National Conference with International Participation
ENGINEERING MECHANICS 2001
Svratka, Czech Republic, May 14 - 17, 2001

RECENT AUTOMOTIVE GEARBOX SYNCHRONIZATION ANALYSIS

Josef ŠTĚTINA, Pavel RAMÍK•

Summary: *Recent automotive gearboxes fundamental properties. The possibilities of measurement on gearboxes for purpose to obtain information about gear changes synchronization. Example of concrete testing bench developed for Škoda-auto a.s. company. Examples of data acquired on gearboxes tested. Signal processing methods, especially distant values elimination methods. Calculated quantities as gear change work, acceleration etc. The possibilities of acquired and calculated data statistical processing. Observation to synchronization properties alternation during gearbox lifetime.*

1. INTRODUCTION

Recent automotive gearboxes are equipped by sychronization mechanism, which guarantees smooth and easy gears change. The development of the synchronization with high user's comfort and especially long lifetime requires testing equipment, that enables long-duration tests without subjective effects, whose distort testing in the car.

2. REQUIREMENTS ON TEST BENCH

Testing equipment has to ensure (using simply construction) conditions equivalent to in-car operation, i.e. gearbox output shaft revolution must not to decrease. Furthermore, automatic gearing device must not to affect gear change process. The scheme of the testing bench mechanical arrangement you can see on **Fig. 1**. Gearbox is on the input side driven by DC motor with digitally controlled converter using dimensional flywheel. Input gearbox shaft including clutch plate is equipped by revolutions measurement. On the connecting shaft between the flywheel and the gearbox there is used torque measurement shaft [1]. Automatic gearing device, controlled by six pneumatic linear drives, is provided by gearing force and gearing trajectory measurement. Whole testing equipment is supplied by system controlling the gearbox state,

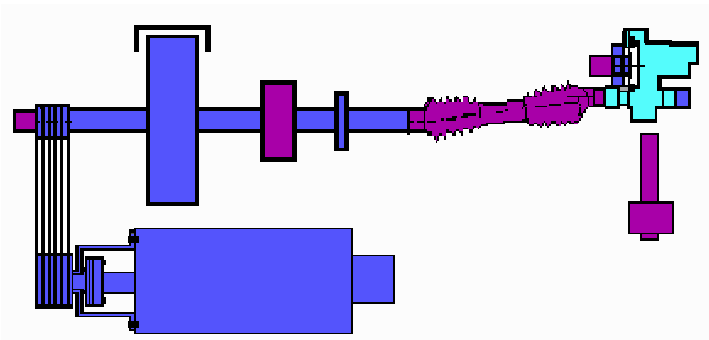

Fig. 1 Test bench arrangement scheme

• Dipl.-Ing. Josef Štětina, Brno University of Technology, Faculty of Mechanical Engineering, Technická 2, 616 69 Brno, CZ , e-mail: stetina@eu.fme.vutbr.cz, phone: ++420 5 41143269
• Dipl.-Ing. Pavel Ramík, Brno University of Technology, Faculty of Mechanical Engineering, Technická 2, 616 69 Brno, CZ , e-mail: ramik@udt.fme.vutbr.cz, phone: ++420 5 41142269

and in the case of exceeding prescribe values (vibrations, temperatures) the testing process immediately stopped.

Data acquisition and control system must to fulfill three fundamental tasks:

- to control the test bench
- to carry-out fast gear change
- to process test results

It was designed the solution consisting of so called board mounted PC computer, mounted on switchboard door. Fundamental measurement and control functions are realized by conventional data-acquisition card Advantech PCL 818L. Fundamental frequency for data acquisition, control and all supervisory and safety functions is 20 Hz.

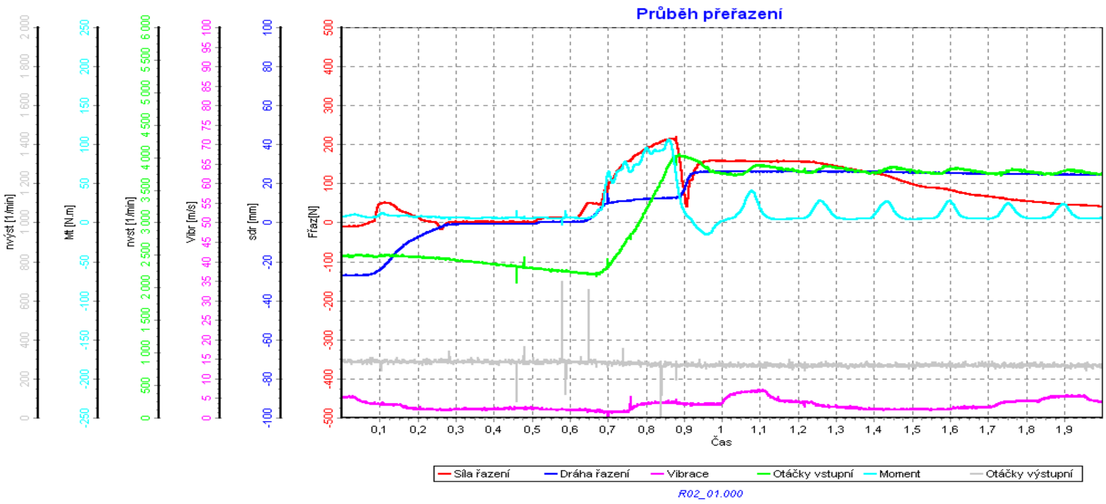

Fig. 2 Gear change acquired signals with distant values

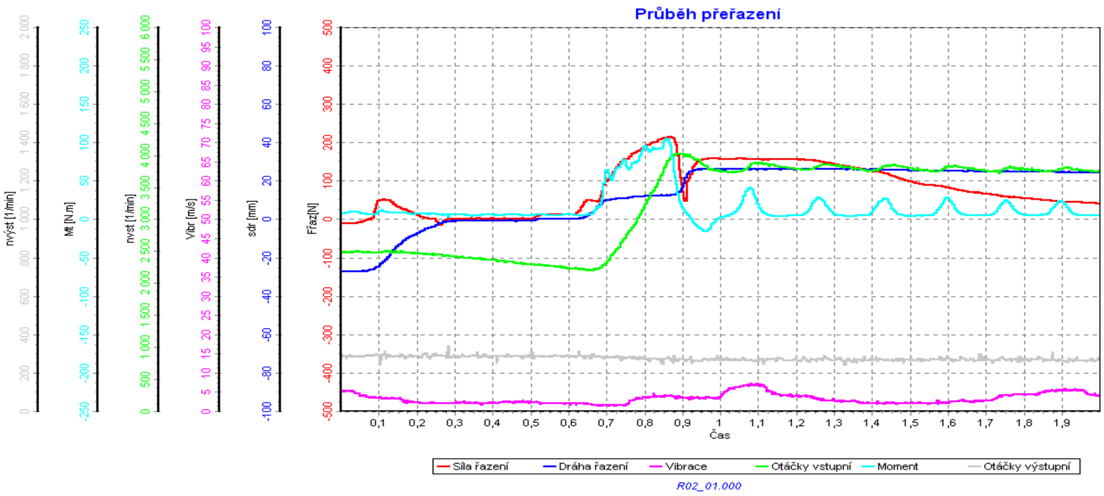

Fig. 3 Gear change signals after distant values elimination

For fast data-acquisition the card Tedia PCA 1248 is used, which has unique conception and features. It is 8-channels card with maximum sample rate of 1 MHz, is equipped by 2 MB memory (i.e. approximately 1 million samples). The main and unique feature of this card is the ability to function during data acquisition as autonomous data-logger. After starting acquisition (by program way, trigger signal, exceeding the level on the channel), the card acquires and stories data into it's memory, no to utilize the PC computer. After measurement it is possible to do fast acquired data transfer using block operation into PC memory.

3. FAST ACQUIRED DATA PROCESSING

Quantities regarding gearing are acquired with fast sample rate, because whole gear change action endures max. 2 seconds. As basic sample rate it has been chosen the frequency of 1 kHz at each of 6 measured channels. Test bench equipped by controllable electric drive, including automatic gear change device, causes the interference of all electric signals. Any signal filtering involves improper acquired signal distortion (e.g. phase shift). The interference causes so called distant values on the measured signal (**Fig. 2**). As a suitable it was found out the method for distant values elimination based on the glide median. It is calculated the vector

$$y_i^{'} = median(y_{i-\frac{n-1}{2}}, \ldots y_i, \ldots . y_{i+\frac{n-1}{2}}) \qquad (1)$$

Further error vector ***r=y-y'*** is computed, which is smoothed again using formula (1) to vector ***r'*** . The resultant smoothed vector is calculated using relation

$$y_{smooth} - y' + r' \qquad (2)$$

An example of smoothed signal from **Fig. 2** is given on **Fig. 3**.

Such way of signal conditioning has an advantage, because involves no signal additional distortion affecting further calculated quantities (as gear change work etc). Respectively for calculated quantities as input and output shaft or gearing mechanism acceleration (**Fig. 4**) it is necessary to use numerical derivation method, that at once notable smoothes the derived signal. Appropriate method

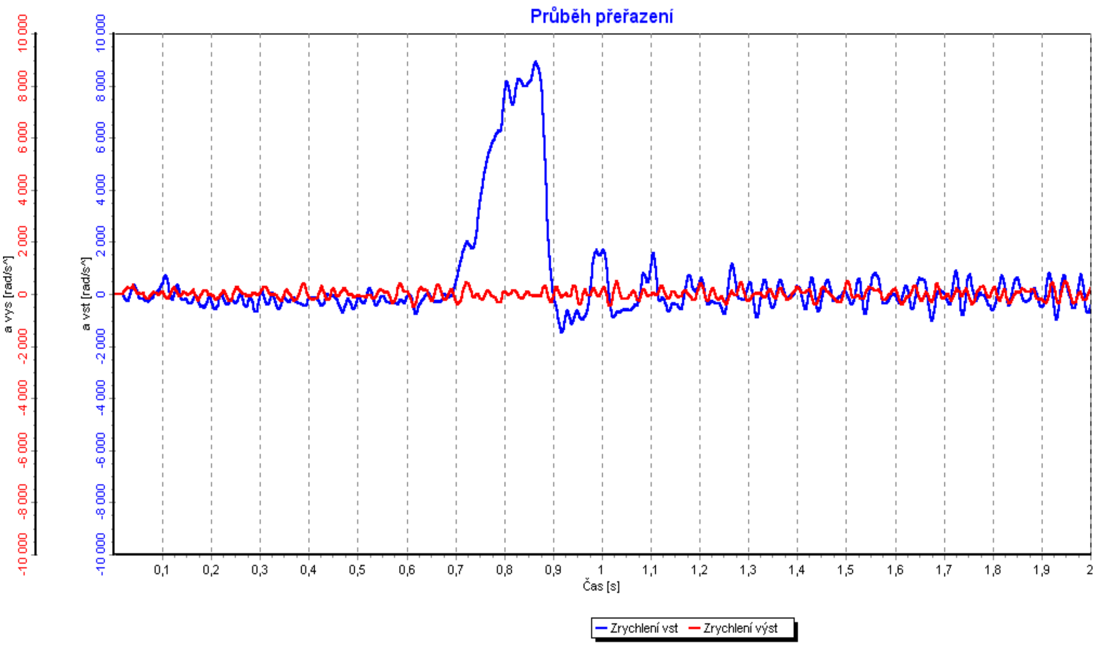

Fig. 4 Input and output gearbox shaft acceleration

is based on acquired values glide approximation using parabola (2nd order curve) by least square method. The level of smoothing is chosen by number of point, over whose the approximation is done. The derivation of parabola can be carried out analytically.

4. MEASUREMENT EXAMPLES

The results of gear change measurement are processed by postprocessing software BRTOP. An example of GUI is on **Fig. 5**. Some properties of this program can be gathered to these items:

- multiple quantities course display and individual scales choice
- smoothing selection (distant values elimination)
- moving cursors, zoom functions and ability to save the selected range to a file
- graphs printing with preview, export to graphic file of BMP, WMF transfer using clipboard
- acquired and smoothed data export to html, CSV, Excel files etc.

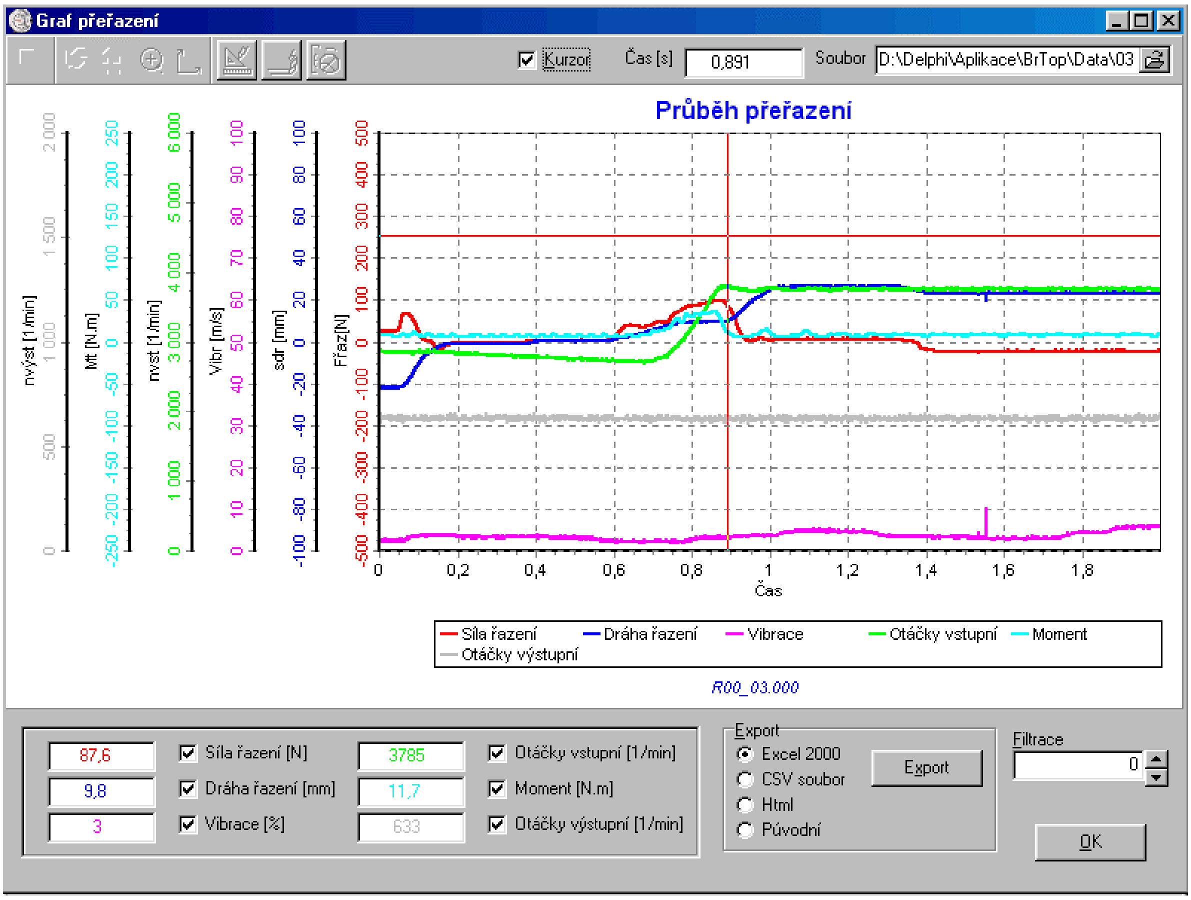

Fig. 5 GUI of postprocessing program BRTOP

5. CONCLUSION

Described testing equipment was originally designed using technical experience in testing and control system design. Computational methods described above have appeared to be appropriate for real gearing processes and have been used in software part of the equipment. The test bench had successfully full-fill compliance tests and it has been used at Škoda-auto a.s. company.

The gearbox test bench was designed and made by MEZservis s.r.o. Vsetín company.

6. REFERENCES

[1] Pavelek, M.,Štětina, J.: Experimentální metody v technice prostředí, Nakladatelství VUT Brno, Brno, 1998