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COMPUTER AIDED ANALYSIS AND CORRECTION OF CERTAIN KINEMATIC AND GEOMETRICAL PARAMETERS OF ROBOT KINEMATIC PARAMETERS

Summary. The paper presents the computer system for the analysis of travelling units guides with respect to the shape and position errors of the guiding elements. The system allows also to perform a correction of the guides positions depending on certain movement parameters of the travelling unit.

Development of new manufacturing techniques of machine parts aims at improving their performance also through minimizing shape and position errors of kinematic pairs to the technologically justified level. The paper presents computer aided system for certain shope and position quide surfa ces errors analysis. The described system allows to assess machine tool and robot guides basing on accepted criteria. Analysing system cooperates with the laser interferometer measuring system which performs translatio nal and rotational displacement measurements. The system enables the correction of cartesian robot kinematic pairs performance parameters.

The main functions of the system are as follows:

- communication with the measuring system through the IEE 488 interface for automatic data collection (measurement results for processing);
- data analysis basing on accepted geometrical criteria for guiding elements or travelling units;

- graphical representation of the obtained results;
- kinematic pair correction data verification;

The block diagram of the system is shown on fig. 1.

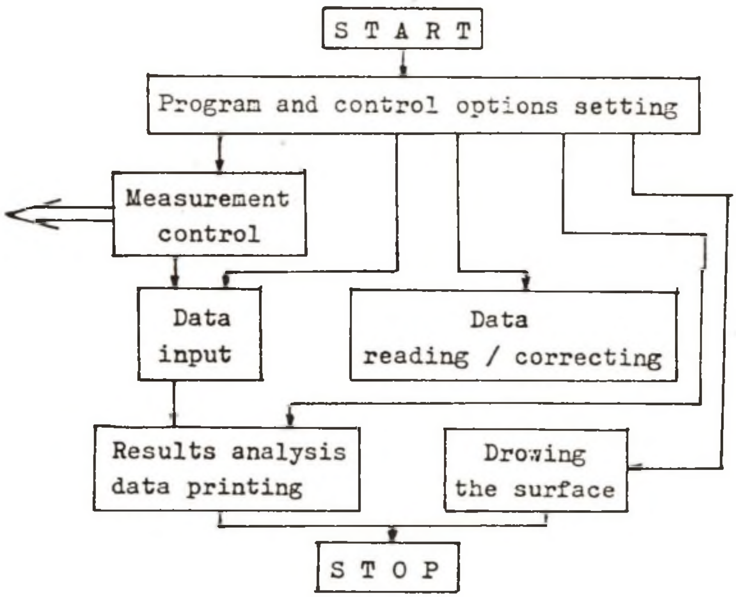

Fig. 1. Block diagram of the program

1. Communication with the measuring system

This part of the program is responsible for:

- measuring system control
- setting the task parameters (kind of shape error to inspect, way of determining positioning error of the travelling unit, travelling unit movement control parameters).

General version enables to evaluate the errors of straightness and flat ness of quiding surfaces, their distance variation (including relative orientation), movement velocity, its fluctuation of orientation of the travelling unit, (in two perpendicular directions) during its linear motion. The above can be measured with the usage of specially designed measuring system with the laser multiaxis interferometer. Present version of the system is adapted for use with the three - axes measuring system performing the inspection of three parameters at a time.

Other options of this part of the program are used for data input and corrections, forming analysis files and creating base measuring line, e.g. in the case of flateness errors, the base measuring line parameters are given at first, then each measuring point coordinates and the slope of the relevant segment - accordingly to the surface discretization (fig. 2).

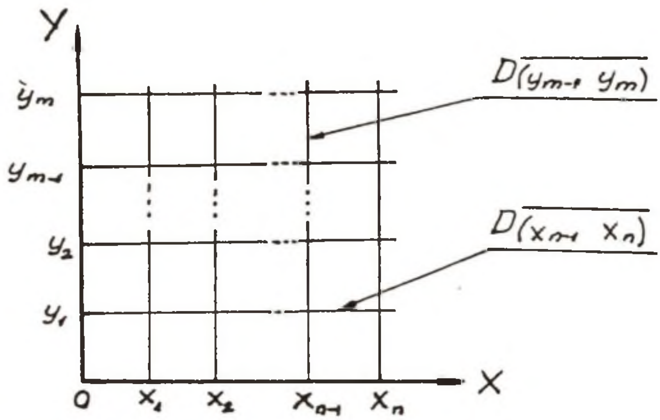

Fig. 2. Discretization of the measured surface

For the analysis purpose, for each n-th point (n = 2..N) of the measuring line, X_n coordinate and slope D_n (segment X_{n-1} X_n) are given. Additionally for each n-th point and m-th line (m = 2..M), the measured distance from the point Y_m to the base line and the slope D_m (segment Y_{m-1} Y_m) are given. All input data are written into the file. In case of inspecting movement parameters of the travelling unit, the linear and angular coordinates for its cooresponding positions (measuring points) are given, together with the time of travel from the last position in the same measuring line.

2. Data analysis

Procedure "analysis" comprises two main parts. The first one concerns shape and position errors, whereas the second one includes positioning and movement parameters of the travelling unit. The block diagram of the procedure is shown on fig. 3.

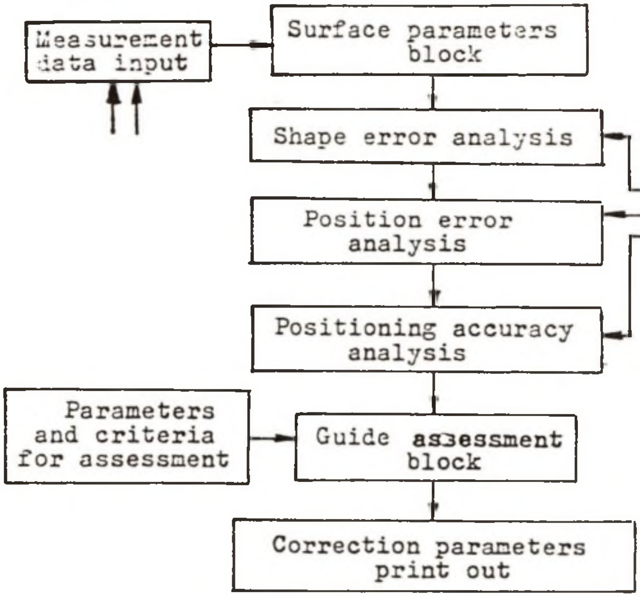

Fig. 3. Analysis block diagram

Shape and position errors are represented by: flatness, straightness, parallelness, orthogonality and relative orientation of guides. The above are the subject of the analysis. Nominal conditions and assessment criteria are determined by the design and manufacturing requirements, including the shape of the guide. Strightness and flatness errors are calculated in accordance with the relevant standard, parallelness errors is directly connected with the reference surface in the measuring sub-area. Measuring points which determinate the reference coordinate system and the non - parallelness vector are evaluated. The non - parallelness is defined as the variation of the distance between the surfaces or the planes representing them. Having the sub-area on the plane F the point P on the plane f (fig.4), and the vector $\overrightarrow{OS}$ of the measurment direction, the distance from the point $P \in f$ from the plane F in the $\overrightarrow{OS}$ direction can be calculated: $NP = \alpha x_0 + \beta y_0 + \gamma z_0 + \delta$, where: α, β, γ - direction cosines of the vector $\bar{n}$, δ - vector measure in OS axis .

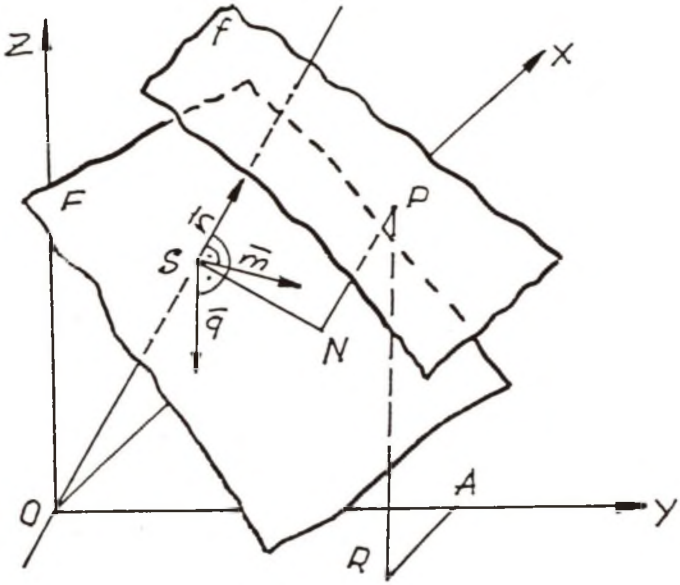

Fig. 4. Determination of the distance between guides

The values of flatness and parallelness deviations depend on the choice of the reference. Depending on requirements, functions and kind of the transla tion kinematic pair, various reference planes can be taken, differing in respect of spatial orientation to the inspected guide surface. The program is designed to perform analysis related to the following planes: - mean, adjacent, nominal or user's (defined mathematically).

The second part of the program using the obtained data (angular and linear position of the travelling unit in time function) and basing on accepted criteria evaluates the following parameters:

- linear and angular positioning in a given point of the robot
- velocity and its variations, distances in definite time intervals
- angular and linear position of the robot travelling unit.

3. Correction data block

This is an open - type subprogram featuring the possibility of introducing user defined criteria of robot guide and travelling unit assessment. When establishing new criteria it is possible to take an advantage of evaluated in this block shape and position errors and chosen movement parameters. In that case the criteria must be given in the form of function. The subprogram, in its basic version, calculates correction parameters, which can be used (e.g. in case of shape and position errors) for achieving guiding elements position so that existing parallelness and orthogonality errors of the guide surfaces are minimized, the flateness and straightness errors of the guides being measured.

Upon made analysis one can conclude that in order to determine complex position and shape error of guiding elements, it is necessery to take into consideration both flateness or straightness errors and the variation of the actual distance between inspected guide surfaces.

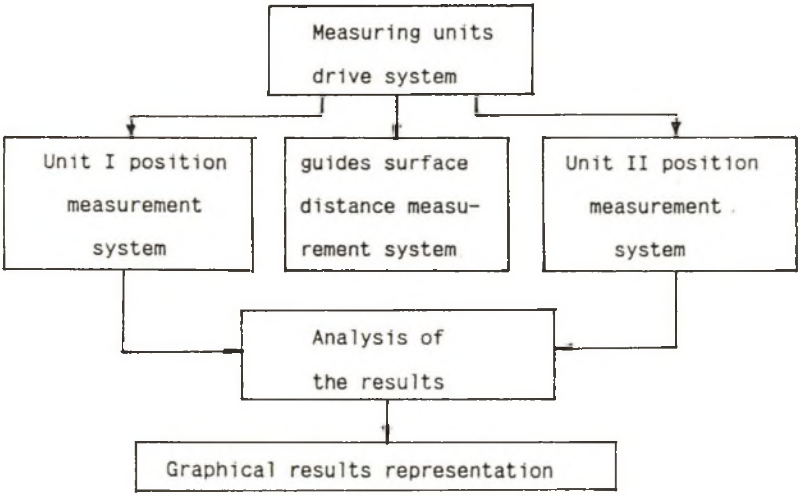

Fig. 5. Inspection and measurement system

The developed method is suitable for the assessment and correction of the robots and processing machines, especially the great size ones, by means of measuring variation of the distance between inspected surfaces and their straightness error (fig. 5).

These parameters are determined simultaneously in assumed guide segments the error parameters are calculated with reference to assumed base lines or planes. The global out-of-parallelness factor (GOF) was definited in order to create on overall qualitative and quantitative description of the complex error of the guides. GOF is the function describing the actual measured distances between guides and their straightness errors, which in compa rison with parallelness errors,have much stronger influence on static and dynamic positioning of travelling units (there is a possibility of defining GOF replacing straighness with parallelness).

GOF is defined as a vector :

$$GOF = \begin{bmatrix} A \\ B \end{bmatrix}$$

where : $A = \dfrac{F_A(x,y)}{A_o}$ $B = \dfrac{F_B(x,y)}{B_o}$

F_A -surface distances function (measured values)

F_B - parallelness or straightness error function (in assumed area)

A_o , B_o -base distance and flatness values.

F function describes parallelness errors of the guide surface calculated with reference to assumed regression planes (mean or adjacent). A and B functions give the values of position correction parameters for the chosen set of points.

4. Graphical representation of the results

The results of performed analysis are presented in graphical form as 2D or 3D graphs (e.g. the graph showing the guides distance variation in cartesian coordinates of the inspected surface). Additionally, the program generates a 3D picture of the analysed guiding elements, taking into account their actual mutual position and orientation in space.

Conclusion

The developed computer analysis system based on assumed criteria, enables to perform a qualitative and quantitative analysis of the guiding or moving elements of certain processing machines and robots.
The assessment criteria were based on existing shape and position guide errors and assumed permissible tolerances of kinematic parameters.
The presented system also provides an automatic control of measurements and data analysis with graphical presentation of results.
The geometrical identification of the guides makes it possible to minimize their parallelness errors and provide correction data which can be used for improving kinematic parameters of the guiding elements.

References.

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