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USING NETWORK CAN-BUS FOR ASSESSMENT TRANSMISSION LOAD OF VEHICLE

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Summary: *More and more digital technology is used in modern cars to operate electrical and mechanical systems. CAN-Bus communication takes significant place in these days. European car production networks use standard communication interface but all car CAN-based higher-layer protocols used are nonstandard and the connection is specialized only for car diagnostics. This article tryes to explain how to solve these problems at Skoda vehicles by data acquisition from CAN-Bus of Skoda Fabia for analysis of car dynamic behaviour.*

1. Data bus of vehicle

The design of modern vehicles with great numbers of electronic components involves necessity usage on-board information networks. These digital buses are connecting individual units and they are makes it possible mutual communication of all apparatus inside car. Important parameters of these networks are baud rate and electromagnetic compatibility in very aggressive environment. In the car industry, several type of networks were apply as are: CAN-Bus (Controller Area Network), LIN (Local Interconnect Network), K+L-line, FlexRay, MOST, SAE J1850, X-By-Wire, Byteflight atd.

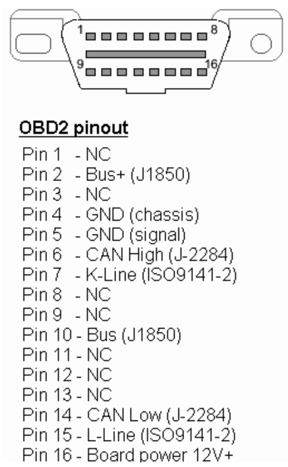

Fig. 1: EOBD connector

From figure of diagnostic connector EOBD is result, that many of these networks are easily user accessible. Since 2000, this connector is obligatory. The exception is K-line. In the event of standard cars are use individual networks only to service diagnostics, with using many professional apparatuses and analyzers. This situation is complication, single European producers define self communication protocol and in many cases connection with control unit of car it is not possible without proper information. The mentioned networks have often various properties. Control unit of ABS or engine has high requirements on transfer rate of information; other for control unit of air conditioning is sufficient transfer rate in network slower.

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2. Problems of fatigue dimensioning of drive train

At drive train dimensioning of car it is impossible act with method supposing forward load. A load structure of drive train is different for various types of cars and it is depending on the process conditions. At the vehicle is a change of running resistance, dynamic beat at shifting, braking and other contingencies. The most of drive train components is stressed cyclic loading. For calculation of service life of single part transmission with the method of linear commutation of fatigue damage is necessary know so-called “spectra of load” and Whöler curves of material of gear wheels (Moravec, 2000).

At make-up of load spectrum is using partition of total load range to several load levels and next evaluation of number of gear revolution on this levels in given test interval. Cycle count of fatigue curve N_i at corresponding level of load σ_i is:

$$N_i = N_W \cdot \left(\frac{\bar{\sigma}_W}{\left|\bar{\sigma}_i\right|} \right)^W , \qquad (1)$$

where N_w, σ_w, and W are parameters of Whöler curve. Because, these values are proportional for given material unchanging and equivalent strain is directly proportional of load torque, it is possible write equation for cycles per second of fatigue curve on i torque load in the form:

$$N_i = A \cdot \left(\frac{1}{\left|M_i\right|} \right)^W , \qquad (2)$$

where A is constant for given material and shape of tooth system. In addition, in this adjustment of form, it is possible influence appraise various driving mode on fatigue damage without intimacy parameters of tooth system.

For optimal assessment of tooth system parameters for new transmission, it is necessary has exact statistical evaluation of gears, driving torques and revolutions. This load spectrum is finding for every one new vehicle, in all cases of process conditions. Identification of load spectrum is assumed continuing and periodic value scanning of torque and rotational frequency for individual gears. For every one gear, it is following elaboration to shape histogram expressive number of rotation input shaft on of that torque level. The partial spectrums for individual sections and operating modes serve to creation real spectrum, that is for vehicles relative to distance moved.

Number	Received time	Type	Id 1	Id 2	Bytes	B0	B1	B2	B3	B4	B5	B6	B7
5260	23:20:15.308	St	337		4	0	80	32	112				
5259	23:20:15.308	St	1425		3	0	0	11					
5258	23:20:15.308	St	1025		6	2	1	0	0	0	0		
5257	23:20:15.308	St	881		2	192	128						
5256	23:20:15.298	St	849		7	68	124	73	0	0	129	129	
5255	23:20:15.298	St	1489		2	0	0						
5254	23:20:15.298	St	1589		3	38	255	0					
5253	23:20:15.298	St	851		6	128	12	54	180	0	0		
5252	23:20:15.298	St	1361		1	2							
5251	23:20:15.288	St	625		2	135	128						

Fig. 2: The demonstration of dataflow record CAN-Bus of vehicle Skoda Fabia

3. Description of solving method

We have the deliberation, for assessment of load course of transmission mechanism is necessary have the course of velocity, acceleration depending on time and basic characteristics of monitored vehicle. We are capable find this acceleration in the case stability and high frequency at data acquisition from on board of vehicle network. From course of acceleration, it is possible appoint force on wheel and driving force of engine at known gearbox efficiency, total gear ratio and wheel radius.

To CAN-bus it is possible join only special converter. On figure 2 is record of this communication. Every report has respective sequence number and time of coming. In network, individual reports are marked with the aid of identifier ID. The reports go after network in periods or on call RTR (remote transmission request). The value of one data frame has maximum size 8 bytes. For calculation of driving parameters, the values of reports were used with ID 851 – revolution of engine and ID 849 – velocity of vehicle. In both reports, the self values are state in two 8-bit bytes, so-called up byte B2 and down byte B1. Other the values of data bytes are not important for calculation.

4. The evaluation and analysis technique of measuring data

As has already been noted, it is possible determine from course of acceleration driving force on wheel and at know efficiency transmission mechanism, total gear ratio and wheel radius torque and power engine too. The basic equation for calculation of spectrums, force balance is between drive unit force *TF* and total vehicle resistance *R*:

$$F_{net} = TF - R, \qquad (3)$$

where F_{net} is force remaining for necessary acceleration of vehicle. At premise of drive on trace without degree of incline, it is possible use simple model for assessment drive force *TF*:

$$TF = ma + F_R + K.v^2. \qquad (4)$$

Aerodynamic parameters of test vehicle are included to one aerodynamic constant *K*. This constant is checking together with tire resistance F_R with the aid of coasting with expressed speed gear.

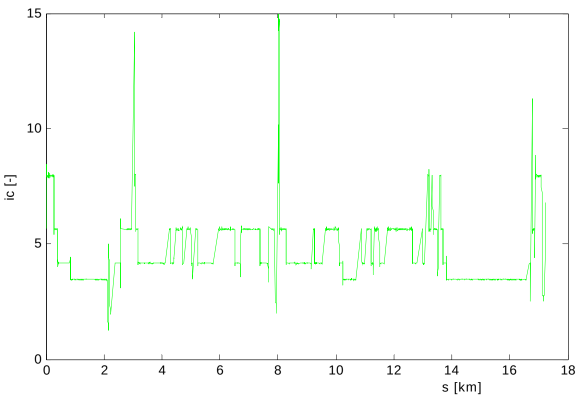

Fig. 3: Identification of total ration gear i_C

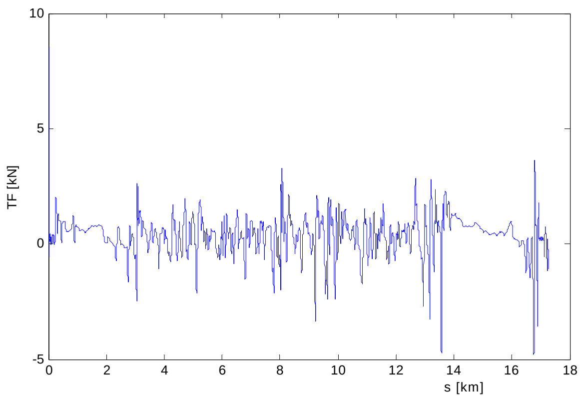

Fig. 4: Course of driving force on wheel TF

The acceptable choices of data from calculation sequence all sorts of information is needed periodic sampling of observed values. For elaboration internal data form control unit is necessary obtain transfer constants. These constants can be determinacy experimental on the basis comparison with data from dashboard of vehicle. The scanning values are loaded with noise. On these account values of velocity is necessary filter. For this purpose is acceptable low-pass filter FIR with frequency 1 Hz. The velocity of vehicle is convert form tire dynamic radius r_d to wheel revolutions. From rate of engine revolutions and wheel revolutions is obtaining total gear ratio in every one moment of measurement.

For next calculation of driving force of vehicle is necessary assessment of longitudinal vehicle acceleration. Provided sufficiency measured values of velocity and provided constant period Δt (in our case cca 0,01 s) are results good with trivial method of numerical derivation:

$$a_n = \frac{v_n - v_{n-1}}{\Delta t} \tag{5}$$

Before next calculation is acceptable sequence of acceleration again filtration with low-pass filter. For calculation of displacement is used numerical integration of velocity. Next, it is possible course of driving force between wheel and road (fig. 4) determine with equation (4). Censorship is following for negative driving force (braking with engine) and selection of data for specific gear. From driving force *TF* is possible on the basis knowledge of tire dynamic radius r_d**,** immediate gear ration i_C and efficiency of transmissions system determine driving torque of engine *M*:

$$M = \frac{TF}{r_d . i_c} + M_z \tag{6}$$

At assessment efficiency of transmission in various modes was used measurement of power dissipation of transmission Skoda Fabia, which we are making in our test-room in the past. For simplified calculation is sufficient order constant idle moment M_z for pro every one test. Next step is partition of load moment choice gear to select number of moment levels. In our case, we are determining 15 levels between 0 and 150 Nm, this is maximum of torque engine. All of results are reducing on displacement 1 km of road. The spectrum is depictured in histogram for each gear apart (fig. 5). We are solving algorithm with small computer program in MATLAB.

File name: jizda_2.vyb

Length of test: 17.3 km

Time of drive: 16.2 min

Average speed: 64.2 km/h

Gear:	2	3	4	5
Total ratio [-]:	8.14	5.57	4.19	3.46
Mean value of rotational frequency [RPM]:	2466	3012	3162	3869
Mean value of drive torque [Nm]:	49.9	56.7	63.2	68.8
Speed rate of gear [%]:	5.27	27.6	39.4	27.6

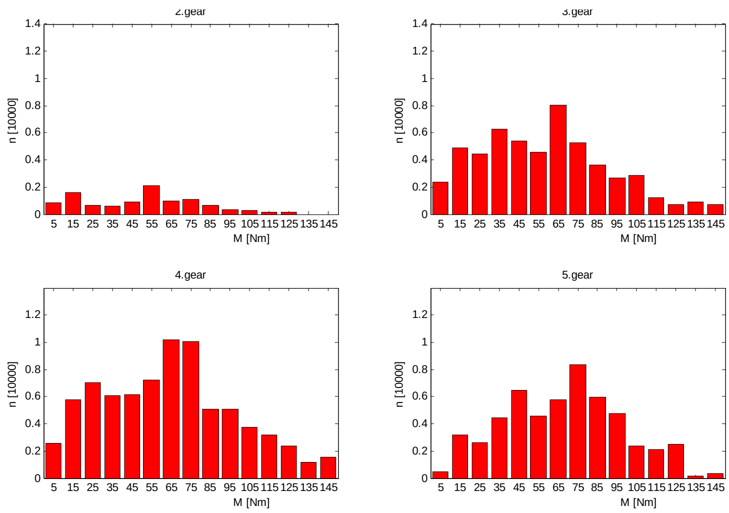

Fig. 5: Driving parameters and load spectrum for 2., 3., 4. and 5. gear

5. Description of experiment

Converter CAN-bus (CAN-Bus High speed medium access, type USB2CAN) to USB common PC was used for data logging form on-board system. This converter makes it possible to data logging form on-board system to file and their next (Dvořáček & Mazůrek, 2006) analysis with the aid of software PP2CAN. For requirement of engine circuit are sending on CAN-bus information about revolution a speed of vehicle with frequence to 100 Hz.

To experiment was used vehicle Skoda Fabia 1.4. Before tests, it was performed speed calibration measurement of vehicle with tachometer, on-board network and GPS. The appropriate values of speed from on-board system were convert accordance with this calibration.

As noted previously, route was choice with minimum degree of incline. We are chose length of route 8.5 km (3 km speedway, 5.5 km curvy road along the side road from that 1 km passage of village). The route was passing in both directions, i.e. total length of route is 17 km. Al all of drive traffic regulations was observing, including maximum speed on speedway and in village. Our experiment checks only the method, but it is acceptable several repeat this lap by various traffic conditions. With analytical software, it is possible the spectrum add from different drives. The direct section of road on speedway was used for tests of coast along.

Tests of coast along were performed from several velocity and they were used for accurate determination of constants F_R and K. For elimination influence of incline degree of road or wind ahead, the tests were repeating in counter. The analysis of date was evaluating finding parameters in this values $F_R = 200$ N, $K = 0.035$ N/km/h. Total weight fueled vehicle was $m = 1340$ kg.

6. Conclusion

For example on vehicle Skoda Fabia, we are showing measurement with minimum economic and time costs finding of gear ratio and revolution of engine, but also drive torque on wheel form date of CAN-bus. For examination of fatigue loading of drive train, load spectrum is possible determine from next analysis. No less important it is survey about gear ratio usage, analysis of vehicle behavior during drive and monitoring attendant effect (for example rash braking). For simplification in calculation, constant value of tire dynamic radius has been used in place of real values. This simplification slightly lowers accuracy. Influence of gas mileage on the change of vehicle weight has not been impeaching too.

Proposed method requires dereliction of gradient resistance. In our case, we are minimalism small degree of incline repetitive drive after the same route back and forth. Next specification is possible with the aid of network CAN-bus from on-board accelerometer. This electronic circuit to measured values of longitudinal acceleration vector add gravity acceleration vector. It is using to identification longitudinal incline of the roadway.

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7. Literature

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