TEST BENCH WITH AFM AND STM MODULES FOR WEAR RESEARCHES PASSANGERS CAR SUSPENSIONS ELEMENTS

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Abstract: *This paper presents test bench which is equipped in Scanning Microscope with two heads: STM (Scanning Tunneling Microscope) and AFM (Atomic Force Microscope). The microscope allows to show the scans of working surface in nano scale. Additional it allows to presents the degree of wear top surfaces and draw their profiles. The ball joints of passengers car suspensions are given researches on the described test bench. The wear degree are given on the previous base of surface analyze of the new ball joint and then doing series of researches of used ball joints. The difference are calculated in the percents.*

Keywords: AFM, STM, MICROSCOPE, BALL JOINT

1. Introduction

Every year in a car accidents die hundred and even thousands persons. How the statistics show one of causes of the incidents is the unsuitable technical state of vehicle. In the report of Manager of Department Analyses' and Supervision MSWiA in year 2007 was registered 114 incidents caused through defective vehicles, in which death sustain 21 persons and 114 it became wounded. In year 2008 was registered was 143 incidents caused through inefficient cars, in which death sustain 3 person and 185 wounded however 2 persons death in year 2009 in 71 incidents (this data is only for months since January till August).

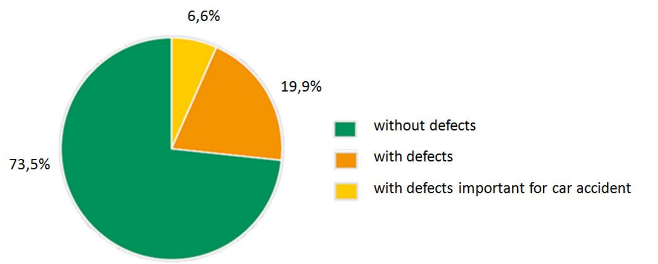

Fig. 1 *Technical state of vehicles which took the part in the car accidents Грешка! Източникът на препратката не е намерен..*

According to the investigations conducted by DEKRA group almost 27% cars participating in the accidents possessed technical defects (figure 1). It was it been worth to recall, that the investigations were conducted in Germany, where the average age of cars is deciding lower then in Poland, the stations of control of vehicles act more rigorously and considerably less it is in relation of the car accidents to number of registered vehicles[1]. One of the technical defects group showed on below graph are suspension defects (11,4%), which generally comes from the roads for which the vehicles are driving (figure 2).

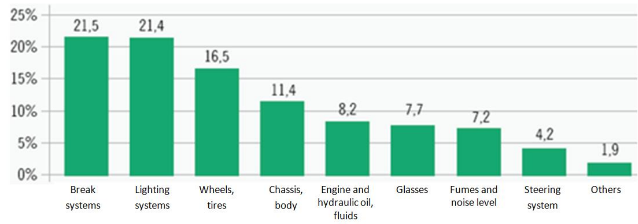

Fig. 2 *Define types of defects* **Грешка! Източникът на препратката не е намерен..**

One of the most important component of any front suspension car is ball joints which in common parlance are named bolt of track control arm. Moveable connection (kinematic pair) enabling the rotatory oscillative movement of the one connected component in relation to the second element are ball joint named. The axis pass through the ball joint, round which takes the place the turn of wheel in moment of turn the steering gear of vehicle by driver. Additionally the ball joint enable the angle deflection and transmit the shearing and longitudinal forces (along the ball joint axis). Because in the time of work ball joints performs swing-rotational movement, they are lubricated by solid oil by grease nipple or by graphite grease when the ball joint construction are knead by machinery in housing. Build and description of main components of ball joint shows figure 3.

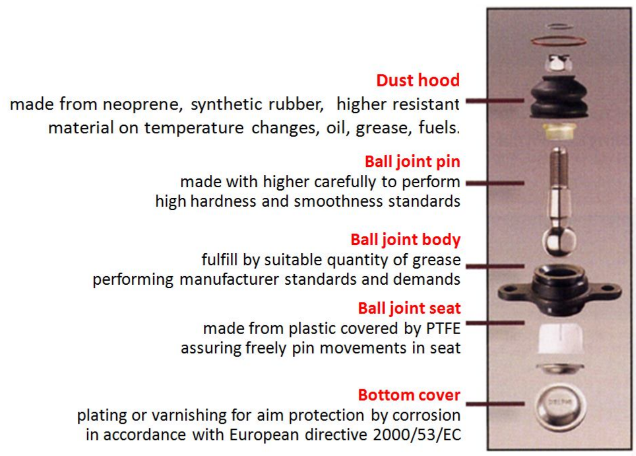

Fig. 3 *Build and description selected elements of ball joint [2].*

The ball joints construction approach to minimalize friction by polishing the pin of ball joints. The grease used inside and pin additionally covered by teflon are also contributed to smooth working and for fast reaction time. Dust hood are mainly made from neoprene (CR), which characterize protection to temperature changes , oil and fuel conditions and protection to variable weather conditions. Nylon insertion inside nut prevents forming among pin and nut corrosion inside, as well as makes impossible coming unscrewed nut. The most often ball joints defects are: get inside water, sand and other foreign matter are result of faster wear mates elements in ball joints are effect of splitting rubber cover. Additionally water cause pin ball joint corrosion. The most important reason of disrupted rubber cover is grease outside or his lack it causes insufficient lubricating which finishes with immobilized ball joint pin. Next often meet case is canting of ball joint pin which is a reason of hitting on roadblock (kerb or road unevenness) by wheel. Used both cooperating of elements, corrected ball joint assembly (wrong tighten up a nut) is rarely case. Additionally it could be a result smash of stub axle or putting out ball joint pin from stub axle during drive on the unevenness[2].

The most frequent symptoms of damaged ball joints are: knocking and creaking during drive on not even surface example: ride through slower on housing estates and even during getting to car, knocking during corner driving and during breaking and accelerating. Moreover drive with knocked out ball joints accelerates wasting of different components of car suspension.

2. The test bench measurements

The study was conducted as a feature in the scanning tunneling microscope. A scanning tunneling microscope (STM, figure 4) is an instrument for imaging surfaces at the atomic level. Its development in 1981 earned its inventors, Gerd Binnig and Heinrich Rohrer (at IBM Zürich), the Nobel Prize in Physics in 1986. For an STM, good resolution is considered to be 0.1 nm lateral resolution and 0.01 nm depth resolution. With this resolution, individual atoms within materials are routinely imaged and manipulated. The STM can be used not only in ultra-high vacuum but also in air, water, and various other liquid or gas ambients, and at temperatures ranging from near zero kelvin to a few hundred degrees Celsius.

Fig. 4 *Test bench of STM and AFM microscope*

The STM is based on the concept of quantum tunneling. When a conducting tip is brought very near to the surface to be examined, a bias (voltage difference) applied between the two can allow electrons to tunnel through the vacuum between them. The resulting tunneling current is a function of tip position, applied voltage, and the local density of states (LDOS) of the sample. Information is acquired by monitoring the current as the tip's position scans across the surface, and is usually displayed in image form. STM can be a challenging technique, as it requires extremely clean and stable surfaces, sharp tips, excellent vibration control, and sophisticated electronics[3].

First, a voltage bias is applied and the tip is brought close to the sample by some coarse sample-to-tip control, which is turned off when the tip and sample are sufficiently close. At close range, fine control of the tip in all three dimensions when near the sample is typically piezoelectric, maintaining tipsample separation W typically in the 4-7 Å range, which is the equilibrium position between attractive (3<W<10Å) and repulsive (W<3Å) interactions. In this situation, the voltage bias will cause electrons to tunnel between the tip and sample, creating a current that can be measured. Once tunneling is established, the tip's bias and position with respect to the sample can be varied (with the details of this variation depending on the experiment) and data are obtained from the resulting changes in current[3].

If the tip is moved across the sample in the x-y plane, the changes in surface height and density of states cause changes in current. These changes are mapped in images. This change in current with respect to position can be measured itself, or the height, z, of the tip corresponding to a constant current can be measured. These two modes are called constant height mode and constant current mode, respectively. In constant current mode, feedback electronics adjust the height by a voltage to the piezoelectric height control mechanism. This leads to a height variation and thus the image comes from the tip topography across the sample and gives a constant charge density surface; this means contrast on the image is due to variations in charge density. In constant height mode, the voltage and height are both held constant while the current changes to keep the voltage from changing; this leads to an image made of current changes over the surface, which can be related to charge density. The benefit to using a constant height mode is that it is faster, as the piezoelectric movements require more time to register the height change in constant current mode, than the voltage change in constant height mode. All images produced by STM are grayscale, with color optionally added in post-processing in order to visually emphasize important features.

In addition to scanning across the sample, information on the electronic structure at a given location in the sample can be obtained by sweeping voltage and measuring current at a specific location. This type of measurement is called scanning tunneling spectroscopy (STS) and typically results in a plot of the local density of states as a function of energy within the sample. The advantage of STM over other measurements of the density of states lies in its ability to make extremely local measurements: for example, the density of states at an impurity site can be compared to the density of states far from impurities.

Framerates of at least 1 Hz enable so called Video-STM (up to 50 Hz is possible). This can be used to scan surface diffusion. The components of an STM include scanning tip, piezoelectric controlled height and x,y scanner, coarse sample-to-tip control, vibration isolation system, and computer.

The resolution of an image is limited by the radius of curvature of the scanning tip of the STM. Additionally, image artifacts can occur if the tip has two tips at the end rather than a single atom; this leads to "double-tip imaging," a situation in which both tips contribute to the tunneling. Therefore it has been essential to develop processes for consistently obtaining sharp, usable tips. Recently, carbon nanotubes have been used in this instance.

The tip is often made of tungsten or platinum-iridium, though gold is also used. Tungsten tips are usually made by electrochemical etching, and platinum-iridium tips by mechanical shearing. Due to the extreme sensitivity of tunnel current to height, proper vibration isolation or an extremely rigid STM body is imperative for obtaining usable results. In the first STM by Binnig and Rohrer, magnetic levitation was used to keep the STM free from vibrations; now mechanical spring or gas spring systems are often used. Additionally, mechanisms for reducing eddy currents are sometimes implemented.

Maintaining the tip position with respect to the sample, scanning the sample and acquiring the data is computer controlled. The computer may also be used for enhancing the image with the help of image processing as well as performing quantitative measurements.

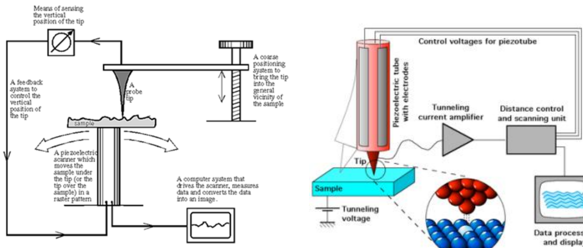

Fig. 5 *Diagram of a microscope* [3,5].

3. The results

Measurements were subjected to the new bolt joints (figure 6a), and their exhausted counterparts (figure 6b).

a)

b)

Fig. 6 *New and exhausted ball joints.*

3.1. Conditions of the measurements

Test conditions:

- STM: constant current mode, needles prepared from Pt-Ir wire (10% iridium, 90% platinum) 0,25 mm in diameter cut tongs with sharp blades.
- Scanning was carried out in air at atmospheric pressure, temperature room[5,6].

3.2. Determination of surface state

Images of the STM enabled the determination of the roughness peaks of the samples. The following is a sample picture and graphs of the surface topography (figure 7).

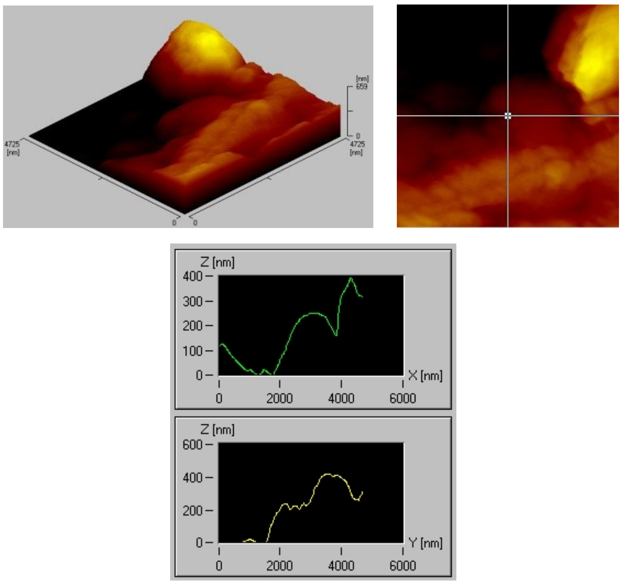

***Fig.** 7 Sample scans.*

The amount of surface roughness defined peaks along the z axis. Comparing the images we are able to determine the changes of surface roughness as a function of miles driven. This is an intermediate result, because the valves are operated with varying degrees of kilometers course. The changes of the parameter as a function of number of kilometers driven. Research shows that over the pins wear affects not only the mileage but also the operating conditions and other factors such as temperature, humidity and the type of road on which the vehicle is driving.

4. Conclusions

Made the tests are a prelude to further analysis of spherical pivots wear process in order to select the most favorable operating conditions (city driving cycle and extra urban driving cycle) and allow to select the better material.

Images obtained in the STM microscopy was performed after a certain number of cycles, after a certain number of kilometers driven for pins made of steel. Comparing results from the measurements it is possible to affirm, that:

1. Research on stem tunneling microscope images give an accurate working surface and allow the deletion of the parameter as a function of number of driven kilometers.
2. Comparing the traces of the 75000 km of mixed driving cycle (city and highway) noted significant differences for the surface shape of these traces. Wear trace depth has increased from 180 nm to 400 nm. The photograph shows the surface smearing the spigot and pin spherical shells.
3. There are no changes for geometry surfaces for ball joints with 45000 km trip, like ball joints with higher trip, above 70000 km.
4. Clearly, the most intense wear present in the range 68000 km to 80000 km. It can be assumed that it was in this respect is wiping the ball joint of the user interface.
5. The next stage of research will be to determine the percentage rate of wear pin set on the basis of theoretical studies carried out on the test vehicle suspensions bench created in the Vehicle Department of Technical University of Lodz with the results obtained by microscopy.

5. References

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