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Providing for Positioning Accuracy when Assembling Large-Sized Constructions

K.A. Odnokurtsev*, E.V. Zykova

Irkutsk National Research Technical University, 83, Lermontova St, Irkutsk 664074, The Russian Federation

Abstract

A method of performing adaptive coordinate positioning of parts of large-sized constructions is suggested. A number of problems, arising when mounting large-sized constructions and influencing the accuracy of assembling are considered in this article. The methods of providing for accuracy in direct and reversed methods of positioning are considered. The problems of coordinate positioning when assembling large-sized constructions are considered. The method of adaptive positioning for two iterations, which allows equalizing some kinds of inaccuracies when positioning, is suggested. During experimental implementation of the suggested positioning method it was approved that automated positioning for two iterations allows for the significant increase in the accuracy of positioning. Experimental research was performed with the help of the industrial robot KUKA KR 10 R1100 sixx and a complex of three Cartesian positioners with electric slides FESTO EGSK-46-300-10P with stepper motors EMMS-ST-57-M-SEB-G2. Coordinate measurements were performed by the laser tracker API Tracker3. The method is suggested to be used in aircraft engineering, ship building, etc.

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Keywords: coordinate positioning; assembling; coordinate measurements; positioner; laser tracker.

1. Introduction

When assembling of the large-sized constructions providing of accuracy is a very complicated task. To provide the target accuracy of assembling it is necessary to manufacture the parts of constructions assembled with high accuracy that is a very complicated task taking into account their significant sizes (from some meters to some dozens of meters). Additional complexity is in fragility of parts of construction, which often can be deformed under

* Corresponding author. Tel.: +7-395-240-5419; fax: +7-395-240-5130.
E-mail address: kodn82@gmail.com

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the influence of their own weight by the amount exceeding acceptable divergence when assembling. [1-4] Consequently, when assembling such constructions (for instance, in aircraft engineering or ship building) different assembly jigs are widely used [1,2, 4-11]. They provide target relative position of parts of construction assembled and give additional stiffness when assembling. In modern conditions, when components are manufactured according to CAD models, different methods of coordinate positioning, allowing to automatize the process of assembling of large-sized constructions, become more and more widespread [12-20]. Therefore, coordinate positioning is applied in aircraft engineering when mounting assembly tools and in aggregate assembling of aircrafts [8,21]. As a result, the accuracy of assembling is determined by the accuracy of coordinate positioning [22,23].

2. The methods of coordinate positioning

Coordinate positioning is providing of location of the object in space in the coordinates determined for a target location of the object in the basic coordinate system. There are three main methods of coordinate positioning of components: direct, reversed and by mounting plane and different kinds of combined methods [21]. The methods of providing of accuracy of direct and reversed positioning are described in this article.

In the process of direct positioning, the object set on the positioner moves in space from the optional initial location to the target final location. Initial coordinates are measured on a real object in its starting position with the help of automatized means of coordinate measurements. The final coordinates of the object are taken from its CAD-model. The peculiarities of the direct coordinate positioning method are quite high complexity of the controlling positioning system and complicated algorithms of calculation of the positioner's movements, based on affine transformations (inverse kinematic problem is solved here).

By the reversed positioning, at first one or several positioners provide target spatial location of the mounting seats for object of positioning installation, then the object is mounted on mounting seats assigned. This case the control of movement is proceeded by the initial and final coordinates of the positioner tool. The coordinates of the object itself from its CAD-model are necessary further to control the results of positioning. The peculiarities of the reversed positioning are quite simple algorithm of movements and simple controlling system, and convenience of using for mounting of large-sized objects with several positioners. The methods of combined positioning which are a combination of the direct and reversed positioning are widely used in industry. Such methods claim more complicated construction of positioners with free travel of some axes and complicated controlling system with clearance of movements of several driving units at the same time.

3. The problems of coordinate positioning

The technical system of coordinate positioning of the object according to 3D model, beside the object of positioning itself, consists of the following main components [21]:

- Automatized equipment of performing and processing of the results of coordinate measurements;
- Positioners and their controlling movement system, including the algorithms of the track forming.

To provide the target accuracy of positioning of the object it is necessary that all the incoming errors of the components of the technical system concerned to be in the target allowance.

Target accuracy of the positioning object is provided when being manufactured. In spite of the high accuracy of processing reached on the modern equipment with CNC under industrial conditions large parts of constructions often have significant errors exceeding admittance for positioning. To avoid the influence of their manufacturing errors on the accuracy of positioning the control of their geometric parameters after manufacturing should be done. Measured divergences are added to the nominal values of the object coordinates from CAD-model. The method described is applied, for example, in aircraft engineering by the mounting of assembly tools and aggregate assembling [21].

This method, however, does not let us take into account the deformations of little stiff constructions, whereas the spatial location and the pattern of object fixation by the coordinate control after manufacturing and when performing positioning are different, consequently, the distortions of the object change too.

The means of coordinate measurements when performing coordinate positioning let us determine the actual location of the object in space. Whereas coordinate positioning is mainly applied in assembling of large-sized