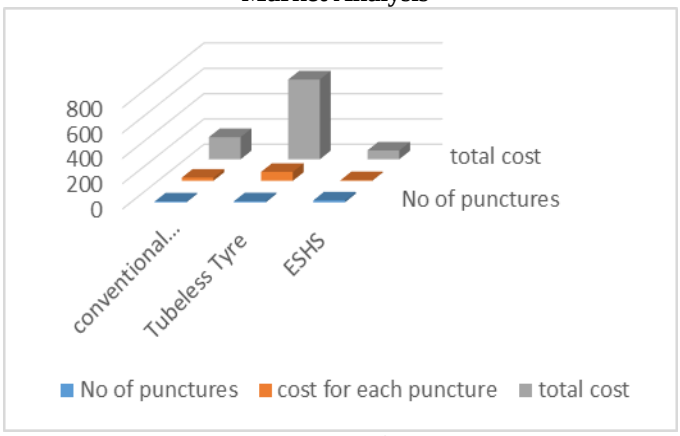

Fig11: Graphical Analysis of various Systems

Fig 10 and Fig 11 shows the superior nature of proposed system ESHS over the others existing.

V. Important Aspects of ESHS

Some important Aspects including cost analysis, feasibility we encountered in our research:

- The need to make the use of ESHS pervasive, lies in the drawbacks of the existing technologies. The frequent breakdown in the conventional tyre-tube system due to punctures gave a reason to come up with new innovations to mitigate the problem.
- The first innovation which is considered to be a milestone in automobile sector, was the fabrication of *tubeless tyre.* it encounters the problem by eliminating the use of a tube in the tyre. Though it

Conventional tube tyre system	Tubeless tyre	ESHS
No. of punctures it can bear = 6-8	No. of punctures it can bear = 8-10	No. of punctures it can bear= 15-20
Cost of repairing one puncture =25	Cost of repairing one puncture =70	Cost of repairing one strip = 50
Total cost incurred =150-200	Total Cost incurred = 560-700	Total cost incurred = 50 per strip

- could not solve the problem permanently. It was still vulnerable to the punctures, but it mitigated the immediate effects of a puncture and allowed the driver to fix the problem afterwards. Also the money spent to fix the puncture was almost 'half' of the total cost of the tyre. Also it was only compatible with the vehicles having 'alloy wheels'. Regardless of the above limitations, *Tubeless Tyre* is still dominating the market as a substitute to the conventional tyres.
- Another commendable innovation was of *tuffless tube.* it was one step forward to tubeless tyre. It came with a provision of healing the tube itself within no time. It was based on the concept of instant solidification at the place of puncture with the help of a liquid which had precipitating properties. The limitation associated with this tube was that the liquid used to drain or dry away with time. Also the whole tube had to be replaced which was quite expensive.
- In the past, technology has always come up with the solutions like indicating the petrol scarcity, service reminders, battery bank reminders but no such solutions encountering puncturing of tyres has been developed.
- The controlling Unit comprising of micro-controller module costing not more than Rs300.00 on fabrication which includes wireless module as well.
- MEMS Sensors are the key part of the system to be used widely along the tires are made on specific terms in industries and are known to be very cheap
- MEMS are equipped with power sources such as Peizo-electric materials.
- Controlling unit derive their power from a battery source.
- The estimation of pressure can also be crosschecked by a relative speed pressure algorithm which can be calculated from speedometer present.
- The Solid Sealant is to be kept in a thin plastic polymeric layer which is only exposed during the reaction.
- The total System is cheap as the polymers used are cheap, while the controlling unit and MEMS are neither expensive.
- The whole ESHS layer is a series of several units having a pattern of sensors. In case the defected layer has to be changed, only the defected unit is replaced which consequently make ESHS more cost effective
- The Best of ESHS is that it can be integrated with any vehicle whether big or small.

VI. Conclusion and Future Possibilities

ESHS provides an enhanced solution as it incorporates three components: Controlling Unit; MEMS; Polymeric Solid Adhesive Sealant. It's a permanent solution as the solid sealant repels the cause of a puncture. It is equipped with highly efficient pressure sensing MEMS technology. MEMS technology being very small in size, makes the overall system less bulky and more compact. The only system which has the provision of indication of pressure change and the detection of the puncture with the help of a display interface. ESHS is a very reliable solution because it prevents vehicle breakdown. It is a very cost effective technology as it allows the user to not replace the whole tube but only a strip of the sealant. It saves TIME and capable of preventing hazardous accidents.

There is always a scope for the improvement in any technology. Even ESHS is vulnerable to have future advancements and modifications.

- As the technology will become adapted and widespread, the cost effectiveness will improve further.
- The electronic section of the system can get to have more reliability with the introduction of more embedded features.
- The patterns in which MEMS are arranged can be modified in order to minimise the number of sensors used and their efficiency.
- The chemical compound can have modifications in context to its Reaction Time, Solidification Properties, and Adhesive Properties.

Acknowledgment

First of all we would like to acknowledge Prof Yasir from Department of Applied Chemistry, Aligarh Muslim University for his help in experimentation (achieved and in processs). We would also like to acknowledge Dr OP Bansal, Professor, Department of Chemistry ,DS College, Aligarh for his valuable insights during the course.

References

[1] Tai-Ran Hsu, MEMS and Microsystem Design and Manufacture, Tata McGraw-Hill, 2002, pp.70-157.

[2] Google Patent on Tire Selant Liquid Container, Publication number : EP 2165822 B1

[3] Mihaly Zimonyi, New puncture-proof tyre reduces waste and space, article by forum for future, 18th May 2012.

[4] Puncture-proof technology invented in VSSUT, an article by The Hindu,30Th September 2013

[5] Intelligent Transportation System Magazine, Volume 5 Issue 2, pp 23-36.

[6] Tai-Ran Hsu, Reliability In Mems Packaging, 44th International Reliability Physics Symposium, San Jose, CA, March 26-30, 2006.

[7] David S. Eddy , Application Of Mems Technology In Automotive Sensors And Actuators, Proceedings Of The Ieee, Vol. 86, No. 8, August 1998.

[8] Bruce R. Donald, Simultaneous Control of Multiple MEMS Microrobots.

APPENDIX

Coding for Pressure Sensor and LCD display (Sample)

```
#include <avr/io.h>
 #include <util/delay.h>
 #define SEVEN_SEGMENT_PORT PORTD
 #define SEVEN_SEGMENT_DDR DDRD
 int main()
{
DDRB=0xff;
DDRD=0xff;
unsigned int i,
brightness=0;
int n;
initpwm();
while(1)
{
 for(i=255;i>=0;i--)
{
   OCR0=i;
   _delay_ms(10);
 }
return 0;
void initpwm(void)
{
TCCR0|=(1<<WGM00)|(1<<WGM01)|(1<<COM01)|(1<<CS00);
DDRB|=(1<<PB3);
}
{
 SEVEN_SEGMENT_PORT=0b00000011; // Displays 'P' for the puncture//
}
```