STUDIES ON CURRENT TRENDS IN THE FIELD OF MEASUREMENT AND CONTROL OF BEARINGS

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Abstract: For an absolute novelty and actuality in the local landscape, this paper deals, in a complex and rigorous manner, with the study of methods and means of measurement and control of intelligent measurement systems produced by Taylor Hobson company in the field of bearings, highlighting the current state of trends in measuring and controlling the bearings through machines of passive and active control and intelligent measurement systems, such Form Talysurf, Tesa, Top Gage that uses Windows 2000 and Windows XP ® platform, using TalyMap software and Ultra Program available for both systems regarding surface smoothness and circularity, bringing a high degree of uniformity of program capabilities for all Taylor-Hobson tools, in order to measure the bearings raceway.

Keywords - circularity, converter, interface, microprocessor, reliability, resolution, roughness, transducers.

1. Introduction

Intelligent systems of measurement can be represented as a genuine network of capture, transmission and reception of measurement information. They are composed of different measurement converters, connected in such a way to establish a dependency between the measured size and the user.

Measurement converters can be divided into three categories:
- Input converters, which convert the measured size into an electrical signal (sensors and transducers);
- Processing converters, which convert the electric signal that they can actuate the output converter (multipliers, comparators, etc.)
- Output converters, which give the user the ability to read and record the size of the measured value

Processing the measuring information and decision making prior to the incorporation of microprocessors in the structure of electrical measurements devices were made by a human operator using a computer connected to the system. After incorporating a microprocessor in a unit of measurement, the operator role has significantly dropped, his actions being taken in part or in whole by the device, which acts as a „smart” system.

By incorporating microprocessors in a measuring device will be provided:

Processing of control functions of the device by automatically selecting the measuring range, the input and output command, the display and the mode of operation;

Processing of measuring information, which means multiplying by some parameters, determination of some average values, maximum or real, comparison with certain limit values, statistical calculations, etc.

Self calibration of device through automatic compensation of environmental influence on the indications received from the device and display of defect component part;

Increase of reliability, operating speed and accuracy of measurements that can be achieved by eliminating errors, introducing corrections, reduction of integrated circuits number, of the connections number and use of programming methods.

Below I tried to make a choice of several measurement instruments whose construction and operation rely on the theoretical concepts outlined above.

Taylor-Hobson is a company that produces cutting-edge technology, to the highest standards of precision in the field of surface and shape metrology. The company provides solutions for measuring both by contact and non-contact for the most various applications such as: automotive, bearings, optical instruments, hard disks, semiconductors, etc.

Taylor Hobson - England, no longer needs any introduction, (TALYROND has become a universal symbol of the instrument to measure the circularity)
makes equipment for measuring surface and form irregularities into two distinct categories of devices:

a) Devices for measuring roughness (DUO Surtronic and Surtronic 25), devices for measuring roughness, ripple and surface form (Form Talysurf Intra, Talysurf CCI 3000, etc.);

b) Measurements of deviations from circularity with a greater or less degree of automation (Talyrond 130 & 131, Talyrond 265, Talyrond 290, Talyrond 440 & 450, Talyrond 73, “the king” of accuracy in the analysis of circularity with an accuracy from + -25 [nm] to + -5 [nm].

2. Content of work

2.1. Precision instruments for measuring deviations

2.1.1. Precision instrument for measuring circularity

It is equipped with a rotary table on air cushion and a high resolution transducer in order to measure the mass production. The strength of this device is the rotary table on air cushion, very precise.

The user can control and program the unit through a software program called Ultra, launched in 1998, easy to use, with display options and results storage. This software incorporates all functions of the measurement device (control, calibration and measurement) and works under Windows 2000 and Windows XP platform, giving information about the status of instrument and the measurement process, using a combination of graphical and numerical data in a printed or displayed report.

Software features: total control of the instrument, automatic or manual measurement of components, checking tolerances providing a clear and simple information about the piece (good or reject), the possibility to exclude some data from measurements to have an analysis of only one parameter or a set of data, special measurement skills on specific tools, optionally you can choose to measure the speed of analysis (for high precision bearings) and the running paths (for hydro-dynamic bearings).

2.1.2. Precision instruments for measuring roughness, linearity and shape

Form Talysurf Series (Form Talysurf Series Inductive) is the global standard for roughness, linearity and shape measuring. Key features include a very precise linear bar of reference, high resolution inductive transducer with a 1mm stroke and of course, the market leader software: Ultra.

The product is designed so that it can be used in workshops or laboratories, the user accommodating easily with the help of the manual and some programming techniques. Particular areas of applicability for Form Talysurf PGI range:

- Measurements of non-spherical shape;
- Performance to measure 1/10λ form for optical industry;
- Bearings industry measurements;
- Measurements of surface finishing and form for bearings;

Characteristics:
- Sleepers from 120 [mm] to 200 [mm];
- Transducers from 4[mm] to 12.5 [mm] suitable for any application and budget;
- Transducer resolution from 0.8 [nm] to 12.8 [nm];
- Transducer having the stroke of 1[mm] and 16 [mm] resolution, available with units of sleepers of 50 [mm] and 120 [mm];
- Wide-Range option for contour measurements with a stroke up to 28 [mm] and analyze software customized for contour: Ultra Contour.

Unique sphere calibration technology of Taylor Hobson Company provides an unexampled linearity of the transducer, ensuring accuracy both for shape and surface measurements over the entire range of measurement.

Ultra Windows Software is programmed, with all international parameters included. There is also 3D measurement option with hardware and software specialized.

Fig.1: Taylor Hobson device to measure the circularity
Fig. 2: Precision instrument to measure linearity and shape

**Form Talysurf Intra**
- realizes measurements in the industrial field of shape and surface;
- can operate at distance with infrared waves;
- has a color VGA display with a touch screen
- is strong, with easy-to-use software;
- selectable parameters and a wide range of accessories;
- optional software for advanced analysis and to create a measurement report.

Surtronic Duo is a portable battery-powered roughness tester, capable of measuring many parameters in a single trace. It instantaneously measures roughness with the push of a button and it is available in two variants: Rz and Ra, or Ra, Rz, Rp, Rv and Rt;
- it is portable and easy to use;
- ideal for workshops;
- it can be used in the laboratory or outside it, being easy to use;
- it has automatic calibration.

Surtronic 25 combines advanced technology with precision and the ability to effectively measure surface finishing in the workshops, metrology rooms and laboratories. Portable and flexible, Surtronic 25 is ideal for measuring a wide range of pieces and components even if they are inaccessible or difficult to move.

**Surtronic 25**
- Accurately measurement of the surface roughness:
- portable and suitable for workshops and laboratories;
- selectable parameters and a wide range of accessories;
- optional software for advanced analysis and to create a measurement report.

Surtronic 25 is a portable battery-powered roughness tester, capable of measuring many parameters in a single trace. It instantaneously measures roughness with the push of a button and it is available in two variants: Rz and Ra, or Ra, Rz, Rp, Rv and Rt;
- it is portable and easy to use;
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- it has automatic calibration.

2.1.3. **Precision instrument for measuring asphericity**

**Form Talysurf PGI 1240**, 1/10λ performances for asphericity measurements, 200 [mm] Ř x 12.5 [mm] SAG capacity, capacity that can be increased by 50 [mm] with special stylus. It provides feedback for processing on machines tools at rectification, polishing and diamond grinding. The transducer of 0.8 [nm] and the sound of 1[nm] RMS system provide the tool ability to measure optical components. The new software for asphericity analysis meets both users in the production department and those from the research department.

**Form Talysurf PGI 1240** is a reference in the shape measurement industry. The transducer of 12.5[mm], stoke and the resolution of 0.8 [nm] provide measurements both in shape, size and texture of the surface with a single crossing. Key features include:
- reduced noise of the system less than 1 [nm] (RMS);
- 0.1 [µm] linearity on traverse of 200 [mm];
- Increment data reading on the X axis of 0.125 [µm];

Form Talysurf PGI 1240 is endowed with a cabinet in order to isolate from ambient to reduce vibration effects induced by air. Calibration on sphere and correction throughout the race ensure optimum measurement accuracy. Form Talysurf PGI 1240 is designed for flexibility and to allow the user from laboratory or division to use it manually or programmed. NEW - Form Talysurf PGI 1250A system for measuring dies non-spherical. This system personalized for non-spherical dies uses single software to be easily used in production.

**Fig.5: Precision instrument to measure non-spherical shape**

The unique calibration on sphere technology from Taylor Hobson Company provides an unmatched linearity of the transducer, ensuring accuracy of both shape and surface measurements over the entire range of measurement. Increment data reading on X axis of 0.125 [µm]; Form Talysurf PGI 1240 is equipped with a cabinet in order to isolate from ambient to reduce vibration effects induced by air.

**Talysurf CLI Systems**

Talysurf CLI range consists of a variety of platforms and transducers providing:
- Measurements by 3D contact and non-contact;
- Simple calibrations and routines for measurement (programs);
- Talymap analysis software;
- Easy-to-use software.

Three platforms are now available for measurement. Three variants are available each with a maximum volume that can be measured: Talysurf CLI 2000 - 200 [mm³], Talysurf CLI 1000-100 [mm³], Talysurf CLI 500-50 [mm³]. All systems offer a good linearity (0.34 [µm] / 50 [mm]) that facilitates an accurate 3D measurement. The speed and data storage, all axes are moving at 30 [mm/ sec] and stores data at 0.5 [µm], which provides an accurate measurement.

CLI transducers offer three different technologies of transducers: transducers that use the principle of chromatic length aberration, non-contact transducers with good characteristics of resolution and measuring range.

The device measures with precision and without contact the 3D parts: transducers that use laser (laser triangulation), providing an accurate 3D non-contact measurement; inductive transducers which provide the quality of measurements by contact. Transducers are available in various measuring ranges and resolutions, depending on the requirements and needs.

3D Talymap analysis software has been specifically designed for the metrology industry and includes many advanced features: zoom, filtering, smoothing with the method of least squares, symmetry, rotation, setting thresholds of sensitivity, the elimination of cylindrical, spherical or polynomial form and many more.

**CCI (Coherence Correlation Interferometer)** is a non-contact measuring device and non-destructive suitable for profiles with peaks between 1 [nm] and 100 [µm] and 0.01 [µm] resolution with a high speed of measurement and data acquisition. Talysurf CCI 6000 is the most accurate optical device of 3D surface profile measurement. It combines the
quality of a microscope surface image with the ability to accurately measure the conventional surface measuring instruments. Talysurf CCI 6000 is a non-contact measurement tool that uses technology of interferometry (Coherence Correlation interferometry). It can stock over 1 million points in less than 10 [seconds] with a resolution of 0.01 [nm].

Fig. 7: Talysurf CCI 6000- optical device for 3D measurement of surface profile

2.2. Ultra Software at Taylor-Hobson devices

Ultra Software was first launched in 1998. It was specially designed by metrology specialists for Taylor Hobson instruments that use PC. It is software that incorporates all systems of measurement control, calibration and measurement functions. Ultra works under Windows 2000 ® and Windows XP ® platform, and presents the status of the device and information of simple and clear measurement, using a combination of images.

Ultra program is available for both systems - surface smoothness and roundness - bringing a high level of uniformity in the program capability for all Taylor-Hobson devices.

Ultra program characteristics:
- full control of the instrument;
- the latest ISO standards are offered with continuously actualizations in order to prevent market developments;
- wide on-line assistance covers the use of the instrument, analysis and display of results, but also provides basic information in metrology;
- support and training through the Centers of Excellence provide customers with access to unmatched experience in metrology of Taylor Hobson Company;
- users can write or edit programs of measurement in order to perform repetitive tasks - increases the volume of tracks measured in serial production.
- measures components either manually or automatically;
- examine measured data, display and print results for circularity, horizontal and vertical straightness, flatness, cylindricity, surface texture, ripple, shape, non-spherical, taper and dual profile;
- excludes regions within a previous measurement to the required analysis;
- provides display and print modes of personalized results;
- option of simplified interface with the user (single touch of a button to execute a program);
- checking tolerances providing a clear and simple information: good piece / reject;
- possibility to exclude certain data from measurements to have an analysis of only one parameter or a data set;
- data export for SPC analysis (SPC software is not included);
- personalized layouts for measurement or analysis reports (including a firm header, comments, etc..)
- specific capabilities of measurement on specific tools for cylinders using TalyMap optional software;
- optional-choice: speed analyze measuring (for high-precision bearings) and raceway measuring (for fluid-dynamic bearings);
- the possibility of data exporting for a detailed analysis using UltraContur software;
- on-line help covering the use of instruments, analysis and report preparation;

Fig. 8: Ultra software methods of use, analyze and results display
2.3. Electronic devices for display, acquisition and measured data processing

They can function in the industrial environment and are equipped with a microprocessor for processing the measured data. They perform statistical or dynamical measures and display values, selection can be achieved manually or automatically. Such a device is B 100, which can be connected in cascade with other three devices, realizing automatic division on accuracy classes of the measured marker. Numeric display may show both absolute and relative measurement values as well as classification of measured markers. This device is ideal for checking internal diameters or for a quick measurement for a device with multiple sensors.

![Fig.9: Special measurements skills on some tools for cylinders, using a TalyMap optional software](image)

![Fig.10: Measuring the speed of analysis (for high-precision bearings) and measuring raceways (for fluid-dynamic bearings)](image)

2.4. The Top Gage program for Statistical and Quality Control

Top Gage is an easy to set up program so that it can work with a wide range of measuring instruments, from those of general use such as calipers, to special measuring devices, with inductive or pneumatic sensors. It is able to satisfy both quality control and statistical process monitoring. It provides static and dynamic measurements, manually, semiautomatic or automatic with the control of measurement device, the acquired data being processed in real time.

It has two modules:
- QC quality control: data from measurements are interpreted with regard to the limits of tolerance, with the possibility of sorting measured markers in classes of tolerance. In making a measurement, there is the possibility to introduce comments on events that may occur during the process (tool wear,
patches, etc.). All these data together with information on the person who made the measurements, date, hour, are recorded in a document that constitutes the report of measurement.

- SPC, statistical process control: the data from the report of measurement are statistically interpreted and displayed in charts that highlight the parameters (such as limit control) by which the process can be analyzed and brought under control in order obtain maximum stability.

The program works under Windows operating system and data acquisition from instruments is via standard interfaces.

2.5. Optical Measurement Systems type TESA

Optical Measurement Systems offer complete solutions to verify small pieces. They are non-contact systems, being designed as systems of scanning, profile projectors, microscopes and accessories.

TESA offer a complete range of electronic sensors and complete solutions (for stoking, processing and evaluation of data) for the most complex applications.

2.6. Profile projectors

Profile projectors are used to verify the form of a profile. When using the projection method, it is done, in optical manner, the real and increased image of the measured thing, image that is compared to the given profile. Micro-technique was the first company in the world that in 1954 realized a profile projector with a display of 1000 [mm] diameter.

Cyclop-1 version contains devices that use cutting-edge technique, concerning the position of projector in front of the light beam. This design solution offers the advantage of a higher precision on X-Y axis of the mass, because they are not influenced by vertical movements of the mass.
2.7. Wireless Connection Systems

They are radio transmission modules of measured data to the USB computer port. Miniature radio transmission modules represent a new technology that eliminates data cables and interfaces connected to your computer.

3. Conclusions

- Measurement principles of measuring methods depend on the nature of physical phenomena on which their functioning is based, differing from one mean to another;
- The mean of measurement can be represented as a network of capture, transmission and reception of information, network that can be called chain of measurement. The mean of measurement is an informational channel along which circulates an energetic signal carrying measuring information – metrological signal;
- The structure of measurement means is in continuously changing, currently being used elements whose function is to perform arithmetic operations (addition, multiplication, etc.), analytical operations (derivation, integration, etc.), logical operations (encoding, decoding, etc.) and the introduction of microprocessors leads to adding new functions and performance;
- The means of control are built according to the shape and dimensions of the checked parts, as well as to the kind and number of controlled dimensions. It is recommended that, wherever possible, they should be made of standard elements, normalized or standardized. When using multi-dimensional devices, the control of analyzed sizes is made successively or simultaneously. Simultaneous verification of many dimensions is more productive but requires the development of some complex devices or machines and more expensive;
- By placing microprocessors in a measuring device it is ensured: processing of command functions of the device by automatically selecting the measuring range, the command of input and output, of display and the way of operation; measuring information processing, which means multiplying by some constants, determination of some average values, maximum or real comparisons with certain limit values, etc.; self-calibration of the device by automatic compensation of environmental influence on the indications received from the device and display of the damaged component; increase of reliability, operating speed and of measurements accuracy, that can be achieved by eliminating errors, introducing corrections, reduction of the number of integrated circuit, the number of connections and use of programming methods, so companies wanting quality will completely replace manual methods by automatic ones to minimize errors in the machine;
- Automatic control, with electronic display of the done results, carries out a substantial increase in precision and productivity. Depending on the mutual action between the counter device and measured object it can be distinguished contact devices and devices without contact. At the contact devices, during measurement, it is a direct contact between the measuring surfaces of the device and the surface of the measuring object. There can be distinguished devices with one or more contacts;
- The choice of measurement and control means and methods is based on standard and calibration parameters (the scale, the limits of measurement, measuring forces, etc.) and economic (price of measuring devices, productivity, sustainability, etc.). The decisive role can be played, from one case to another, by standard and calibration parameters or economic ones. Standard and calibration parameters prevail if precision prescribed to jobs so requires.

4. Bibliography


[19] *** Methods of using Ultra software, analyze and display results.

[20] *** Special Capabilities some tools to measure cylinders, using an optional software TalyMap.


