40. EAN
40. MEZINÁRODNÍ KONFERENCE EXPERIMENTÁLNÍ ANALÝZY NAPĚTÍ
40th INTERNATIONAL CONFERENCE EXPERIMENTAL STRESS ANALYSIS
3. – 6. VI. 2002, PRAHA/PRAGUE, CZECH REPUBLIC

EXPERIMENTAL ANALYSES OF SERVICE LIFE AND REILIABILITY OF MACHINE ´S DRIVE

EXPEIMENTÁLNÍ ANALÝZA ŽIVOTNOSTI A SPOLEHLIVOSTI STROJNÍCH POHONŮ

Ing. Vojtěch Dynybyl, Ph. D.

The paper deals with experimental evaluation of life service and reliability of machine ´s drive or their parts. To transfer the power during required service life is the first duty of drive. There are others parameters, which are very important. Especially kinematic accuracy of special drive used in robots or production machines is the main parameter. It is very interesting parameter because it determines motion of driven parts. It depends on service wear, which changes during service life influence distribution of load. Experimental simulation of service load is an important to predict service life and reliability of drive. To manage experiment the LabView software is used.

Keywords: machine ´s drives, service life, reliability, accuracy, experimental simulation

1. Introduction

This paper is concerned with identification of drive ´s service parameters. Experimental evaluation of drive systems with transmission mechanisms is based on simulation of service loading, service kinematics conditions etc. It includes assessment of these main parameters: input and output torque moment and speed. Having these four parameters we can determinate a lot of useful parameters: real reduction ratio, torsion stiffness, lost motion, backlash, transmission accuracy, efficiency.

2. Basic system of measuring

Division of Machine Elements and Mechanisms of FME CTU in Prague is focussed on this topic for a long time, but to increase quality of this process some last years the measure station has been reconstructed. Fig. 1 shows basic system of measuring for enumerating of main parameters of drives.

It consist of these equipments and devices:

1 Measured drive
2 Drive motor
3 Loading unit
4 Computer
5 Sensor of position
6 Torque moment measuring device
7 Control unit of drive motor and loading unit
8 Operating feedback
9 Temperature measuring unit.

This measuring station makes possibilities of appreciation rotary and linear drives with transmission mechanisms. Asynchronous electric motor is the most used motor in drives of machines. To reduce its speed the reducers are used. Combination of these two parts is very frequent. This measuring station makes possibilities of appreciation rotary and linear drives with transmission mechanisms. Asynchronous electric motor is the most used motor in drives of machines. To reduce its speed the reducers are used. Combination of these two parts is very frequent.

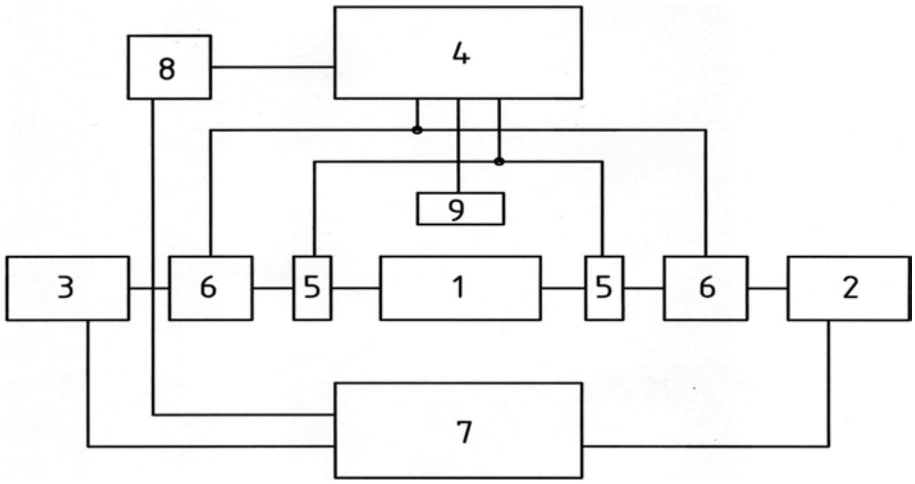

Fig. 1. Basic measuring system

3. Transfer of measured data

Data ´s recording is done by software LabVIEW. It enable to develop applications on Windows with graphical programming, then download the program to run on an independent hardware target with a real time operating system. To create those programs the user interface is build by using a set of tools and objects. The user interface is known as the front panel. The graphical functions are assembled on a block diagrams. Fig. 1 shows the example of structure of application.

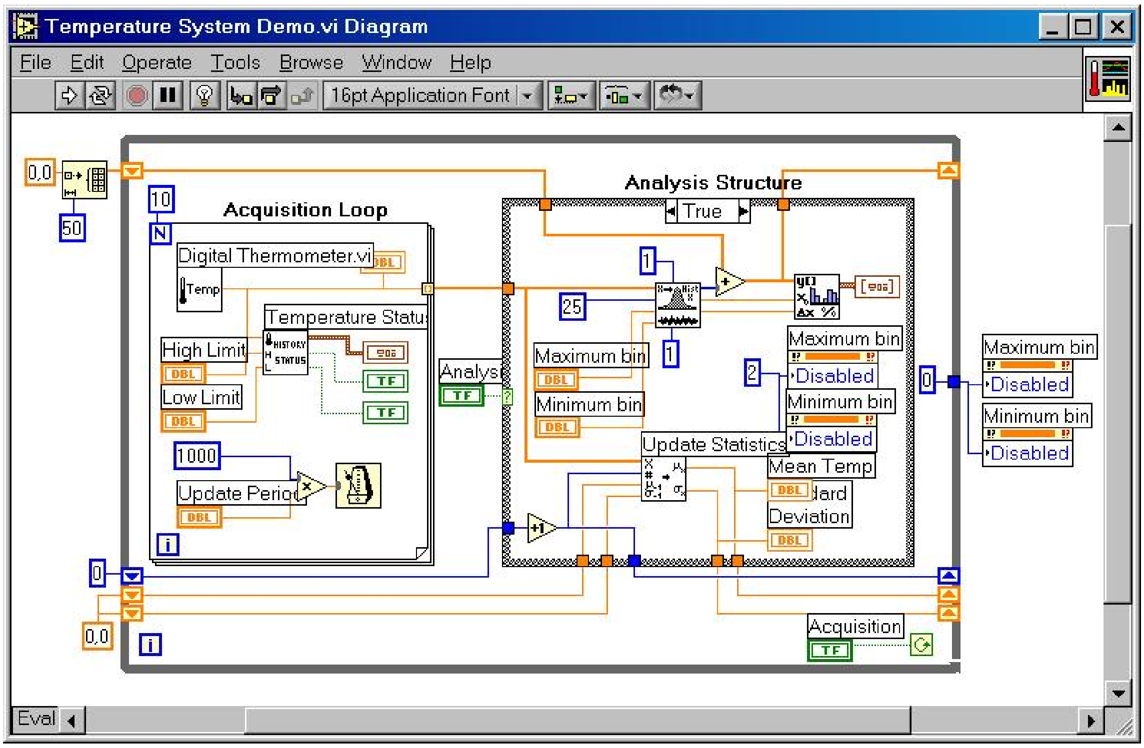

Fig. 2. The example of application on Windows with graphical programming

Those applications can be developed according requirements of experiments. Templates for measuring of various values can be connected to develop new application. Controlling and searching of measured data is possible using tools palettes. Fig. 3 shows the example of it. Analyses of measured data and presentation of them can be done too. The LabVIEW software is supported with DAQ 6024/E, multifunction I/O board. It features 16 channels of analog input, two channels of analog output, a 68-pin connector and 8 lines of digital I/O.

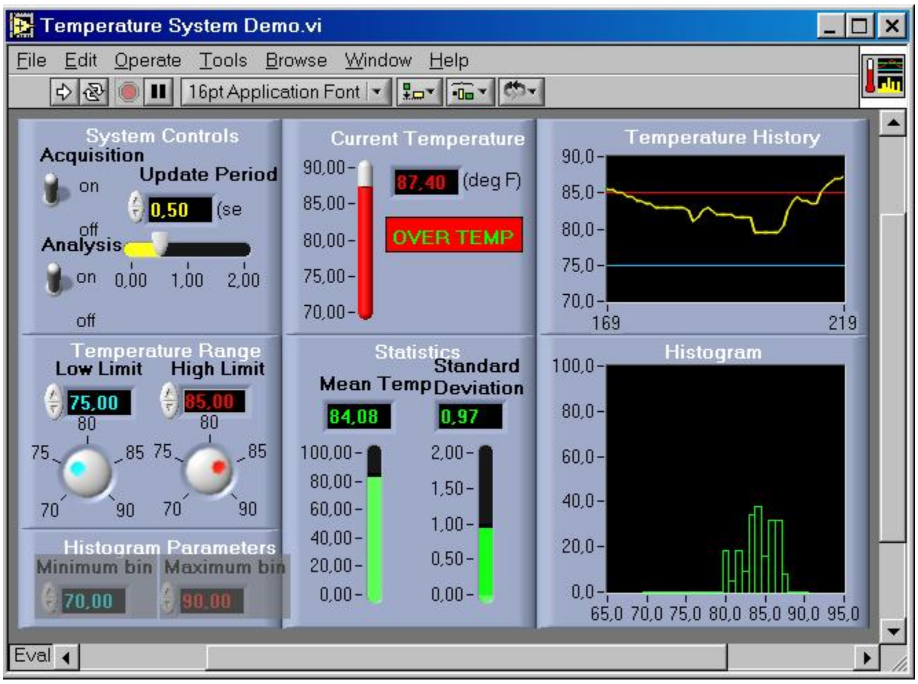

Fig. 3. En example of tools palette

4. Simulation of service

Very easy way how to arrange the measured post is the positioning of two drives opposite itself. Asynchronous electric motor of the first one is the drive motor and asynchronous electric motor of the second one is the loading unit. Regulation of torque moments and speeds of both motors can be done with operating feedback. Programmable software controls couple of frequency converters MasterDrives Vector 7,5 kW firm Siemens. They are able to operate both torque moments and speeds of both electric motors. Loading unit for rotary drives needs acceleration transmission to increase frequency of rotary motion. The brake is usually realized with asynchronous electric motor controlled with frequency converter. Linear loading unit can be done via hydraulic piston or ball screw. The rotary speed of ball screw ought to be accelerated and the asynchronous electric motor controlled with frequency converter can load the system.

5. Variants of experiments

Short time measurements are focused on transient phenomenon for example damping in coupling, braking moment in brakes or deformation and stress dependence on motion or load. Since these effects are very fast and short the oscilloscope has to be used. The data are record to memory of the oscilloscope using data dependence on time. ASCII code data are ready to be transformed to graph. This method is acceptable for recording of analog signals.

The second group of measurement is recording of information of motion. See fig. 1, position 5. The accuracy of transfer of motion is the main and the most important quality of precise transmission systems. It means reducers, ball screws etc. The operating principle of used sensors is based on photoelectric scanning of individual periodic graduation tracks. It means that the measured value is determined by counting. It is an incremental measuring. Since a reference is required to find absolute positions, graduated disks feature a reference mark on an additional track nest to the incremental grating. The reference mark is also scanned photoelectrical.

Kinematic mistake define accuracy of transmission. In the case of rotary reducer it is error of angle:

$$\Delta\varphi = \varphi_2 - \frac{\varphi_1}{i_{12}} , \qquad (1)$$

where φ_1 measured angle of rotary of input shaft,

φ_2 measured angle of rotary of output shaft,

i_{12} transmission ratio.

This value can be changed if the wear is determined by service life. It depends on the loading of the system.

Middle time measurement describes the effects in the start of service of drive. It means measuring of temperature from starting service to steady service, definition of efficiency depending on degree of loading etc. Usually, the information of temperature of environment of the gearbox and of the oil is recorded. See fig. 1 position 9. Efficiency can be defined:

$$\eta = \frac{P_{output}}{P_{input}} \quad , \tag{2}$$

where

$$P_{output} = T_{output} . \omega_{output} \tag{3}$$

and

$$P_{input} = T_{input} . \omega_{input} \quad . \tag{4}$$

Since:

$$\omega_{input} = \omega_{output} . i_{12} \quad , \tag{5}$$

we can count :

$$\eta = \frac{T_{output}}{T_{input} . i_{12}} \tag{6}$$

There is η efficiency of transmission,
P_{input} input power,
P_{output} output power,
T_{input} input torque moment,
T_{output} output torque moment.

Both input torque moment and output torque moment are measured values. See fig. 1, position 6.

Long time measurements are focused on study of reliability, kinematic accuracy and other parameters during whole service life, we have to simulate loading for a long time. It means loading for thousands hours. It is necessary to design the optimal type of loading cycle. It usually consists of starting, running, braking, reversing, waiting etc. The most important parameters are temperature, torque moment, and speed. They have to be recoded to control the measure process. To evaluate wearing process or changes of efficiency the long time experiment has to be interrupt and the short or middle time measurement can be done according what type of methodology has been designed.

6. Conclusion

Designed measure station provides possibilities to evaluate a large assortment of types of rotary and linear transmission members. Using modern universal device for checking, adjusting and displaying data quick and exact evaluation of drives can be provide.

7. References:

[1] Dynybyl, V.: *Evaluation of Stress of Flexspline of Harmonic Drive Unit Using Compare Methods*, PhD theses, Prague 2000, Czech Republic.

[2] Dynybyl, V.: *Identification of Drive´s Service Parameters Using Experimental Simulations,* Workshop 2002, CUT Prague, pp. 736-737

[3] Češpíro, Z., Dynybyl, V., Kanaval, J., Tomek, P.: *Experimental evoluation of Epicyclic Gearbox TS030383/125,* Proceedings of Conference of Depart-ments of Machine Parts and Mechanisms, pp. 44-46, STU Bratislava, 1997, ISBN 80-227-0971-9.

[4] Dynybyl, V. Španiel, M. Jančík, L. Šimek, D.: *The Results of Modeling and Testing of Harmonic Drive.* In: Extended Sum. of 18-th DAS on Experimental Methods in Solid Mechanics. Vienna : 2001, p. 159-160.

[5] Žídek, J.: *Programování v grafickém vývojovém prostředí LabVIEW*, Katedra elektrických měření, Fakulta elektrotechniky a informatiky, VŠB Ostrava, 2000.

[6] *DAQ, Multifunction I/O Board for PCI, PXI, and CompactPCI Bus Computer*, National Instruments

This research has been supported by J04/98: 212000008.

Ing. Vojtěch Dynybyl, Ph. D., Technická 4, 166 07 Praha 6, dynybyl@fsid.cvut.cz