Experimental Stand for Diagnosis of Mechano-Hydraulic Continuous Variable Transmission

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Abstract: *The paper presents an experimental setup able to identify the malfunctions of the dynamic equipment, using spectral analysis of the mechanical vibrations. For this study, it was chosen a continuous variable transmission (CVT) equipped with piezoelectric transmitter which measures the level of vibrations (accelerometer). The acquisition data are then processed to determine the technical conditions and the faults of the machines. The importance of achieving this stand results from the large number of such systems that equip vehicles and the possibility of their use in other systems, such as those for energy production from wind.*

Keywords*: vibration analysis, CVT diagnosis, fault location.*

1. Introduction

A concept more and more common among modern machinery and tools is the maintenance of function status. According to this, the machinery interventions are made only when machine condition deteriorates over a set point. The problem is to determine the state of the machine at any time of its operation. Such a concept was applied in the particular case of the exploitation of gearbox with variable speed- CVT type.
Combining the softwares specialized in the acquisition, processing and analysing the data collected from the sensors attached to a technical system, in order to control, monitor or diagnose it, has become an indispensable tool nowadays. [1, 2]
The usage of different components product status worsens, leading to a situation where performances are not insured by the system, and therefore it cannot be used. This wear that does not involve a fundamental change in functional parameters, occurs gradually over time, and leads to a certain limit, the irreversible damage to the gearbox.
Signal analysis product is the wide body wave frequency can be used for surveillance gearboxes, monitor the technical and product defects diagnosis.
Structurally, CVT transmissions are like variators with movable cones and belt or chain, combining, but the advantages it presents these two types of variators. Thus, the drive and driven washers are composed of two conical discs on the inside, which can change the axial distance between them, by axial displacement of one of the disk, following a command from the outside. The flexible element presents, however, features both of the belts and chains, is called pushing belt and is made of steel elements. The belt runs on two pulleys, namely the primary pulley (driver) at the engine side and the secondary pulley (driven) at the wheel side. Each pulley is composed of one fixed conical sheave and second conical sheave movable in its axial direction. Because the axial distance between the two wheels of each pulley varies, the belt can move radially inward or outward, causing a speed that works safely, as shown in figure 1.
Thus, if the transmissions with gearbox have a capacity index of 100 points, at the transmission with pushing belt by metal this index can reach 60...70 points, while on the variable conventional chain index maximum is 18, and those classic with belt is 10. Also, the durability is higher due to hertzian contact between metal surfaces.

The main element is a transmission kinematic gear ratio according to formula 1:

$$i = \frac{\omega_1}{\omega_2} = \frac{R_2}{R_1}, \quad (1)$$

where ω_1 and $\omega 2$ represent the angular speeds of the driving and driven element, also the rolling rays (contact) R_1 and R_2.

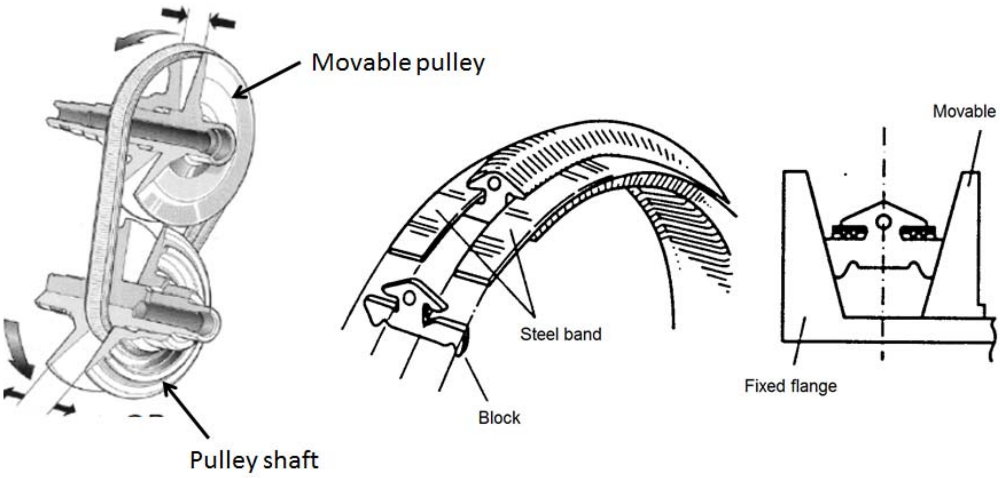


Fig. 1. CVT components

The adjustment range is defined by the relationship of formula 2:

$$G = \frac{i_{max}}{i_{min}}, \tag{2}$$

The torque that is transmitted through the variator can be calculated using the force balance on a pulley:

$$T_{cvt,p,s} = \frac{2\mu(\upsilon)F_{p,s}R_{p,s}}{\cos(\theta)} \tag{3}$$

where ϴ is the rolling cone angle, Rp is the major axis radius, Rs is the secondary axis radius.

2. The experimental set-up

The diagnostic process for automatic gear boxes requires, first of all, a large number of tests and the processing of a large quantity of data and information. This thing isn't possible if we don't use a performance device.

The need to diagnose these automatic gearboxes, made in an efficient and effective way, inevitably led to the apparition and the consecration of the electrical control systems of the functional parameters of the machines. The systems allow data acquisition and storage during the operation, with the possibility of saving and of processing those using computers and advanced software.

Was used a CVT type gearbox, set in motion by an electric motor and equipped with an acoustic sensor in order to record its behavior in dynamic working regime figure 2.

In order to be interpreted the acoustic emission signals requires a chain of subsystems, devices or appliances, which are designed primarily to separate the useful part of the signal from the source "interesting" in terms of the control of the background noise, produced by the environment or some phenomena which are not examined now. To this end, the signals are filtered in a suitable frequency band, amplified, digitized, counted.

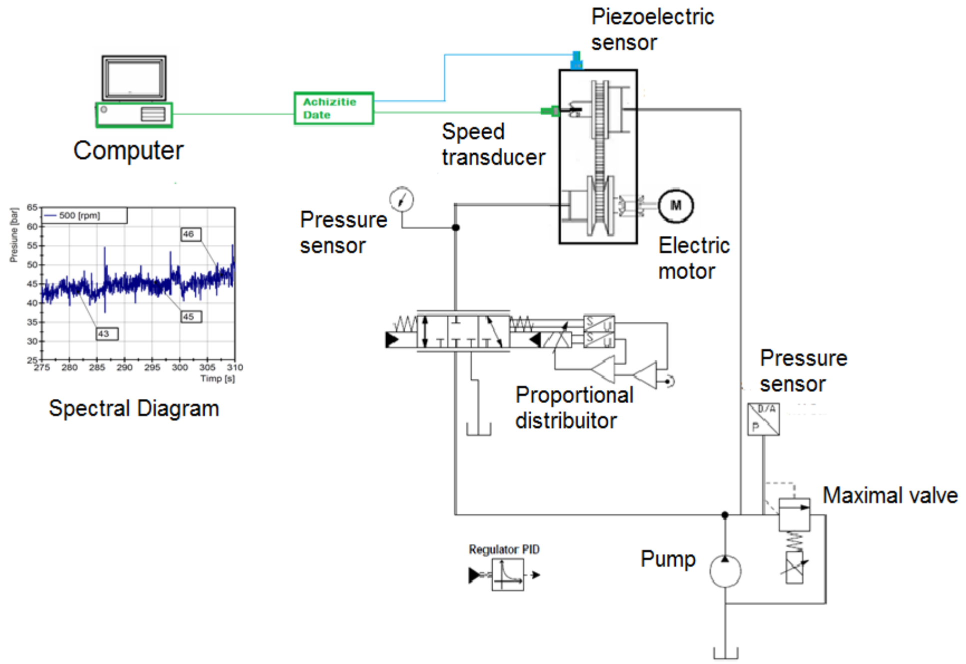
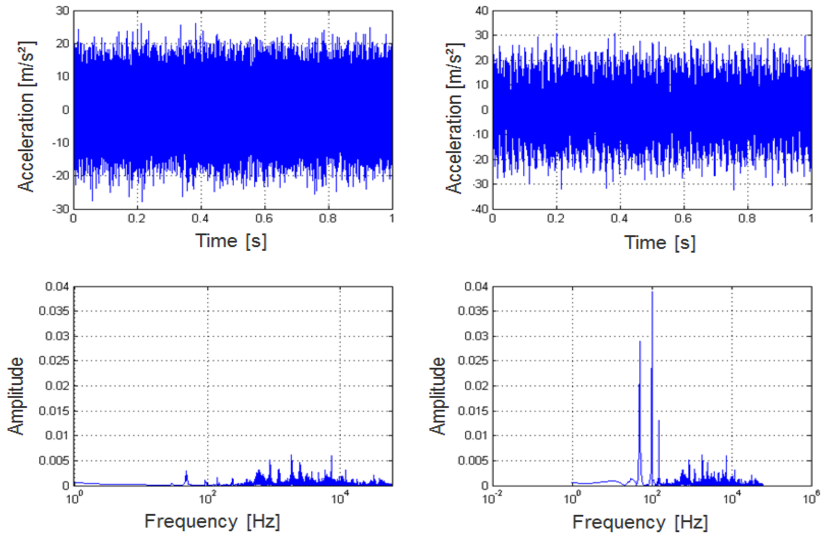


Fig. 2. CVT with its sensors

The experimental stand is presented in figure 3, consisting of multiple systems: 1 – hydraulic group, 2- electrical motor cabinet, 3- engine control unit, 4- CVT gearbox, 5 – sensor power supply unit, 6 –dSPACE Board and National Instruments, 7- computer.

Fig. 3. CVT gearbox with sensor components

In figure 4 are presented the results obtained with the vibration analysis experimental stand, for a new CVT and one with a defect.



Etalon Defect

Fig. 4. Spectral analysis standard gearbox compared to the damage

We can note that depending on the defect placed on one of the axes of the gear transmission, this leads to the emergence of large amplitude signals which are frequently different depending on the defect.

3. Conclusions

Diagnosing of the automatic gearbox based on experimental data it falls into the category of modern methods of analytical to their behaviour in different function modes.

The existence of the data relating to the good functioning of the automatic transmission or malfunction and/or its components, in the form of some dynamic experimental series (vector values), they enable the establishment of the overall operating equations by applying the procedures to identify of the faults systems. It has been shown that the comparison between the oscillatory processes continuously variable transmission can substitute whole package of evidence on the stand to the manufacturer for their execution quality certification and have established technical and economic arguments recommending diagnostics using oscillating signal.

The importance of achieving this stand results from the large number of such systems that equip vehicles, and the possibility of their use in other systems such as the energy production from wind [5, 6].

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