A PROGRAM TO AID MEASUREMENT ON A THREEDIMENSIONAL MEASURING MACHINE

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ABSTRACT

We introduce here a software designed for the threedimensional measuring machine produced by the R.N.U.R.

This programme, developped by the A.D.E.P.A., is able to master, in the three-dimensional space, any measure read on a drawing. This software results from three innovations:

1. Geometrical elements (straight line, circle, sphere, plane, cylinder, cone) are derived from the palpated points by an optimising programme (Annals of the C.I.R.P. Vol. 25/1/1976, page 359) whose performances are of course directly related to the number of points being palpated.

2. All calculations being processed in a threedimensional referential, no physical balancing of the object is needed.

3. The metrological operations (parameters of a surface, distance, angle, middle, intersection of two geometrical elements) are combined into a schedule recorded on tape.

INTRODUCTION

The use of threedimensional measuring machines makes it evident that the following is needed:

1. An objective association of theoretical surfaces and a set of measured points.
2. The determination of the relative positions between the theoretical surfaces.
3. The constitution of a control sequence well arranged to control the geometry of a mechanical element with the maximum accuracy.

Using these three processes implies the need of a computer-treatment of the date and the establishment of a dialogue man-machine accurate enough to eliminate any possible error and help the operator into elaborating a sequence of rational measure.

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This programme (doped by A.D.E.P.A.*) is able to control in space any dimension given on a mechanical drawing, in so far as the surfaces concerned can be reached by the probe.

The geometrical elements, whatever arrangement they have in space, can be:

— point
— line
— plane
— circle
— sphere
— cylinder
— cone.

The dimensions can be:

Distances and angles between any geometrical figure consistent with the above list.

Morever, new geometrical elements can be defined by the intersection of any geometrical figure given in the above list.

It is possible to introduce geometrical elements which are not directly defined by the probe (middle, intersection, point at a given distance from a plane, and any geometrical definition of a line and a plane).

The association of a geometrical element with points defined by the probe is carried out according to an optimalisation programme whose possibilities will be all the better as the number of probed points will be important. (The theory of optimalisation used here is that which is defined by: P. BOURDET and A. CLEMENT C.I.R.P. Annals PARIS, Aout 1976).

EXAMPLE

Three probed points are enough to define a plane. But to have a more precise idea of the plane, particularly of any faulty shape and a more precise position in space, more than three points will be needed for the measurement.

Thus, the operator will have to probe the most effective points of the surface since the surface is only known by the number of probed points.

The user of PROMESUR will be able to ask for:

— any faulty shape in any probed element
— alignment according to a plane, one, two or three axis in space
— the results in cartesian or polar coordinates
— a change of probe (one or more than one) with resetting to probe zero
— a comparison between the results of the measurement and the given data.

The results will appear in a table easily readable and put in records. The conception of PROMESUR is based upon two major innovations:

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1. All calculation being done in a threedimensional set of references, any physical alignment of the mechanical part is suppressed. The user defines a plane, one, two or three axis of projection on which he will get his results which decreases the preparation period and increases the accuracy of the results.

2. All the operations of metrology which the programme allows can be combined into a schedule which can be recorded on tape.

Several modes of utilization are then available (in the manual version as well as in the numeric control version).

— to write down and realize successively a set of operations, then to record (or not) on tape the schedule thus elaborated.

— to write a succession of operations and realize the schedule thus given, which can be recorded or not on tape.

— to realize a schedule already recorded on tape: the realization of the schedule is done in a conversational mode and helps the operator in his decisions.

When a schedule is to be realized, the calculator commands the probing of the surfaces and keeps in memory all the specification necessary for the realization of the programme.

That unique conception offers other advantages:

— to keep the usual possibility of controlling a unitary part

— not to write the schedule in the consol of two identical parts or belonging to the same category

— to enable the schedules to be recorded on tape in the view of a further use

— to enable the schedule to be written on a calculator not connected to the measuring machine (M.M.T.)

— in the case of a D.N.C. machine, the control of the first part is done manually, a memory button can record the moves of the probe. All the other parts are then automatically controlled, whatever position they have in the machine-space.

PROMESUR offers a large number of further possibilities which make its use even easier:

— immediate detection and correction of standards errors in writing.

— detection of error-messages and cancellation of probes mathematically not consonant with the demanded geometrical element

— cancellation of last probed point

— cancellation of last written instruction

— printing of schedule on printer

— usual control on thermical printer of instructions typed on Key-board.

GEOMETRICAL ELEMENTS

Point, line, plane, circle, sphere, cylinder, and cone can be associated with surfaces defined by measuring points whatever their position may be in the measuring machine-space.

The association of a geometrical element with a measured surface is *optimised* according to the minimal faulty shape condition.

The maximum number of measuring points chosen to define a surface is only limited by the memory capacity of the calculator.

The minimum number of points is that which is needed to a strictly mathematical definition.

The following table gives, per geometrical element, the different number of measuring points consistent with a memory capacity of $16K$ octets (basic version).

	Minimum number	Number chosen by promesur	Maximum number
point	1	1	1
line	2 + 1	3 + 1	49 + 1
plane	3	4	50
circle	3	4	50
sphere	4	8	50
cylinder	5	8	50
cone	6	8	50

INSTRUCTION AND OPERATION

1. *Instructions*

The operator has answered the first two series of questions concerning the PROMESUR mode of use and the choice of the number of measuring points, the display shows "WAIT INST". The operator can then choose on the PROMESUR key-board one of the following instructions:

- — Parameter — The operator asks for specifications of a surface associated with a geometrical element.
- — Distance — The operator asks for the distance between two geometrical elements.
- — Middle — The operator asks for the middle between two geometrical elements.
- — Angle — The operator asks for the angle between two geometrical elements.
- — Intersection — The operator asks for the intersection between two geometrical elements.
- — Probe zero — The operator wants the introduction of the radius of the different probes and, if necessary, he will do the probings of machine zero.
- — Alignement — The operator asks for the introduction of a plan or one, two or three axis of projection.
- — Polar — The operator asks for the results in polar coordinates.
- — Schedule list — The operator asks for the printing of the schedule in memory. He can make any necessary correction (insertion--correction-suppression).

-- Data — The operator wants to put in the date of the part in the next instructions.

— Faulty shape — The operator wants the faulty shapes to be printed in the next parameter instruction.

— Gauging plane — The operator asks for the distance between the gauging plane of a sphere and a plane.

2. *Metrology*

An operation of metrology can be written only if: WAIT INSTRUCTION is displayed.

It must begin by an instruction of PROMESUR Keyboard and will be possibly followed by answers to questions asked to the calculator.

EXAMPLE

The last numbered surface is surface 7. We want to write:

Distance between a non-numbered cylinder and cylinder N° 3:

Display	Key	Calculator
Wait instruction	Distance	
Distance		Distance
First geometrical element	Cylinder	Cylinder
Has it a number?	No	8
Second geometrical element	Cylinder	
Cylinder		Cylinder
Has it a number?	3	3
Correct instruction	Continue Yes/No	

When the whole operation has been described, it can be accepted or cancelled by answering the question: Correct instruction.

NUMBERING OF GEOMETRICAL ELEMENTS AND OPERATIONS

1. The numbering of the different geometrical elements of the mechanical part is done automatically in the order of the schedule. The operator therefore, will be able to use only the numbers of geometrical elements already given by the calculator.

2. The operations are numbered automatically along with the writing of the schedule. The operator cannot attribute an operation number.

The maximum number of operations is limited to 100 in the basic version (16*K* octets).

CONCLUSION

This programme has been in use for six months in industry on M.M.T. measuring SEIV automation machines (Groupe RENAULT).

It seems to correspond perfectly to the needs of those who control mechanical parts of any conception, single or in series.

The possibilities of measurement thus offered, by their precision and accuracy: (parametering necessary and sufficient of the relative positions of surfaces), should give lead to a more accurate definition of parts belonging to a mechanical set.