MOTOR VEHICLE CORROSION FROM ENVIRONMENTAL SALT WATERS AND CAR SAFETY

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ABSTRACT

This paper examines the mechanism and design characteristics that are responsible for the corrosion damage caused to vehicles.

Based upon this examination, the authors suggest a correlation between the number of accident victims and the loss of progressive collapse of the car structure with accident time resulting from corrosion. This implication is discussed in terms of car safety.

1. INTRODUCTION

To the owner-driver the problems of corrosion in motor cars are only too familiar. Many private motorists particularly in the Delta areas of Nigeria are concerned by the rapid deterioration of their motor vehicles, resulting from internally-initiated corrosion from salt water in their environment. Salt accelerates the corrosion reaction and quickly exposes those areas where, for one reason or another, the road dirt has been allowed to accumulate during the vehicle's life.

The aim of this paper is to examine the mechanism and design characteristics that are responsible for the corrosion damage caused to vehicles.

In order to describe how the internally-initiated corrosion arises, several related parameters have to be studied.

2. Road Dirt and Salt Water Spray

The particle size in the spray generated by a rotating wheel is inversely dependent upon the cube power of the vehicle speed[1]. A car travelling at 100 kph creates a very fine spray of mud and water.

For this high velocity water spray to form a microdroplet, surface free energy theory suggests it must have a nucleus upon which to form. The nucleus is road dirt on worn road surfaces and tyres. The small amount of water present on each road dirt particle will mean that this dirt is artificially compacted, by the phenomenon of surface tension effects, into a high density mud pocket in areas which are out of the path of direct water washes.

The slower the car travels the larger will be these spray droplets and the more water they can contain. The larger, heavier micro droplets have a high momentum and so travel in straight lines, unaffected by pressure eddies beneath the car body. Smaller particles on the other hand, will be affected by these eddies and drift and deposit in areas outside of the wheel spray trajectory. These similar particles can also be drawn into the manufacturer's process drainage holes[2].

A car travelling at 100 kph with respect to the road will throw water spray from the top of the rotating wheel at twice the vehicle speed (200 kph with respect to the road)[3]. If this velocity is made with respect to the vehicle, then the under-side of the wheel arches are constantly bombarded with road dirt and low momentum salt water spray which are drawn through the bottom of the doors and the sills and front and rear panels. This highlights the mechanism of build up of aggressive microclimate on internal hidden body panels.

3. The Corrosion Reaction

The evidence produced from low kilometre vehicles which have been involved in accidents in the Delta area has shown that the internally-initiated corrosion results from a layer of "dust" which contains environmetal salt[4]. This layer is deposited on a very thin film of electro deposited paint which soon fails and allows corrosion to proceed until rust through is the external manifestation. See Plates 1-4.

The galvanic corrosion mechanism responsible is the differential aeration cell, which

is demonstrated in Figure 1.

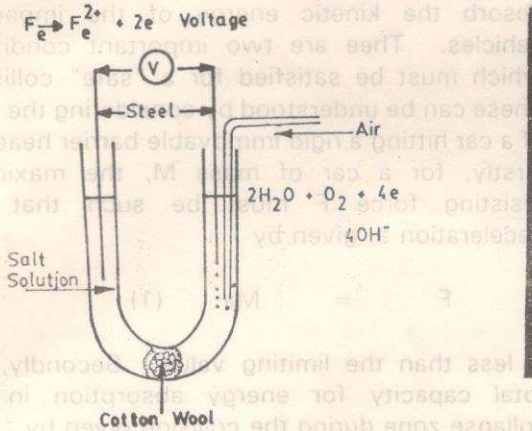


Fig. 1: Two pieces of mild steel connected to a dvm, as shown and immersed in a saline electrolyte with tissue paper or cotton wool to prevent the liquids in the two arms from mixing.

Air blown down oneside of the U tube will produce +80mV, and if air is then passed down the other side, -80mV can be recorded. Thus, the availability of oxygen in the two limbs has produced a potential reversal. The voltage is produced from the dissolving of the steel and the plentiful supply of oxygen being transformed crates an alkaline environment, which is a good paint stripper.

Applying this concept to the salt particle deposited on the internal panels of the car body, as shown in cross-section in Fig. 2, the anodic or dissolving areas are those regions which are denuded of oxygen. This can be the following[5]:

- interwelds, or two body panels forming a crevice at the overlap;
- areas beneath the salt/dirt particle; or
- area at the front of a corrosion pit or rust-through area.

These regions dissolve at the expense of those which are plentifully supplied with oxygen and are usually outside the interweld, overlap joint crevice or pitted area.

Figure 2(A) shows a schematic view of the salt concentrating at the base of the road aggregate which helps fix the aggressive environment on vertical surfaces. Figure 2(b) shows the



PLATE 1: TYRE COMPACT OF MUD, ROAD DIRT AND LOW MOMENTUM SALT WATER SPRAY CAUSING INTERNALLY INITIATED CORROSION



PLATE 2: CORROSION ARISING FROM THE UNDERSIDE OF THE WHEEL ARCHES DUE TO CONSTANT BOMBARDMENT WITH ROAD DIRT AND SALT WATER

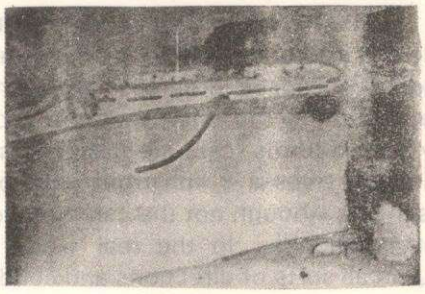


PLATE 3: CORROSION INITIATED THROUGH PROCESS DRAINAGE HOLES AND SILLS ON A DOOR

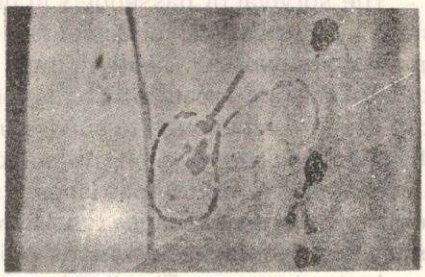


PLATE 4: BUILD UP OF AGGRESSIVE MICROCLIMATE ON THE REAR PANEL, ALLOWING CORROSION TO PROCEED UNTIL RUST-THROUGH

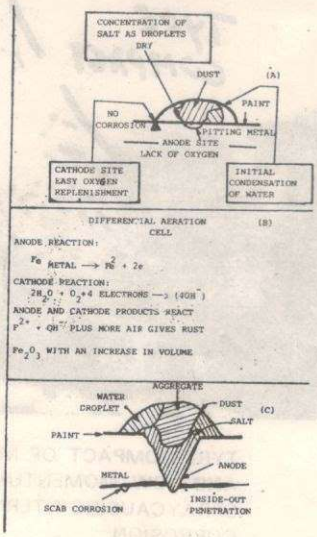


FIG. 2:

chemical reactions pertaining to the differential aeration cell. Fig. 2(C) diagrammatically shows the difference between internally-intiated corrosion and metal penetration and scab or surface corrosion beneath a painted surface.

4. Car Safety

The function of a car design is to produce a rigid structure, which in the event of an accident collapses progressively with accident time absorbing the energy of the accident. In very simple terms, cars are designed so that the vehicle survives a 8 kph front collision and the passengers, though not the car, survive a 56 kph front collision[3]. In the real world, collisions occur in all sorts of directions and condition. The car is protected from the damaging effects of low speed collision by the bumper system.

The survival of passengers in high speed collisions involves some fundamentally different design requirement. Clearly, there is little prospect of making a car, which any one would want to use, strong enough to survive unscathed a high speed collision. Even if this could be done in an acceptable form, the passengers would be unlikely to survive because they would be subjected to very high decelerations which would lead to brain damage. The limiting acceptable deceleration used by car designers is about 10g[3]. This is achieved by designing collapse zones into the front and rear ends of the car. The passenger is strapped into a rigid compartment which does not deform. When a collision occurs, the collapse zones deform and absorb the kinetic energy of the impacting vehicles. Thee are two important conditions which must be satisfied for a "safe" collision. These can be understood by considering the case of a car hitting a rigid immovable barrier head on. Firstly, for a car of mass M, the maximum resisting force F must be such that the deceleration a, given by

$$F = Ma \quad (1)$$

is less than the limiting value. Secondly, the total capacity for energy absorption in the collapse zone during the collision given by

$$E_a = \int_{X=0}^{X=L} F dx \quad (2)$$

where X is the collapse distance and L is the maximum possible collapse distance, must be greater than the initial kinetic energy of the car, i.e.

$$E_a \geq \frac{1}{2} M v^2 \quad (3)$$

where V = velocity of car. Equation (2) which defines the progressive collapse has been found to be reduced by corrosion[5].

Figure 3 shows that there may be a correlation between the number of accident victims and the age of vehicle, owing to the loss of progressive collapse resulting from corrosion over a four year study. Graph line A relates the age of vehicle to the percentage of corrosion in the force transmitting members, and as one would expect, these increase with the age of vehicle.

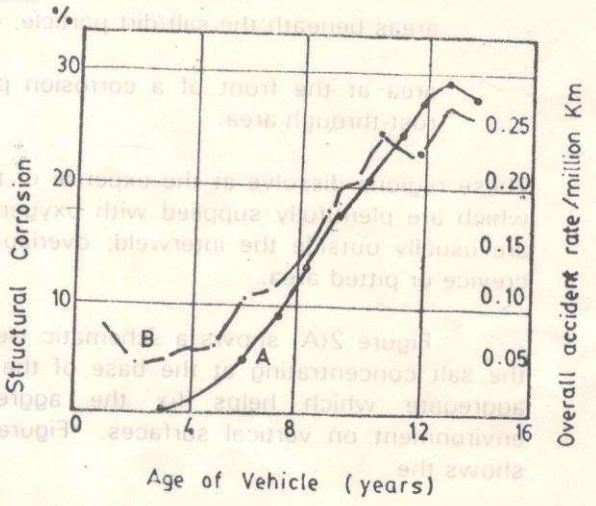


Fig. 3: Corrosion damage and overall accident rate as a function of the age of the vehicle

Graph line B superimposes upon graph A with a common age axis, the overall accident rate per million kilometers and suggest that occupants in an older car are more likely to be injured in the event of an accident because of premature corrosion.

5. CONCLUDING REMARK

It is emphasised that corrosion was not the primary reason for the accidents but caused injuries to car occupants by impairing the energy absorption design features of the vehicle and hence the car safety.

6. REFERENCES

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