SMART AND FLEXIBLE DIMENSIONAL INSPECTION

K.I. Kutchinsky, S.V. Plotnikov and S.P. Yunoshev

Laboratory for Technical Vision
Technological Design Institute of Scientific Instrument Engineering
41, Russkaya str., Novosibirsk, 630058, Russia

Abstract: One of the important requirement for the smart automatic dimensional inspection systems is the operative widening of the inspected object nomenclature. The flexible technology of dimensional inspection, which allows to satisfy this demand, is suggested. This technology is based on the description of the inspected object as a combination of the basic elements – primitives. Such description can be automatically obtained from the object drawing, performed by means of the automatic design program (e.g. AutoCAD), according to certain rules of indication of inspected parameters and tolerances. Then formed description is used to produce an inspection strategy (including creation of the number, position and order of shadow projections on the various object fragments) at the stage of automatically translation the object drawing into its description file in the internal system format.

Proposed technology was successfully applied to the optico-electronic systems for measurement of geometrical parameters.

Keywords: smart dimensional inspection, automatic measurement technology

1 INTRODUCTION

The inspection of articles as well as making decisions about its conformity with technological requirements is an integral part of the technological process in modern industry. Geometrical parameters are the key parameters for a wide range of products in mechanical engineering, nuclear industry and many other industries [1]. Therefore, inspection of conformity of geometrical parameters with required values and tolerances is quite a vital procedure nowadays. At the same time the possibility of inspection automation with fast adjustment of inspected parameter type and value as well as the tolerance, is very important. Flexible technology for smart measurement system development, which complies with the described requirements, is discussed in this paper.

This technology is based on the description of the inspected object as a combination of the basic elements – primitives. Such description gives a priori information about inspection article parameters. Therefore, an inspection strategy producing is simplified and the inspection time is reduced. This description by primitives can be automatically obtained from the object drawing, performed by means of the automatic design program (e.g. AutoCAD) and then it can be stored into the system database.

The described technology was applied to the optical dimensional inspection systems, based on the shadow projection method.

2 FLEXIBLE TECHNOLOGY FOR DIMENSIONAL INSPECTION SYSTEM DEVELOPMENT

As was told above, the proposed technology is based on the description of the inspected object as a combination of primitives. Primitive is an object with the set of characteristics and the set of methods for these characteristics determination. The qualitative structure of characteristics and methods depends on principle of measuring module of the system operation, on the class of inspection parameters and so on. In particular, the base set of primitives for the articles like bodies of revolution consists of "cylinder" and "face" (Fig. 1).

As an example we can consider primitive "cylinder". Its main characteristics are the position of the cylindrical section relatively the base point of reference (as a base point of reference we can take one of the article's faces), width of the cylindrical section, mean diameter on this section, slope of a spin axis and others. Given characteristics can be used for measuring the diameters of articles like bodies of revolution and misalignment of different cylindrical sections.
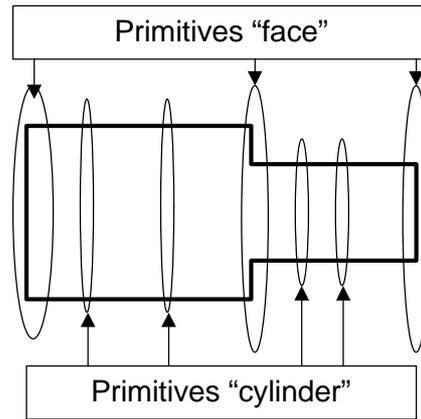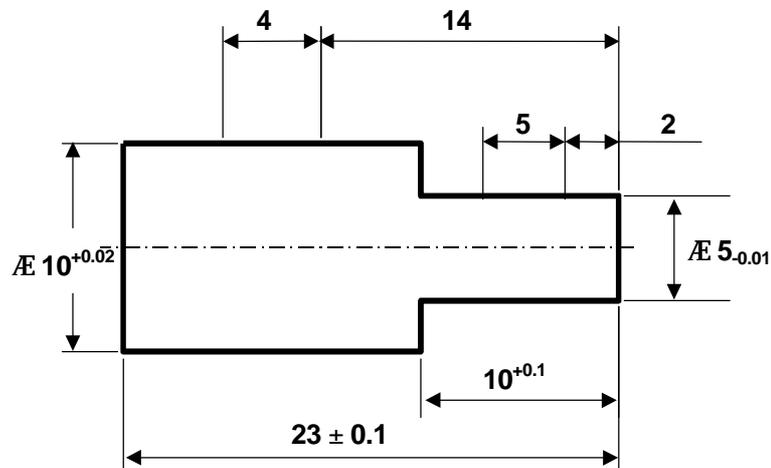
Figure 1. The examples of primitives.

Figure 2. Example of the object drawing.

Such expression by primitives can be automatically obtained from the object drawing, performed by means of the automatic design program which supports DXF format (e.g. AutoCAD), according to certain rules of indication of inspected parameters and tolerances. The example of such drawing one can see in the Figure 2. The horizontal dimensions above axis of symmetry show places of section where it is necessary to measure the diameters. Then formed expression is used to produce an inspection strategy, namely:

- determination of inspected parameter types (Fig. 3);
- selection from the object description the corresponding primitives;
- selection the image processing subprograms;
- finding the parameters of primitives and calculation the detail's geometrical parameters;
- global data processing;
- decision-making about detail's fitness.

This flexible technology gives wide potential for smart inspection system development. First, it allows the operative widening of the inspected object nomenclature. One have only to create the object drawing, according to certain rules of indication of inspected parameters and tolerances. Then system will automatically process this drawing to obtain an expression by primitives and will add this expression into its database. Second, it is easy to change the object's parameters, which are already in the database of system. For that it is necessary to correct the existing object drawing and reset the new description into database. Third, this technology allows the enlargement of the following inspected list of parameters. For the systems, based on shadow projection method, such parameters are the following:

- straightness deviation of cylindrical detail section;
- thread parameters (pitch, profile angle, middle diameter).

To do this it is necessary to add the list of the rules of detail drawing making and library of shadow image processing algorithms by the corresponding subprograms.
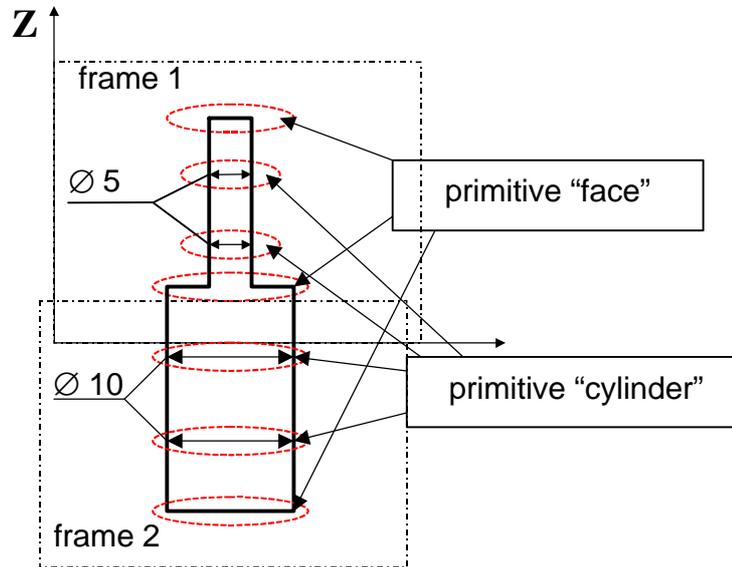

Figure 3. Determination and localization of inspected parameter types.

3   THE SMART OPTICAL DIMENSIONAL INSPECTION SYSTEMS FOR ATOMIC INDUSTRY

The discussed above technology was successfully applied to the dimensional inspection systems designed by the Technological Design Institute of Scientific Instrument Engineering. These optico-electronic systems are based on shadow projection method and are oriented for noncontact complex inspection of the base geometrical parameters like length, diameter, cone angle and facet parameters of industrial articles like bodies of revolution [2].

These systems include the optico-electronic measuring module with two orthogonal shadow sensors and movement mechanism, unit for measuring information processing based on IBM PC with operational system Windows 95 and conjunction module (Fig. 4).

The set of primitives for these systems consists of primitive "cylinder", primitive "face" and primitive "angle". The range of inspection diameters is from 1 mm to 15 mm, the range of inspection lengths is from 1 to 100 mm.

These inspection systems meet all general requirements for the industrial product inspection. Application of the standard CAD provides the opportunity for fast widening of the inspected object nomenclature. A priory information about inspected article, obtained while processing the drawing, allows to simplify (therefore, speed up) the shadow images analysis and to achieve higher inspection productivity. Using of special image processing algorithms determines the shadow projection's bounds with precision up to ¼ of the CCD–matrix element, which provides low measurement error (5-10µm). The inspection productivity is at most 15 s for the articles with 15-20 inspection parameters.

Measurement process automation enables to obtain objective data due to elimination of the "human factor". Noncontact inspection and high productivity (over 200 objects per hour) allows to apply such systems to technological process monitoring as well as to a 100% output inspection of the large product quantities. Possibility of prompt widening of the inspected object nomenclature as well as changing of the object's parameters, which are already present in the system database, allows to avoid using a large number of specialized limiting calibres and templates. Preservation of the inspection results in the database with the further analysis of the batch, shift and month is of invaluable help to an automated line production engineer in its attempts to elaborate the technological process and to guarantee high quality of the product.

At present these systems are exploited at the plants of the atomic industry.
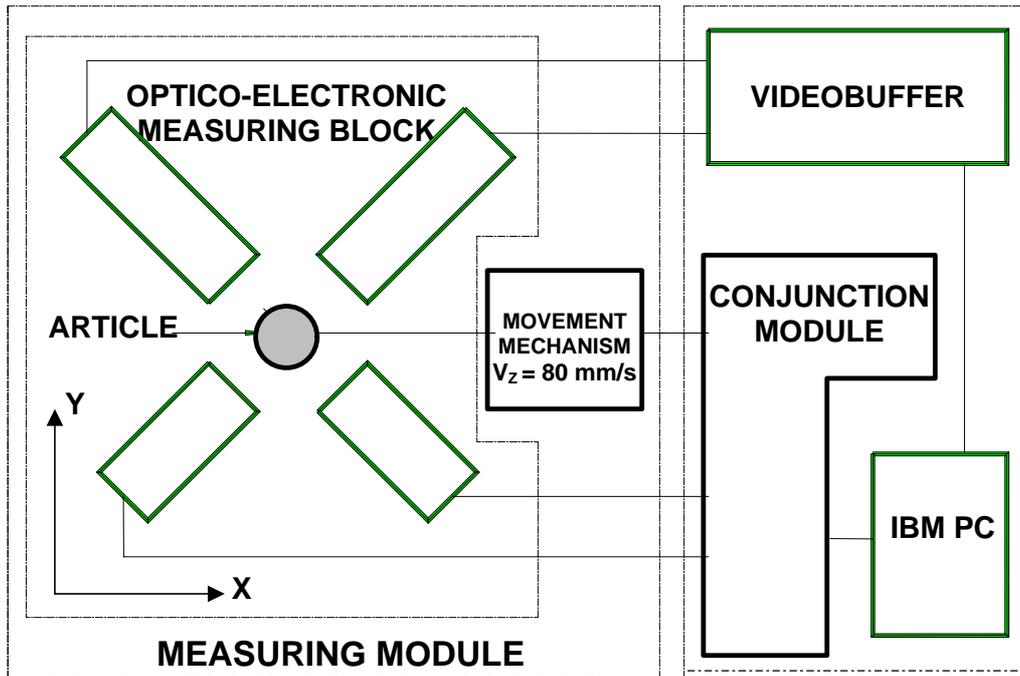
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Figure 4. Structure scheme of the optico-electronic inspection system for measurement of geometrical parameters of articles like bodies of revolution.

4   CONCLUSION

The discussed above technology may be used in the inspection systems with another principle of operation. For that the following sequence of operations is required. First, one have to definite the set of primitives, which completely describes qualitative characteristics of inspection parameters. At that the unique dependence between parameters of primitives and inspection parameters is required. Second, one have to elaborate the way of description of the object under inspection. This description will be used by the program which creates the expression of the inspection object by the combination of primitives. Third, one have to develop the subprograms for finding the parameters of primitives and calculation the detail's geometrical parameters.

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AUTHORS: Konstantin KUTCHINSKY, Sergei PLOTNIKOV and Sergei YUNOSHEV, Laboratory for Technical Vision, Technological Design Institute of Scientific Instrument Engineering, 41, Russkaya str., Novosibirsk, 630058, Russia. Phone Int +7 3832 332.760, Fax Int +7 3832 329.342
E-mail: kik@nmsf.sscc.ru