THE ANNALS "DUNĂREA DE JOS" OF GALAȚI
FASCICLE V, TECHOLOLOGIES IN MECANICAL ENGINEERING, ISSN 1221-4566
2007

# A New Approach of the Dimensional Inspection Based on Dimensions Assembly Identification

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**ABSTRACT**

*In the industry practice are often meet cases when is necessary to identify piece surfaces regarding another surfaces already machined.*

*In present, for these cases, is used the 3-2-1 method in order to determine the reference trihedron, and, after this, to identify the piece surfaces. The reference surfaces identified by this method can't regard the deviations which emerge at actual surfaces.*

*In this paper is proposed a new identification method based on the determination of dimensions assembly, which contain the dimensions reciprocally restricted by tolerances and after this the identifying of this dimensions assembly. The new method is based on neural network modeling.*

**Keywords**: *reconfigurable manufacturing systems, dimensional network, neural network.*

## 1. Introduction

The reconfigurability of the modern manufacturing systems means that these systems are easy to change in order to assure the machining of a small batch keeping the productivity at maximum values. More, these systems can be used as measuring systems, by changing the cutting tool with a touch probe.

Changing the system architecture, is possible to use various identification methods, each of these adequate for a certain piece type, in order to increase the identification speed and to decrease the human effort.

The identification means the mathematical model construction, based on experimental results.

For a surface, the mathematical model is the surface equation which link the points coordinates from this surface.

For a dimension, the identification is defined as the model determination, which link the points coordinates, gathered from the two surfaces which defined the dimension itself and the value of this dimension, idle, $D_1 = f\left(P_1,\ldots P_n, Q_1,\ldots Q_n\right)$ where $P_1,\ldots P_n$ are points coordinates on first surface and $Q_1,\ldots Q_n$ are points coordinates on second surface.

The dimensions assembly identification presume to find the mathematical model which link the values of all dimensions from assembly, by one hand, and, by the other hand the points coordinates from the piece surfaces.

In practice are often meet cases when the certain piece surfaces identification is necessary to be made regarding another surfaces, already machined [1], [4], [5].

In present, for this identification, firstly is identified the reference system trihedron, by 3-2-1 method. This method consist in the gathering of 3 points on one of the thrihedron planes, the identification of this plane, and after this the gathering of 2 points and respectively 1 point on the others two planes on the trihedron in order to identify the others two planes.

Often this method is used despite its main shortcoming is that the identification is made by a very small number of points and isn't possible to be regarded the deviations from theoretically form of the actual surfaces.

By the other hand, on can meet the case when the surface to be identified is tolerated regarding more than one reference system (see figure 1) [2].

As example, the cylindrical surface $S_2$ is tolerated regarding the position on *Oy* axis from the piece reference system, the position on *Ox* axis is tolerated regarding the $S_1$ center position and its axis is tolerated as angular position regarding the axis of $S_1$ cylindrical surface position. More, the diameter of $S_2$ surface is tolerated in its own reference system.

Analyzing the piece is possible to establish a dimensions assembly, being in relative positions give by the tolerated piece dimensions [4].

Now the usually solution presume to individually identify each surface and, after this to associate the mathematical model of these with the mathematical model of the reference system. Working in this way is very difficult due of the big volume of processed data.

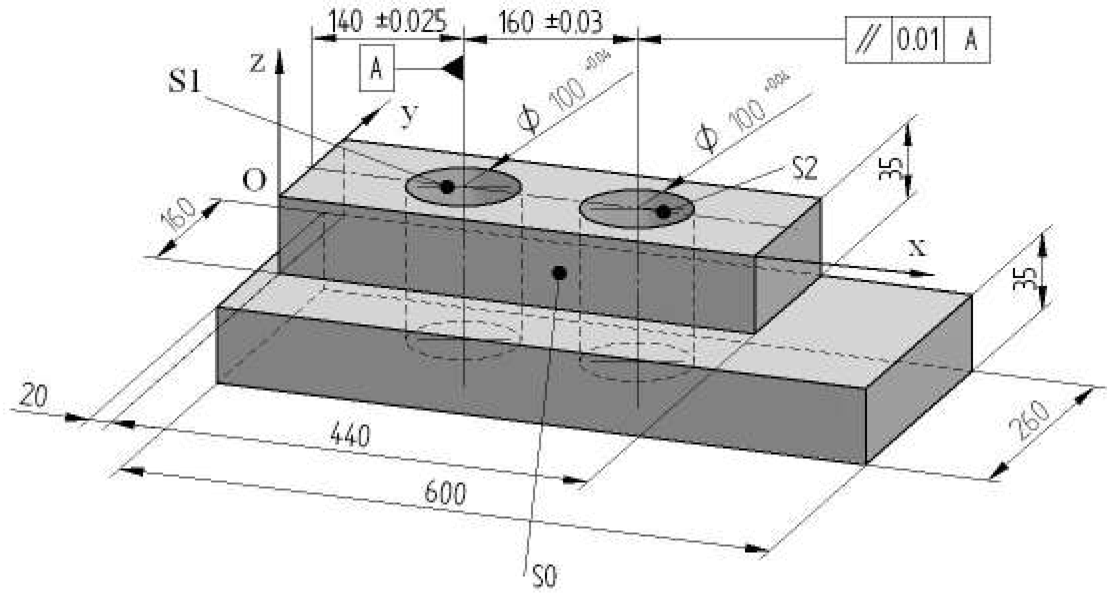


**Fig. 1.** *The piece with dimensions assembly*

In this paper is proposed the determining of a dimensions assembly which contains all the dimensions reciprocally restricted by tolerance and the identification of this dimensions assembly.

## 2. Algorithm for Dimensions Assembly Identification based on Neural Network

As example we can regard the piece presented in figure 2, machined on a reconfigurable machining system.

The important dimensions are the tolerated dimensions. These are identified with the neural network technique.

The important surfaces for piece function are the P, Q and R, plane surfaces and the cylindrical surfaces with diameters $D_1$ and $D_2$.

The models parameters are those deviations that are relevant for the pieces functioning and, for this reason have imposed limits.

We can consider that the pieces model have 7 independent parameters: the two distances from holes axis to reference surface (the P plane), the distance between $D_2$ axis and the Q plane, the distance between the holes axis, the $D_1$ and $D_2$ diameters and the angle between the holes axis.

The piece measuring is made on the same system as the machining. For the measuring phase, the cutting tool is replaced by a touching probe which is moved on a certain trajectory.

After the points cloud gathering, is made the piece surfaces identify by scope function minimization [3].

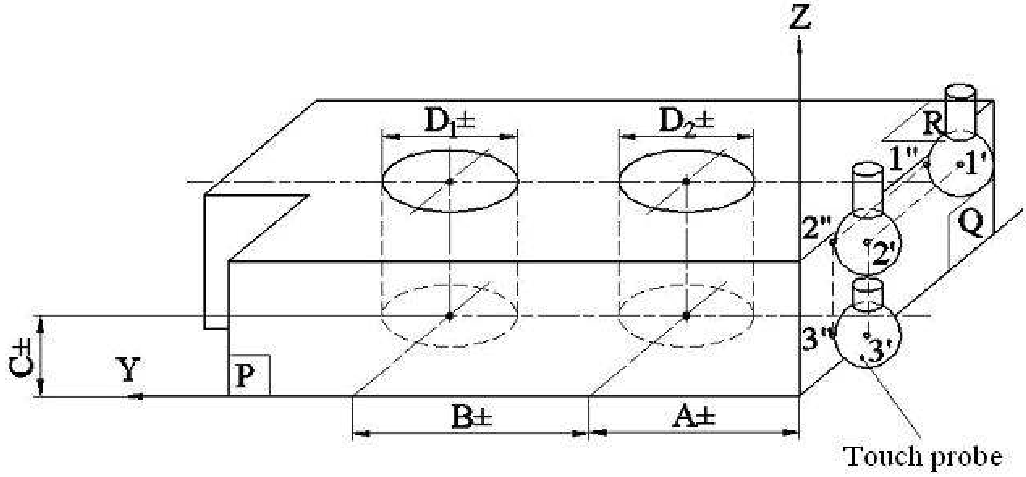


**Fig. 2.** *Machined piece*

We will not identify each of the piece surfaces, finding its models, but we will identify the links between the measured points coordinates and the deviations of the dimensions which will form the dimensions assembly.

We have to notice that all the measured coordinates must be influent regarding the dimension deviations. If not, the neural network will have very poor results.

If exists dimensions which are not influenced by some of the coordinates, these dimensions have to be individually identified by another neural network.

## 3. Dimensions Assembly Identification Using Neural Network

In order to verify the algorithm was realized applications which have the previously presented phases.

It was choose a piece with plane and cylindrical surfaces and was established the dimensional deviations and the position deviations which appear between the functional surfaces.

As functional surfaces was considered the holes with diameter 100 mm ($S_1$ and $S_2$) and the $S_0$ plane surface.

It was regarded as important the holes diameters, the position of holes regarding the $S_0$ plane surface, the position regarding the yOz reference system and the distance between the holes axis.

The parameters which describe the piece model will be, in this case, the distances between $S_0$ to each of the holes, the dimension on Ox axis for $S_1$ axis, the distance between the holes axis and the relative angle between the holes axis, in total 7 parameters.

We can consider that the parameters set is composed by

$$\{y_{01}, \varphi_1, R_1, x_{02}, y_{02}, \varphi_2, R_2\}, \qquad (1)$$

where:

$y_{01}$ is the $S_1$ hole center coordinate on Oy axis direction;

$\varphi_1$ — the rotation around the Ox axis of $S_1$ hole;

$R_1$ — the actual radius of $S_1$ hole;

$x_{02}$ —the displacement of $S_2$ hole center regarding the $S_1$ center, on the Ox axis;

$y_{02}$ —the displacement of $S_2$ hole center regarding the $S_1$ center on Oy axis;

$\varphi_2$ —the angle between the $S_2$ and $S_1$ axis in plane yOz;

$R_2$ —the actual radius of $S_2$ hole.

For each of the $S_1$ and $S_2$ surfaces, was measured 25 points along a cylindrical helix with constant pitch.

At neural network training for each *i* point was applied a coordinate transformation in a modified reference system with conformity parameters and was calculated the *f* function as deviation of point position regarding the cylindrical surface:

$$f = (x + X_0)^2 + (y + Y_0)^2 - R_0^2, \qquad (2)$$

where $X_0$ and $Y_0$ are the theoretically coordinates of the cylindrical surface centre and the $R_0$ is the theoretically radius of this cylinder.

The $y_{01}$, $y_{02}$, $x_{02}$, $R_1$ and $R_2$ parameters have deviations between $\pm 0.04$ mm, and the angular parameters $\varphi_1$ and $\varphi_2$ have deviations between $\pm 0.025°$.

In this way was obtained a data base with

$$M = \prod_{i=1}^{7} v_i = 3^7 = 2187 \qquad (3)$$

records, each record with 57 fields (50 values for *f* function and 7 values for the parameters set).

In table 1 is presented the accuracy for the neural network interrogation. The interrogation parameters are inside of the training domain.

*Table 1. The neural network precision*

| Parameter | Actual | Calculated | Error |
|---|---|---|---|
| $y_{01}$ [mm] | 80.03000 | 80.03532 | -0.00532 |
| $\varphi_1$ [°] | -0.00030 | -0.00025 | -0.00005 |
| $R_1$ [mm] | 50.01000 | 50.01338 | -0.00338 |
| $x_{02}$ [mm] | 160.02000 | 160.02361 | -0.00361 |
| $y_{02}$ [mm] | -0.03000 | -0.03151 | 0.00151 |
| $\varphi_2$ [°] | 0.00025 | 0.00027 | -0.00002 |
| $R_2$ [mm] | 49.98000 | 49.98331 | -0.00331 |

## 5. Conclusion

This method may be applied for more complex topological structures composed by plane and cylindrical surfaces and for various deviations (perpendicularity, parallelism, distances etc.).

The numerical results prove that the identification using dimensions assembly has same precision as the individual identification of each surface.

This way to describe the piece geometrical features is closer to the real application of the mathematical model in industry.

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## Identificarea ansamblurilor de dimensiuni pe baza rețelelor neuronale

### Rezumat

În practica industrială sunt des întâlnite cazurile în care este necesară identificarea suprafețelor unei piese, în raport cu alte suprafețe, deja prelucrate.

În prezent, pentru aceste cazuri, se aplică metoda 3-2-1, determinându-se triedrul sistemului de referință şi, apoi, identificând suprafețele piesei. Identificarea suprafețelor de referință prin această metodă nu poate ține seama de abaterile care apar la realizarea suprafețelor reale.

În prezenta lucrare este propusă o nouă metodă bazată pe determinarea unui ansamblu de dimensiuni, ansamblu ce conține dimensiunile tolerate ale piesei, şi, după aceasta, identificarea acestui ansamblu de dimensiuni utilizând rețele neuronale.

## Identification du Dimensions Assemblée fondée sur de réseaux de neurones

### Résumé

Dans les pratiques de l'industrie sont souvent les cas où est nécessaire d'identifier une pièce concernant les surfaces des surfaces déjà usinées.

À présent, pour ces cas, on utilise le 3-2-1 méthode afin de déterminer la référence trihedron, et ce après la pièce d'identifier les surfaces. La référence, les surfaces identification par cette méthode ne peut considérer les écarts qui se dégagent lors des surfaces réelles.

Dans cet article est proposé une nouvelle méthode basée sur la détermination de l'assemblée de dimensions, qui contiennent les dimensions restreintes par les tolérances mutuellement, et ce, après l'identification des dimensions de cette assemblée.