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A PASSENGER VEHICLE MAINTENANCE STUDY USING EXPERIMENTAL VIBRATION ANALYSIS

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Abstract: *The technical state of a passenger car can be appreciated by its status parameter values that suffer permanent, continuous or discrete changes during operation. Component maintenance of means of transport based on the evaluation of mechanical vibration involves obtaining of the phenomenon vibrator, by measurement and analysis and accurate description. This article presents a study of maintenance passenger vehicle based on the results of experimental measurements of vibration, carried out in three significant points. It highlights the fact that the vibrations can both indicate a failure and reflect the quality of maintenance.*

Key words: *vehicle vibration, vehicles maintenance, vibrational behaviour, vehicle wear.*

1. INTRODUCTION

Transportation is one field of economic and social activity through which the movement in space is made of people and goods in order to meet the material and spiritual needs of society.

The main maintenance operations for means of transport are: replacement of worn parts, refilling working fluids, regulating components and removal of wear factors (vibration, water, dust, acids etc.) [1].

Inadequate operation and maintenance of the vehicle (using improper maintenance and repair materials, not following the periodicity of technical maintenance and current repairs, innapropriate adjustments, thermal regimes and overly high mechanical stress etc.) determines an accelerated wear of parts and subassemblies vehicle, but with similar features to the normal wear processes [3].

The maintenance of the transport means, especially motor vehicles, is represented by means of the operating regime curve (Fig.1).

According to the curve shown in Figure1, maintenance actions are carried out at certain times and at certain values of vibration levels. It is observed that when the vehicle is new, it is normal to have high levels of vibration. During the period of running, this level decreases to a value that will remain approximately constant during the exploitation period. Significant increase in vibration parameters indicate a fault and there will be needed a remedial intervention. There is a vibration level value that indicates the vehicle is out of order and the repair is mandatory [2].

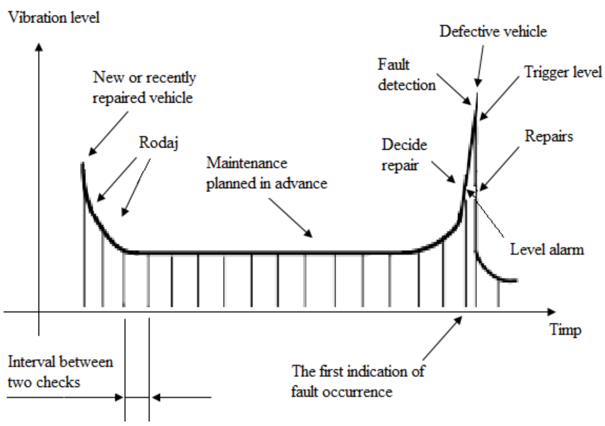

Fig. 1. Operating regimn curve of a vehicles [2].

2. EXPERIMENTAL METHOD

2.1 Description of the of passenger cars whose vibration was measured

In the transport means maintenance, diagnosis on the items using experimental determination of vibration involves the establishment of the measuring device, depending on the parameter to be measured, the measurement points (items) where to put the accelerometer and method of the results analysis.

We used as a SVAN 958 vibrometer as measuring instrument. The data obtained was processed and analyzed using PC software SVAN ++ [4].

To highlight the vibrator response of a transport means, it was experimentally determined the vibrational behaviour of Volkswagen Caravelle vehicle (Fig. 2). The vehicle was im the normal state and had the following technical characteristics (as per registration certificate):

- manufacturing year: 1999;
- registration number: CJ 47 ZEK;
- number of seats: 8+1;
- power source: Diesel;
- maximum mass: 2800 kg;
- power: 75 kW;
- engine capacity: 2461 cm^3;
- total running: 575 366 km.

Fig. 2. Vehicle with CJ 47 ZEK registration number.

2.2 The measurement of the vibration

The measurement was carried out according to the following conditions:

- measurements were performed on ITP stand (Periodic Technical Inspection);
- vehicles had a normal operating condition;
- measurement points for both vehicles were:
  - P1 - screw the cover cleats (rocker arms);
  - P2 - the bodywork (under the windshield);
  - P3 - front driver's seat.
- mounting accelerometers in the three measuring points was performed using special magnetic elements;
- measurement axes were complied according to ISO 8002: 1994 standard. This standard presents analytical parameters and the presenting results method of vibration measurements for land vehicles.

3. EXPERIMENTAL MEASUREMENTS RESULTS OF PASSENGER VEHICLE VIBRATIONS

Vibration measurement mode, in the first measurement point, P1, is givrn in Figure 3.

Fig. 3. Location vibration measuring system for P1 measurement point.

According to Figure 3, the measurement axes of vibrations have the following correspondence with accelerometer measuring channels:

- Oz axis measurement for channel 1 - Ch1;
- Oy axis measurement for channel 2 – Ch2;
- Ox axis measurement for channel 3– Ch3.

Table 1 contains the effective values of vibration acceleration, type Peak, Peak-to-Peak (P-P), Maximum and RMS (Root Mean

Square), obtained in P1 measuring point, determined experimentally on the 3 coordinate axes.

Table 1.
Effective vibration accelerations obtained on the three channels, in P1 measurement point.

Measurement canal	**Acceleration [mm/s²]**			
	PEAK	**P-P**	**MAX**	**RMS**
Ch1	104.954	192.309	19.770	18.450
Ch2	104.954	209.411	19.792	18.450
Ch3	103.633	190.766	20.022	18.535

The numerical values in Table 1 are presented in graphical form in Figure 4.

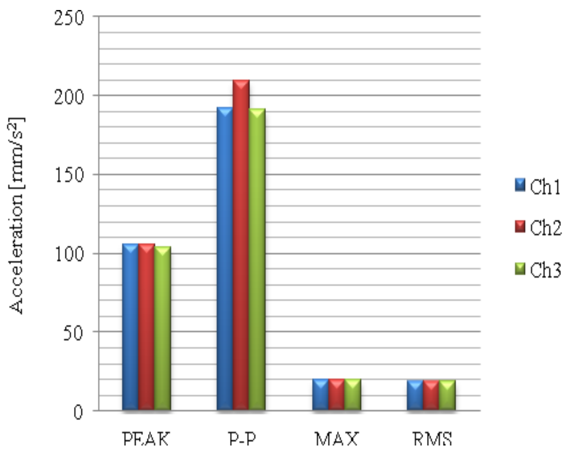

Fig. 4. Chart of effective vibration acceleration measured on the 3 channels, from P1 measuring point.

Figure 5 contains the oscillogram of RMS acceleration for three axes.

Fig. 5. Oscillogram of RMS acceleration from the P1 measuring point.

From the Table 1, Figure 4 and Figure 5, it is observed that the highest values of Peak-to-Peak and Max vibration accelerations are along the Oy transversal direction, 209.4 and 19.8 mm/s^2 respectively.

RMS acceleration is higher along the Ox horizontal direction, value by 18.5 mm/s^2.

Vibration measurement mode, in the second measurement point, P2, is illustrated in Figure 6.

Fig. 6. Location vibration measuring system for P2 measurement point.

According to Figure 6, the measurement axes of vibrations have the following correspondence with accelerometer measuring channels:

- Oz axis measurement for channel 1 - Ch1;
- Oy axis measurement for channel 2 - Ch2;
- Ox axis measurement for channel 3 - Ch3.

Table 2 contains the effective values of vibration acceleration, type Peak, Peak-to-Peak (P-P), Maximum and RMS (Root Mean Square), obtained in P2 measuring point, determined experimentally on the 3 coordinate axes.

Table 2.
Effective vibration accelerations obtained on the three channels, in P2 measurement point.

Measurement canal	**Acceleration [mm/s²]**			
	PEAK	**P-P**	**MAX**	**RMS**
Ch1	99.655	181.134	18.030	16.943
Ch2	96.939	179.887	18.009	16.866
Ch3	96.383	184.289	18.281	17.080

The numerical values in Table 2 are presented in graphical form in Figure 6.

From the Table 2 and Figure 7, it is observed that the highest values of vibration acceleration are along the Ox horizontal direction.

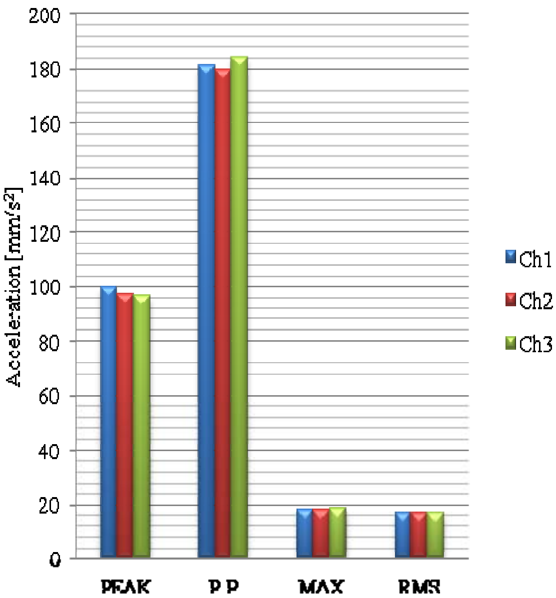

Fig. 7. Chart of effective vibration acceleration measured on the 3 channels, from P2 measuring point.

The maximum RMS acceleration along the Oz vertical direction is 17 mm/s^2. This is confirmed by the oscillogram given in Figure 8.

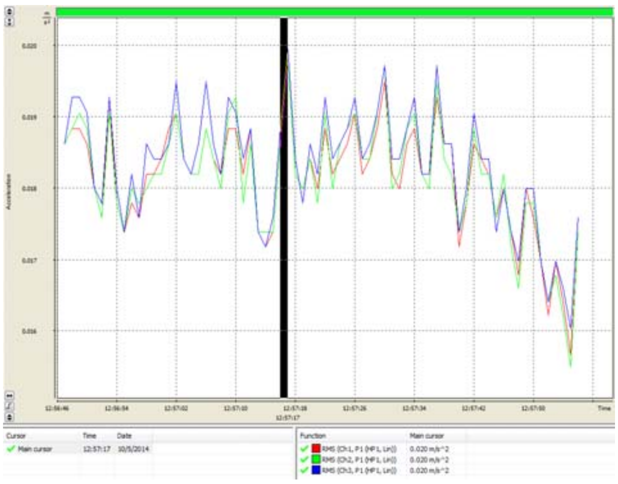

Fig. 8. Oscillogram of RMS acceleration from the P2 measuring point.

Vibration measurement mode, in the third measurement point, P3, is illustrated in Figure 9.

According to this figure, the measurement axes of vibrations have the following correspondence with accelerometer measuring channels:

- Ox axis measurement for channel 1 - Ch1;
- Oy axis measurement for channel 2 - Ch2;
- Oz axis measurement for channel 3 - Ch3.

Fig. 9. Location vibration measuring system for P3 measurement point.

Table 3 contains the effective values of vibration acceleration, type Peak, Peak-to-Peak (P-P), Maximum and RMS (Root Mean Square), obtained in P3 measuring point, determined experimentally on the 3 coordinate axes. The numerical values of the Table 3 are presented in graphical form in Figure 10.

Table 3.

Effective vibration accelerations obtained on the three channels, in P3 measurement point.

Measurement canal	Acceleration [mm/s^2]			
	PEAK	**P-P**	**MAX**	**RMS**
Ch1	710.395	1345.860	257.040	244.343
Ch2	732.825	1380.384	318.787	291.407
Ch3	573.456	1026.833	197.015	188.582

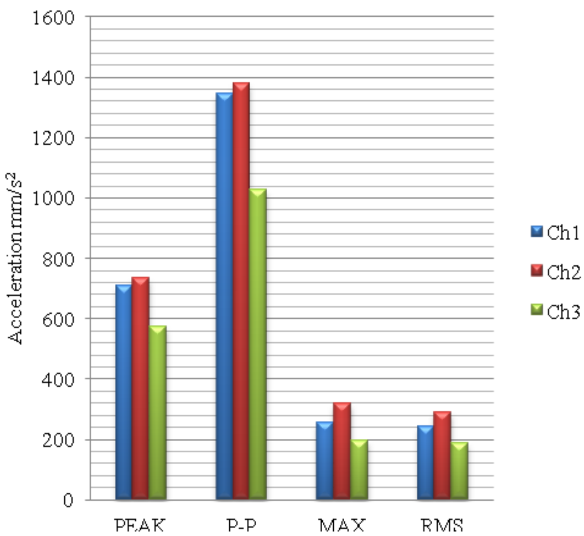

Fig. 10. Chart of effective vibration acceleration measured on the 3channels, from P3 measuring point.

From the Table 3 and Figure 10, it is observed that the highest values of vibration acceleration are along the Oz vertical direction.

For example, the maximum RMS acceleration along the Oy transversal direction is 291.4 mm/s^2. This is confirmed by the oscillogram given in Fig. 11.

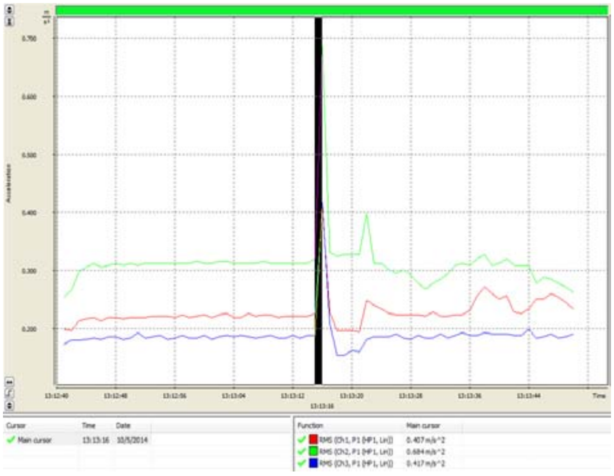

Fig. 11. Oscillogram of RMS acceleration from the P3 measuring point.

Analyzing the results of vibration obtained in the 3 measuring points of the second vehicle, it follows that the acceleration is highest at the P3 point, i.e. the front seat, along the Oy transversal direction. Also acceleration values obtained for the first two measurement points are very close.

4. OPERATIONS HISTORY OF MAINTENANCE

Preventative car maintenance and routine inspections can go a long way when it comes to keeping car in peak condition. Following the manufacturer's car maintenance schedule will save time and money. When it adhere to vehicle maintenance guidelines, it is necessary to take action against unwelcome damage and future costly repairs.

Periodicity of maintenance work is expressed in traveled units, namely equivalent kilometers and it is established by normative function of vehicle and maintenance type.

Repairs have different degrees of complexity. These are the following:

- current repair: technical corrective interventions, troubleshooting applied during operation;
- average repairs: technical corrective interventions consisting of partial disassembly, repair or replacement of aggregates and other review;
- major repairs: complex technical interventions that involve complete disassembly of motor vehicles and reconditioning of all components so as to achieve initial operating parameters (parameters set in the factory).

Table 4 contains the history of the passenger vehicle maintenance operations, the last 3 years.

Table 4.

The passensger vehicle maintenance operations.

Type of intervention	Date	Indicated km
Change engine-oil and filter	22.06.2012	402 300
Change clutch kit: disc, pressure bearing, pressure plate	30.07.2012	407 700
Change engine-oil and filter	01.09.2012	425 000
Change engine-oil and filter	18.09.2012	429 500
Change engine	14.12.2012	445 000
Change engine oil and oil filter, air filter, gas oil filter	14.12.2012	445 000
Change engine-oil and filter	18.02.2013	459 000
Change tire	03.03.2013	461 000
Change rear and front brake pads	09.05.2013	476 000
Change engine-oil and filter	17.07.2013	489 000
Change pollen filter, air filter	27.08.2013	405 000
Replace distribution system	27.08.2013	405 000
Change engine-oil and filter, air filter	12.09.2013	416900
Change clutch kit: disc, pressure bearing, pressure plate	12.09.2013	416 900
Change engine oil and oil filter, air filter	28.11.2013	430 000
Change rear and front brake pads	28.11.2013	430 000
Change engine-oil and filter, air filter	19.12.2013	442 000
Change pollen filter, air distribution system, the bellows, drive shaft and belt	20.01.2014	452 300
Change engine-oil and filter, air filter, gas oil filter	07.03.2014	476 000
Replace distribution system	20.04.2014	481 200
Change rear and front brake pads	05.05.2014	492 000
Change engine-oil and filter, air filter	02.06.2014	508 700
Change pollen filter, air filter, distribution system	16.07.2014	522 000
Change engine-oil and filter	01.08.2014	535 000
Change clutch kit: disc, pressure bearing, pressure plate	01.08.2014	535 000

Change engine-oil and filter	05.11.2014	549 300
Change rear and front brake pads	23.10.2014	551 100
Change tire	23.10.2014	551 100
Change engine-oil and filter, air filter, gas oil filter	12.12.2014	562 800

From Table 4 is observed that for the passenger vehicles was respected periodic maintenance periods and was performed current repairs and media interventions.

Change engine was the most important operation of the vehicle maintenance history studied.

5. CONCLUSION

After the study of maintenance by using vibration measurements, can conclude the following:

- vibration behaviour of vehicles differ according to the measuring point;
- vibratory behaviour of the vehicle depends on how their maintenance and repairs carried out especially during the operation;
- maximum acceleration values are mainly along vertical direction, i.e. along the piston engine movement direction.

4. REFERENCES

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Studiul mentenanței unui mijloc de transport persoane prin analiza experimentală a vibrațiilor

Starea tehnică a unui autoturism se poate aprecia după valorile parametrilor săi de stare, care în timpul exploatării suferă modificări permanente, continue sau discrete. Componenta mentenanței mijlocelor de transport bazată pe evaluarea vibrațiilor mecanice presupune obținerea, prin măsurare şi analiză şi o descriere cât mai exactă a fenomenului vibrator. În acest articol se prezintă studiul mentenanței unui mijloc de transport persoane bazat pe rezultatele determinărilor experimentale ale vibrațiilor, efectuate în trei puncte semnificative. Se evidențiază faptul ca nivelul vibrațiilor poate atât să indice o defecțiune, cât şi să reflecte calitatea procesului de mentenanță.

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